DISSERTATION

FOR THE

MASTER OF MEDICINE (MMED) DEGREE

TITLE PAGE

INJURY SEVERITY SCORE (ISS) VERSUS NEW INJURY SEVERITY SCORE (NISS) AT A LEVEL ONE TRAUMA UNIT IN SOUTH AFRICA.

ARE WE

MISS (MAXIMAL INJURY SEVERITY SCORE) ING THE POINT?

By

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Submitted in partial fulfillment of the academic requirements

for the degree of MMed

in the Department of General Surgery

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Durban

2016

As the candidate's supervisor I have approved this thesis for submission

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DECLARATION OF AUTHORSHIP

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DEDICATION:

To my mother, Late Dr. K. R. Biswas, all your unconditional love and encouragement have inspired me to become who I am today.

ACKNOWLEDGEMENT:

I would like to acknowledge Prof D.J.J. Muckart without whose patience and guidance I would have not been able to embark on this dissertation; Mr. T. Hardcastle for his advice along the way; Prof. Kanchan Chowdhury (Department of Statistics, Jahangirnagar University, Bangladesh) for her assistance in clarifying the statistical analysis and lastly, Mr. Rajib Das for his assistance with initial data preparation for statistical analysis.

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SECTION ONE: **INTRODUCTION**

Introduction

The Injury Severity Score (ISS) was developed to objectively quantify the severity of injury (1). The body is divided into 6 zones (head and neck, face, thorax, abdomen and pelvis, extremities, and skin). Each injury is awarded an Abbreviated Injury Scale (AIS) Score (2) according to a published guide. The three worst injuries are squared and added to give the ISS. Only three anatomical zones may be used and only the worst injury in any one zone may be included, even if more than one injury exists within an individual zone.

This system is problematic in patients with multiple injuries within a single zone as often occurs with penetrating trauma. With that in mind the New Injury Severity Score (NISS) was proposed whereby the three worst scores are used even if within a single zone. No study has addressed the concept of scoring all the injuries and producing a Maximal Injury Severity Score (MISS).

Background to the Research

Polytrauma patients comprise a significant disease burden on the Health Care system of South Africa. As such , in a developing country like South Africa, epidemiological research forms the basis from which health care can be improved upon. The MISS has not been investigated and will be evaluated with a view to improving the current predictive value when assessed in comparison to ISS and NISS at a Level 1 Trauma Unit in Durban, South Africa.

Aim of the Study:

To evaluate the predictive value of Maximal Injury Severity Score at a Level One Trauma Unit in South Africa when compared with current objective systems.

Research Objectives of the Study:

1. To evaluate the predictive value of the ISS versus the NISS in polytrauma trauma patients admitted to a Level 1 Trauma Unit in South Africa.
2. To assess the predictive value of a MISS in patients admitted to a Level 1 Trauma Unit in South Africa compared to ISS and NISS

Research Questions

The following questions have been derived from the aforementioned research objectives and apart from epidemiology of injury mechanism, all will compare ISS, NISS, and MISS:

1. What was the distribution of mechanism of injury and mortality rates?
2. Are these objective systems applicable to all age groups?
3. Does gender impact on outcome?
4. Does the length of stay (LOS) affect outcome?
5. Does the number of regions injured have an effect on outcome?

Hypothesis to be tested.

A Maximal Injury Severity Score has a better predictive value than the ISS or NISS for polytrauma patients admitted to a Level 1 Trauma Unit in South Africa.

Format of the Study

Section 1

This chapter introduces the topic to be researched, the research objectives and defines the hypothesis to be tested. In so doing, this section provides a narrative for the dissertation.

Section 2

The literature review is to place the research topic into perspective both locally and globally and to provide a sound basis for the discussion of findings and future recommendation.

Section 3

The study design and methodology will be elaborated on in this chapter. From ethical approval, sampling, data collection, statistical analysis tools used in this study.

Section 4

The results and data analysis will be discussed in this chapter. It will look at the findings in terms of the cohort as a whole first. The second part of this discussion will be to look at the three population groups, divided by age, with a view to identify difference in the spectrum of trauma, outcomes and a comparison of the predictive values of the injury scores as already defined.

Section 5

In the final chapter conclusions will be drawn based on the results of the data analysed. Comment regarding the applicability of the MISS at a Level I trauma unit. Lastly, depending on the data analysis, recommendation(s) may be made towards provision of a better service and improved outcome.

Conclusion

The ISS and the NISS are anatomic scores. Both depend on the AIS but differ in the calculation method (3). The NISS has gained popularity over the ISS, to evaluate polytrauma patients. It remains to be seen how the MISS will perform in comparison to these two well established severity scores. In the next chapter, the literature review will be discussed so that the scope of this topic can be outlined and placed into context.

SECTION TWO: **LITERATURE REVIEW**

Introduction:

The varied spectrum of injuries can be attributed to the mechanism of injury and age of patients, and outcome to available resources and time to definitive care. However, after sustaining an injury, an individual has a set outcome: survivor or non-survivor. With advances in many spheres of trauma patient management our efforts should be directed towards reduction of deaths and optimizing the quality of life for all those who do survive an injury. Trauma scoring is one such tool that has been developed and revised to facilitate this very outcome. Currently, there is no 'ideal' Trauma Score that predicts the mortality of a given patient perfectly. All the scores to date have their limitations and proposed area of applicability. Therefore, initial investigations should examine precisely where these scores are applicable to better understand the task at hand.

Global burden of disease

More than 5 million people die each year as a result of injuries (4). Road traffic collisions (RTC) are the leading cause of death and account for 24% of trauma mortality worldwide, especially in the 15 - 29 years age group. At this rate, RTC's are predicted to become the 7th leading cause of death by 2030 (4). Developed countries like Australia, and the United States of America have demonstrated a decline in fatalities secondary to RTC's. It is the low and lower-middle income countries where 90% of injury-related deaths occur. There is also a disparity within the gender of these individuals. Almost twice as many males than females die each year (4). The three leading causes of death from injuries for males are road traffic injuries, suicide and homicide, while leading causes of injury-related death for females are road traffic injuries, falls and suicide (4). The financial impact of trauma, be it accidental or non-accidental, is also worthy of note. Road traffic deaths and injuries cost approximately 2% of gross domestic product in high-income countries and as much as 5% of gross domestic product in some low- and middle-income countries (4). Reducing the severity of road collisions has been of concern for transportation authorities for many years. The road, environment, vehicle and human factors are the main components influencing the severity of collisions (5). As

the magnitude of this problem continues to grow, the endeavours by policy-makers and those involved with trauma prevention and implementation of public health strategies remains disproportionately low.

South African context

In South Africa, transport-related (12.1%) and assault (10.6%) accounted for 10 717 non-natural deaths in 2013 (6). KwaZulu/Natal province (1 797 deaths) was second to Eastern Cape (1 875 deaths) in terms of transport-related and assault deaths. The highest number of transport-related deaths was 1 173 in Limpopo and for assault, was Western Cape with 1 102 deaths.   Most of the transport-related deaths were in the 30-44 years age group and most assaults occurred in the 15 – 29 years age group. More than four times as many males (8 550 deaths) died than females (2 054 deaths) when looking at total number of transport related and assault deaths. This demonstrates that despite the advent of road safety awareness, stringent traffic rules, and the implementation of 'Zero Tolerance' policy for speeding in KwaZulu/Natal, RTC's and interpersonal violence still account for a sizeable proportion of non-accidental deaths in the country.

This must come at a cost, not only to human life, nor the economy through loss of quality of life or ability to earn an income, but more importantly to the state. Two small national studies have demonstrated the costs by which trauma has burdened the health care capacity in South Africa. Parkinson et al evaluated the micro-costing of 100 patients admitted to a regional hospital post RTC and found that the total cost of in-patient care for those patients was US$ 698 850 (7). Bowman et al found that the direct medical treatment costs of 48 (including a single burn case) patients, presenting at the Johannesburg hospital for a 5 month period beginning in January 2004 was ZAR 222 070.37 (8).

And yet as this 'Malignant Epidemic' (9) rages on, RTC's and assault are prime examples of preventable causes of injury fatality. Muckart (9) commented upon the

distinct phasic pattern of trauma deaths and recommended how each phase required a different approach for resolution. To date, there have been numerous initiatives to curb the escalation of trauma associated fatalities with little effect.

The current study was undertaken at the Level I Trauma Unit at Inkosi Albert Luthuli Central Hospital in Durban, KwaZulu/Natal which was commissioned in 2007. This tertiary facility serves a catchment area of 94 361 km^2 wherein a population of 10 919 100 people, 19.9% of South Africa's total population (10) reside at a population density of 110/km^2. During the more than four year period of this study there were 1 097 admissions to the trauma unit.

Trauma scoring

Trauma scoring has played a central role in the development of quality assurance for the seriously injured. The definition of a "Polytrauma" patient (first coined by Tscherne et al (11).) remains controversial. The most recent international consensus proposed a new definition: "significant injuries of three or more points in two or more different anatomic AIS regions in conjunction with one or more additional variables from the five physiologic parameters" (12). It awaits further validation to be adopted into the norm. More than 50 scoring systems have been published for the classification of trauma patients in the emergency room and intensive care settings (13). Trauma score models are based on anatomical or physiological descriptors, or combine both (14) as shown in Table 1.

TRAUMA SCORE	EXAMPLES
ANATOMICAL	• Abbreviated injury scale (AIS) • Injury severity score (ISS) • New injury severity score (NISS)
PHYSIOLOGICAL	• Paediatric Trauma Score (PTS) • Revised trauma score (RTS) • APACHE Score
COMBINED	• Trauma Score - Injury Severity Score (TRISS) • Kampala Trauma Score (KTS)

Table 1. Types of Trauma Scoring Systems

In 1969, the U.S.A. Association for the Advancement of Automotive Medicine introduced the Abbreviated Injury Scale (AIS) to assess RTC's victims. The AIS is an anatomically based consensus derived global severity scoring system (15) that classifies each injury in every body region according to its relative importance on a six point ordinal scale. This represents the 'threat to life' associated with an injury and is not meant to represent a comprehensive measure of severity (16).

In a polytrauma patient, the highest AIS is known as the maximum AIS (MAIS). Although MAIS has been used to describe overall severity, evaluations indicated that MAIS was not linearly correlated with the probability of death (17).

The ISS was first proposed in 1974 by Baker et al (18). Using the AIS score, an ISS value is calculated by summing the squares of the highest AIS scores in each of the three most severely injured ISS body regions. ISS has become one of the most prolific scoring systems to assess polytrauma patients. However, there are major limitations that have been identified:

- ISS fails to account for more than one injury per body region
- ISS has a highly positively skewed distribution and its relationship with mortality and other outcomes is not linear
- Identical scores do not necessarily translate into equal outcomes
- Due to the sum of squares certain numbers cannot be achieved
- ISS does not accurately adjust for differing injury severity in different body regions (19)
- The score is retrospective and may only be calculated after all injuries have been identified. As such it is not a useful triage tool.

In 1997, Osler et al (20) introduced the NISS. In contrast, NISS is calculated by summing the squares of the three most severe AIS injuries, regardless of ISS body region. This ability to account for multiple serious injuries in one region reduces the underestimation of mortality seen in ISS (14). However, Moore et al (21) suggest that NISS can lead to an overestimation of mortality. This implies that a second serious

injury in the same body region has a greater impact on outcome than a less severe injury in a different body region (14). The ISS and NISS scales range from 1 to 75 (5).

Current studies comparing ISS and NISS

ISS has been shown to have excellent predictive capability for trauma mortality and has been validated indifferent datasets (22), (23), (24), (25), (26). However, there is a growing body of recent research that favours NISS over ISS, even suggesting that NISS should completely replace ISS.

Hani et al (3)noted in a cohort of 2115 blunt trauma patients, NISS was better than ISS for predicting mortality in that group. The mortality of blunt trauma was significantly affected by high NISS (p < 0.0001), low GCS (p < 0.0001), and hypotension (p = 0.006).

In a prospective analysis of 256 patients that sustained penetrating trauma, Brian et al (27) found that the NISS outperformed ISS as a predictor of both mortality and complications in civilian penetrating trauma patients. The mortality area under the curve (AUC) for NISS was greater than the AUC for ISS in all penetrating patients (0.930 vs. 0.885, p = 0.008), those with penetrating torso injuries (NISS, 0.934 vs. ISS, 0.881, p < 0.001), and those with severe (score 9-25) injuries (NISS, 0.845 vs. ISS, 0.761, p < 0.001). In patients surviving for more than 48 hours, the complications AUC for NISS was also greater than that for ISS (NISS, 0.838 vs. ISS, 0.784; p = 0.023).

Zsolt et al (28) looked at 3100 patients where NISS was found to be more predictive of longer (≥10 days) length of stay (LOS) (p < 0.0001) and ICU admission (p < 0.0001). They also felt that the recognition of this high-risk group is not possible using the traditional ISS alone from retrospective or prospective databases.

From a cohort of 24,263 patients from three urban Level I trauma centres in the province of Quebec, Canada, Lavoie et al (29) were able to determine that the NISS is a more accurate predictor of in-hospital death than the ISS especially in head/neck-

injured patients. In this subpopulation, the NISS versus ISS AUC's were 0.819 and 0.784 respectively ($p < 0.0001$). The NISS Hosmer-Lemeshow goodness of fit statistic was 59 vs. 350 for ISS.

The polytrauma patient is not always an adult with minimal co-morbidities such as the physiological changes associated with either end of the age spectrum namely paediatric or geriatric patients. As such the mortality research outcome in these sub-groups of patient may differ. No doubt, paediatric patients sustain distinct patterns of injuries from causes that differ from those of adults because of their unique anatomical, physiologic, and behavioural characteristics (30). As such, it is not surprising that when Grisoni et al (31) evaluated ISS versus NISS in a cohort of 9151 paediatric trauma patients, they found that the differences in the predictive abilities of the two scoring systems were insignificant.

On the other end of the age spectrum, the elderly patient has a unique disposition. The definition of a geriatric patient remains a range at best from 55 to 70 years. In this subgroup of patients due to decreased physiological reserve, frailty, and pre-injury comorbidities these patients have higher morbidity and mortality on an injury-for-injury basis than their younger counterparts (32). South Africa's population over 65 years is projected to quadruple over the next four decades. The > 85 years age group is growing more rapidly than any other age group. With increased longevity, older persons will have extended periods at risk of physical and mental impairment (33). Chung-Shyuan et al (34) compared 2,403 geriatric patients (aged 65 years and above) 1,909 adult patients (aged 20–64) with trauma post fall. They found that ISS (9.3 ± 4.4 vs. 8.3 ± 6.1, respectively, p =0.007) and NISS (10.3 ± 6.8 vs. 9.5 ± 8.2, respectively, p <0.001) were significantly higher in the elderly than the adult patients. They also found that geriatric patients presented with a bodily injury pattern that differed from that of younger adult patients and had a higher severe injury score, worse outcome, and higher mortality than those of their younger counterparts.

Why MISS?

In theory, the more injuries sustained the higher the mortality rate would be. As with ISS and NISS the MISS would be defined by an anatomical score and would be the sum of all the squared AIS calculated for a given polytrauma patient. Hence, it is not limited by AIS triplets that define ISS or NISS nor the number of body regions. This score has not been proposed to date. It is simple and easy to calculate.

Other Trauma Scoring systems

The two other major groups that categorise trauma scoring systems that have not been elaborated upon as the study investigates anatomical trauma scores primarily will be briefly mentioned, namely the physiological APACHE Score (35)and a combined anatomical and physiological trauma score, the Kampala Trauma Score (36).

Physiological trauma scores encompass various physiological parameters to predict the outcome of a trauma patient. An example of this is the APACHE (Acute Physiology and Chronic Health Evaluation) Score. In 1981, Knaus et al **(35)** looked at 805 ICU patients and developed a physiological parameter based system that was composed of 42 variables to validate the therapeutic effort and mortality of the cohort. The score was made up of two components: physiology score to assess the degree of acute illness and preadmission evaluation to determine the chronic health status of the patient **(35)**.This score has undergone 3 further revisions as well as other derivatives eg. SAPS (Simplified Acute Physiology Score). The most recent revision of APACHE is the APACHE IV **(37)** released in 2006. It has been validated in ICU's in USA only and hence it has limited applicability elsewhere, a view that hasn't changed in the last decade since the benchmark APACHE IV study **(38)**. To date the APACHE Score is reserved for historical significance and the APACHE IV with its 142 variables was recently shown to poorly predict ICU- LOS in severe sepsis cases **(38)**. Another limitation of this scoring system is its heavy weighting of the Glasgow Coma Scale. This has significant predictive shortcomings in the polytrauma patient without head injury.

Furthermore, the system is designed for use only after 24 hours of ICU admission and is therefore not applicable to the non-critically injured patient.

The Kampala Trauma Score (KTS) is an example of a combined trauma score composed of both anatomical and physiological scoring systems. In 2000, Kobusingye et al **(36)** looked at 736 patients in Uganda and devised a composite score that was simple to calculate and applicable to their resource constrained environment. The KTS uses the parameters of age, number of serious injuries, respiratory rate and neurological status, and subsequent to its introduction has demonstrated a statistical performance as a predictor of mortality on a par with that of other scores such as RTS and ISS in countries worldwide **(39)**

Conclusion:

Scoring of trauma is a basic requirement for trauma epidemiology and a robust cornerstone in prediction of mortality and morbidity of trauma patients (26). In the context of resource constrained environment, the optimal management of the polytrauma patient is key. It remains to be seen whether the MISS will be able to assist in this regard. The next chapter elaborates on the study design and research methodology of this dissertation.

SECTION THREE: **STUDY DESIGN AND RESEARCH METHODOLOGY**

Introduction:

This study is a retrospective, non-randomised, uncontrolled qualitative review of the medical records of 1097 patients aged 0 – 90 years.

Study location:

Level 1 Trauma Unit at Inkosi Albert Luthuli Central Hospital in Durban, South Africa.

Study period:

March 2007 to December 2011 encompassing 57 months.

Research Aim:

To evaluate the predictive value of Maximal Injury Severity Score at a Level One Trauma Unit in South Africa.

Ethics:

Approval for the study (BE 302/12) was obtained from our institutional research ethics board. Each patient included in the study was assigned a study number and all identifying information kept in a secure password protected database.

Sampling:

Inclusion criteria: n = 944

1. All patients regardless of injury mechanism admitted during the specified period.
2. Polytrauma patients who were certified dead on arrival.
3. Polytrauma patients transferred from outside hospitals for post-operative ventilation.

Exclusion Criteria: n = 153
1. Patients with one anatomical region injured were excluded.

Data Collection:

The data was obtained from computerised patient records of admissions during the period March 2007 to December 2011.   For each subject, data was collected under the following sub-headings:

1. General Patient Details
2. Demographics
3. Clinical Presentation

and then entered into a MS Excel 2010 ® spreadsheet.

Trauma score calculation:

The AIS was then calculated using the AIS 90 handbook. ISS was calculated by the sum total of the highest AIS score in three different body region. NISS was calculated by the sum total of the three highest AIS score irrespective of body regions. MISS was calculated as the sum of *ALL* the AIS scores for any given patient as shown in Table 2.0

AIS	ISS	NISS	MISS
A			
B	$ISS = A^2 + B^2 + C^2$	$NISS = X_1^2 + X_2^2 + X_3^2$	$MISS = \sum X_y^2$
C			
X			
METHOD	A, B, C are the AIS scores of the three most injured body regions.	X_1, X_2, X_3 are the three highest AIS scores irrespective of body region.	X_y represent an AIS score for an injury and MISS is the sum of all AIS^2 scores for a given patient.

Table 2. Injury Severity Formulas

Data Analysis:

Once the data were tabulated, all subsequent statistical analysis was completed using Addinsoft 2015. XLSTAT 2015: Data Analysis and Statistical Solution for Microsoft Excel. Paris, France (2015).

The following patient parameters were comparatively studied for each study subject: gender, mechanism of injury (MOI), length of stay (LOS), outcome (Alive versus Dead), number of regions injured (#RI), ISS, NISS, MISS.

The cohort was first analysed in total and then in three distinct groups divided by age: Group A (Paediatric, AGE ≤ 18 years), Group B (Adult, 19 years ≥ AGE ≤ 54 years) and Group C (Geriatric, AGE ≥ 55 years).

Categorical variables were presented as percentages. Continuous variables were presented as mean ± standard deviation (SD) (40).

The predictive value of ISS, NISS and MISS was determined by calculation of their respective receiver operator characteristic (ROC) curves. This is a graphic representation of the sensitivity divided by 1-specificity of a diagnostic test (e.g. ISS). A perfect test denotes detection of all true positives and no false positives and has a sensitivity of 1 and a 1-specificity of 0. Graphically, this is represented by a point at the top left corner of the graph and an area under the curve (AUC) equal to 1. Pure chance is represented by the diagonal, and an AUC of 0.5. ROC AUC values of ≥ 0.90 are considered excellent, 0.80–0.89 good, 0.70– 0.79 fair, and <0.70 poor. Thus the higher the AUC of a ROC curve produced by a test, the more effective the test is at discriminating between true positives and false positives (41). Confidence intervals were calculated from the covariance matrix. In these circumstances, two ROC curve areas, which have a statistically significant difference, may have overlapping confidence intervals (19).

The Hosmer-Lemeshow (H-L) X^2 statistic is a measure of how well calibrated a model is. It is calculated by dividing the data into deciles by ISS or NISS or MISS and then comparing the predicted number of non-survivors with the actual number of non-survivors in each decile. The result is evaluated by a Chi squared test. A high (p >0.05) p value implies that the model is robust and that there is no reason to believe that a model is not well calibrated (42). The H-L statistic was obtained from logistic regression models where the dependent variable was mortality and the independent variables were

AGE, Gender, and LOS, #RI, ISS, NISS or MISS. Equation 1.0 is an example of the equation for the model used to compare AGE, ISS, NISS, and MISS.

Pred (OUTCOME) = 1 / (1 + exp(-(4.67456678260366 + 0.0322907544167*AGE + 4.78578588141175E-02*ISS + 3.68825644611004E-02*NISS -3.46636837526175E-03*MISS)

Equation 1.0 Equation of Model (Variable Outcome) used to compare Age, ISS, NISS, and MISS

Statistically significant outcomes were noted when $p < 0.05$.

Outcomes

The primary and secondary outcomes used in the study were inpatient mortality and length of stay (LOS) respectively.

Limitations of the Study:

The retrospective data is sourced from a single centre managing mainly severe trauma. The risk of bias from inaccurate notes is possible. However, this is most likely minimal as all data were compiled by trauma specialists with regular audits and good clinical governance.

Conclusion:

The paucity of available local data regarding trauma severity scoring drives the current study design. The overall objective is to make a meaningful contribution towards understanding and optimising the management of local trauma patient care. In the next section, the statistical analysis of the collected data will be discussed.

SECTION FOUR: **RESULTS AND DATA ANALYSIS**

Introduction

Characteristics of Study Cohort

A total of 944 patients were eligible for this study (Table 3.0). There was a 24% mortality rate (227 patients) with 717 patients alive at discharge from Trauma ICU. Six hundred and ninety (73.1%) patients were male and 254 (26.9%) female aged 6 months to 90 years. Transport - related injuries (67.1%, 633 patients) and inter-personal violence injuries (235 patients, 24.9%) constituted the two largest groups. The mean ISS, NISS and MISS was 26 (SD 14.763), 32 (SD 15.610) and 40 (SD 24.968) respectively. The length of stay ranged from 0 to 312 days.

PATIENT CHARACTERISTICS			
	TOTAL	**ALIVE**	**DEAD**
STUDY SUBJECTS, n (%)	944	717(76.0%)	227 (24.0%)
AGE ,years	0.5 - 90	0.5 – 90	2 - 83
GENDER			
Male n (%)	690 (73.1%)	516 (74.8%)	174(25.2%)
Female n (%)	254 (26.9%)	201(79.1%)	53(20.9%)
MECHANISM OF INJURY			
Motor Vehicle Car n (%)	3 (0.3%)	2	1
Motor Vehicle Car cyclist n (%)	4 (0.4%)	4	0
Motor Vehicle Car driver n (%)	99 (10.4%)	66	33
Motor Vehicle Car motor cycle n (%)	13 (1.4%)	9	4
Motor Vehicle Car pedestrian n (%)	322 (34.1%)	245	77
Motor Vehicle Car passenger n (%)	192(20.3%)	155	37
Assault n (%)	3 (0.3%)	2	1
Gunshot Wound n (%)	157 (16.6%)	114	43
Stab Wound n (%)	73 (7.7%)	63	10
Shot Gun Wound n (%)	1 (0.1%)	1	0
Blunt n (%)	65 (6.9%)	49	16
Crush n (%)	1 (0.1%)	0	1
Fall n (%)	3 (0.3%)	1	2
Other n (%)	2 (0.2%)	2	0
INJURY SEVERITY SCORE			
ISS mean (SD)	26 (14.763)		
NISS mean (SD)	32 (15.610)		
MISS mean (SD)	40 (24.968)		
LENGTH OF STAY, days	0-312		

Table 3. Demographics of Study

Analysis of Injury Severity Scores

The Injury Severity Scores for this cohort all had an AUC of a fair test (AUC value 0.7 – 0.79) as demonstrated in Figure 1 and noted in Table 4.0. The NISS AUC was the highest at a value of 0.754(SD 15.581). Comparing survivors versus non-survivors all the severity scores had a p-value of p< 0.0001 thus one can infer that, for this cohort of patients, the severity scores were able to predict mortality. The H-L X^2 statistic 15.333 (p = 0.082), indicated that the models achieved a good fit. When comparing ISS to NISS, the NISS had a better AUC, suggesting that NISS was a better predictor of mortality in this cohort of patients. While MISS had a comparable AUC and ROC, it was not better at predicting the mortality of patients in this cohort, nor was the actual Age (AUC 0.590, SD 15.306) of the patient.
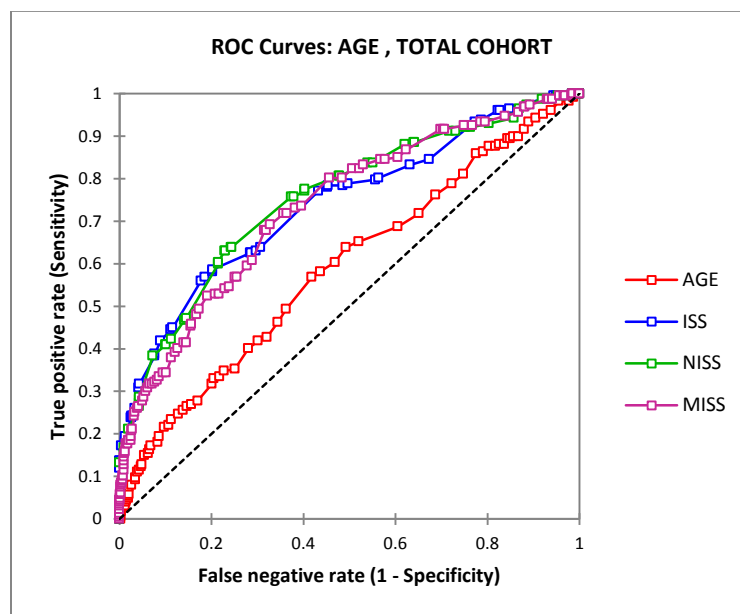
Figure 1. ROC Curves for Total Cohort

COMPARISON OF INJURY SEVERITY SCORES												
TOTAL COHORT												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
AGE	0.590	]0.546, 0.633[	< 0.0001	29	0.5	90	29.455	15.306				
ISS	0.740	]0.700, 0.780[	< 0.0001	29	1	75	25.862	14.763	717	76	227	24
NISS	0.754	]0.715,0.793[	< 0.0001	37	1	75	32.313	15.581				
MISS	0.735	]0.694,0.775[	< 0.0001	38	1	210	39.762	24.968				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			15.333		9		0.082					

Table 4. Comparison of Injury Severity Scores(Total Cohort) to predict mortality

Analysis of injury mechanism (MOI)

Transport-related injuries made up the largest group of MOI with a total of 633 (67.1%) patients. This group included MOI from MVC-pedestrian 322 (34.1%), MVC-passenger 192(20.3%) and MVC-driver 99 (10.4%) accidents. Interpersonal violence was the second largest group with a total of 300 (31.8%) patients. In this group, Gun Shot Wound (GSW) 157 (16.6%) and Stab Wound (SW) 73 (7.3%) were the most common MOI's. These findings are in line with the 2013 South African national mortality figures discussed earlier in the study (6).
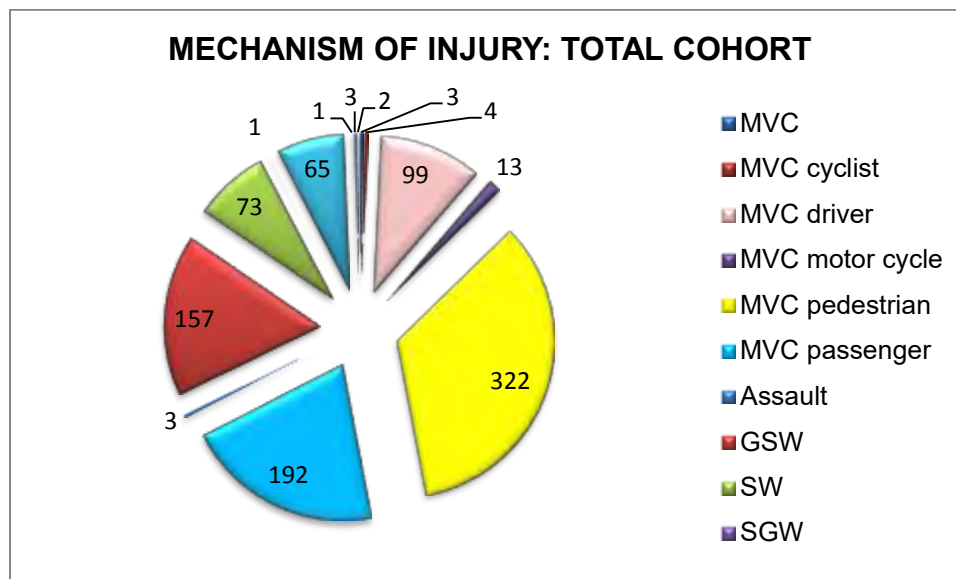
Figure 2. Mechanism of Injury: TOTAL COHORT

Analysis of Gender: Males versus Females.

A total of 690 male patients were admitted with a 25% (174 patients) mortality rate. The AUC for ISS (0.726, SD 14.254), NISS (0.739, SD 15.017), and MISS (0.723, SD 24.893) were statistically significant with p< 0.0001 representative of a fair test. The low H-L X^2 statistic 4.495 (p = 0.810), suggested this model was also very well calibrated. The NISS was better at predicting outcome when compared to ISS and MISS for the total male patient cohort.

The total number of female admissions was 254 with a mortality rate of 21% (53 patients). This ratio of 1: 2.7 is not in keeping with the South African national trends discussed previously (6). As in the male group of patients, the AUC for ISS (0.791, SD 16.056), NISS (0.795, SD 17.047), and MISS (0.773, SD 25.220) were statistically significant with p< 0.0001. The low H-L X^2 statistic 7.881 (p = 0.445) , suggested the model was similarly as good a fit compared to the male group The ROC curves were comparable if not a fraction better AUC values for ISS , NISS, and MISS. NISS predicted the outcomes better than MISS and ISS for the female cohort.
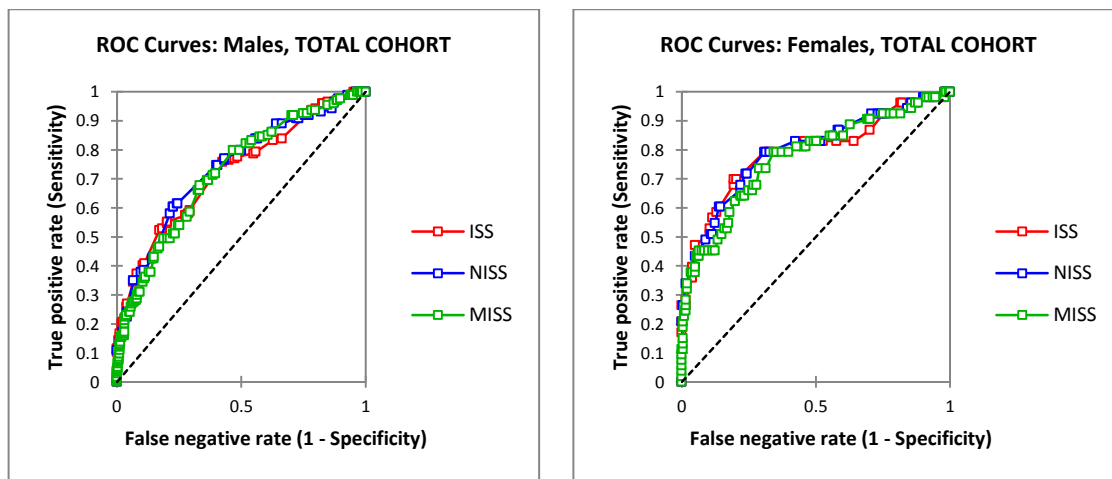
Figure 3. Gender ROC: Total Cohort

COMPARISON OF INJURY SEVERITY SCORES: Males												
TOTAL COHORT, Males												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.726	]0.690,0.773[	< 0.0001	33	1	75	25.512	14.254				
NISS	0.739	]0.693,0.785[	< 0.0001	37	1	75	32.433	15.017	516	75	174	25
MISS	0.723	]0.676,0.770[	< 0.0001	38	2	210	39.726	24.893				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			4.495		8		0.810					
COMPARISON OF INJURY SEVERITY SCORES: Females												
TOTAL COHORT, Females												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.791	]0.714,0.886[	< 0.0001	32	1	75	26.815	16.056				
NISS	0.795	]0.719,0.871[	< 0.0001	33	1	75	31.984	17.047	201	79	53	21
MISS	0.773	]0.695,0.852[	< 0.0001	37	1	150	39.858	25.220				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			7.881		8		0.445					
Test is positive if ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table5. Comparison of Injury Severity Scores for Gender (Total Cohort) to predict mortality

Analysis of Length of Stay

How long a patient is admitted should have a bearing on the outcome of a patient. This was not the finding in this cohort of patients. The LOS range from 0 – 312 days, with a threshold value of > 102 days for a positive test (mortality). The LOS was not a good predictor of outcome with AUC of 0.261 (SD 18.874, p<0.0001) even though it had a statistically significant p-value. The AUC for ISS (0.740, SD14.763), NISS (0.754, SD15.581), and MISS (0.735, SD 24.968) were statistically significant with p< 0.0001 and also suggestive of a fair test. NISS was the better predictor of outcome when compared with LOS, ISS and MISS. The high H-L X^2 statistic of 32.414 (p = 0.000), further corroborated the findings that LOS was not a good predictor of outcome.
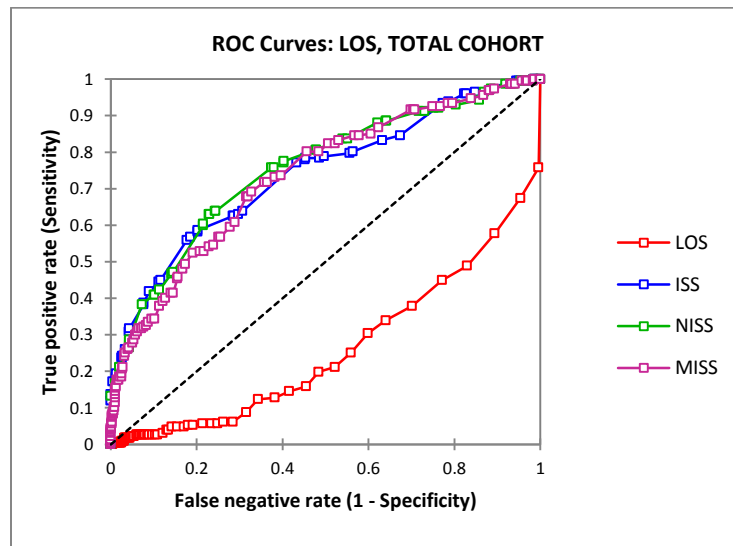
Figure 4. Length of Stay, TOTAL COHORT

COMPARISON OF INJURY SEVERITY SCORES											
TOTAL COHORT											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
LOS	0.261	[0.228, 0.295]	< 0.0001	102	0	312	13.078	18.874				
ISS	0.740	[0.700, 0.780]	< 0.0001	29	1	75	25.862	14.763	717	76	227	24
NISS	0.754	[0.715, 0.793]	< 0.0001	37	1	75	32.313	15.581				
MISS	0.735	[0.694, 0.775]	< 0.0001	38	1	210	39.762	24.968				
		Chi-square , X^2		Degrees of Freedom		Pr > X^2						
Hosmer-Lemeshow (H-L) X^2 statistic		32.414		9		0.000						
Test is positive if LOS, ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 6. Comparison of Injury Severity Scores & Length of Stay, TOTAL COHORT

Analysis of Number of Regions Injured (#RI)

A total of 2162 injuries were sustained by the 944 patients admitted over the 57 month study period. Per anatomical group the aggregates were: Extremity (508), Chest (476), Head/ Neck (469), Abdomen (399), Face (116) and External (93).

DISTRIBUTION OF REGIONS INJURED

	HEAD/NECK	FACE	CHEST	ABD	EXTERNAL	EXTREMITY
TOTAL	469	116	476	399	93	508
GROUP A	113	18	76	85	16	101
GROUP B	331	94	365	291	70	366
GROUP C	24	4	35	23	6	40
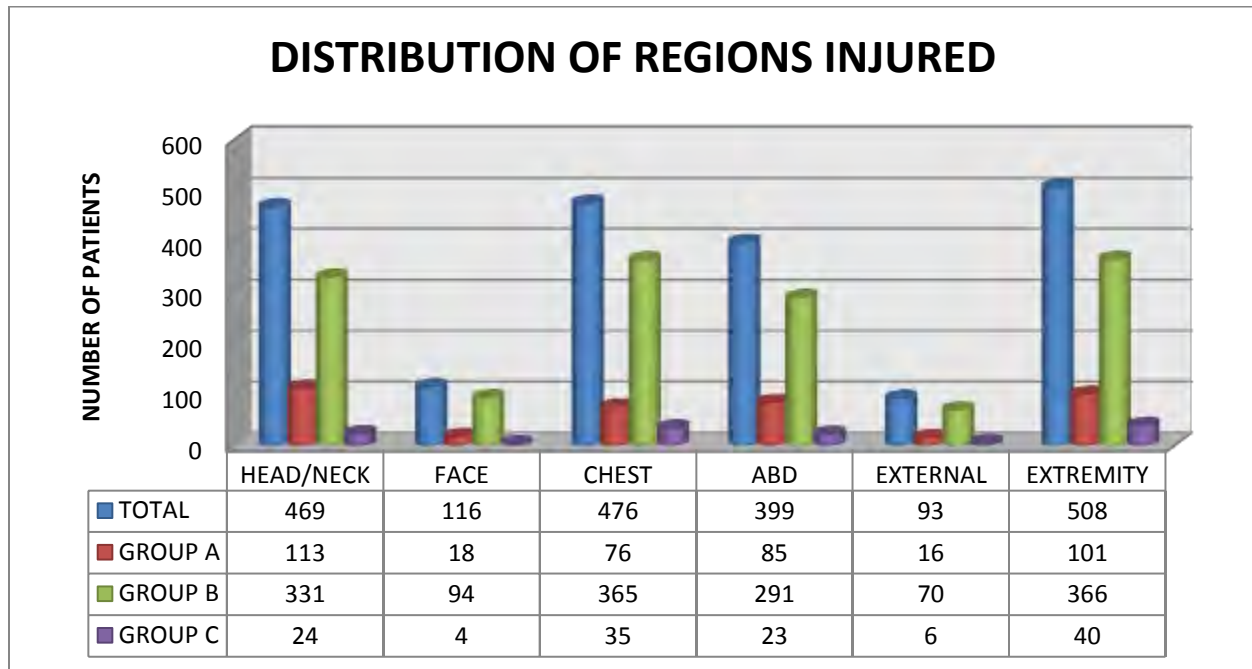
Figure 5 Distribution of Regions Injured

 The total number of regions injured did not have a major effect on outcome of the patient. This is evidenced by and AUC of 0.551 (SD 1.849, p< 0.022). The high H-L X^2 statistic 17.872 (p =0.022) suggested this model was not a good fit. When compared with #RI, NISS (AUC 0.754, SD 15.581, p< 0.0001) was a better predictor of outcome in comparison to ISS (AUC 0.740, SD 14.763), MISS (AUC 0.735, SD 24.968) and #RI. A threshold value of > 5 total #RI would yield a positive test (mortality).
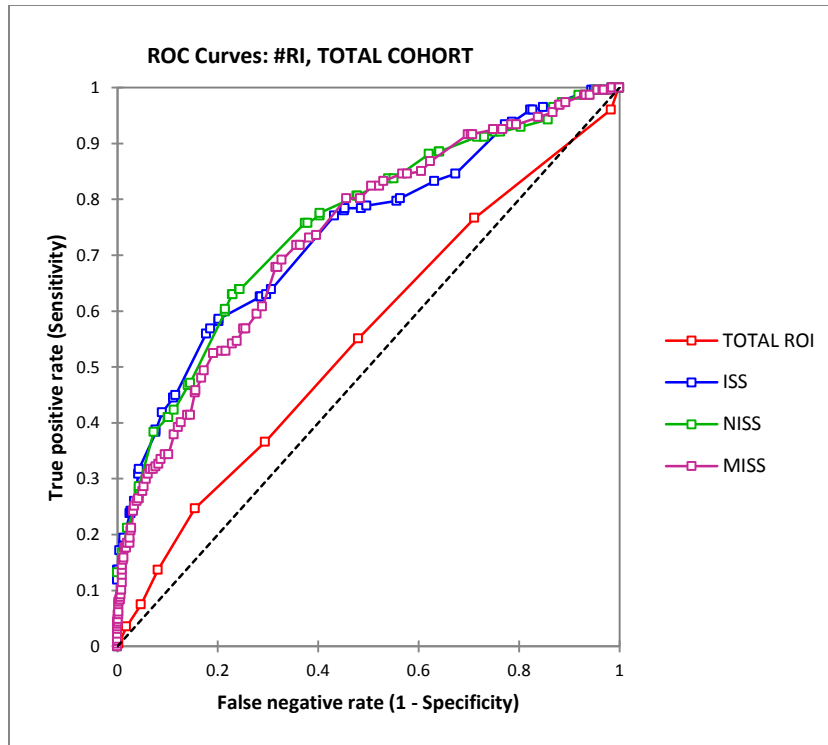
Figure 6. ROC for Number of Regions Injured (#RI), TOTAL COHORT

COMPARISON OF INJURY SEVERITY SCORES												
TOTAL COHORT												
SCORE	Area Under Curve (AUC)	95% CI	p- Value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
#RI	0.551	]0.507,0.595[	0.022	5	0	12	3.864	1.849				
ISS	0.740	]0.700,0.780[	< 0.0001	29	1	75	25.862	14.763				
NISS	0.754	]0.715, 0.793[	< 0.0001	37	1	75	32.313	15.581	717	76	227	24
MISS	0.735	]0.694,0.775[	< 0.0001	38	1	210	39.762	24.968				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			17.872		8		0.022					
Test is positive if LOS, ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 7. Comparison of Injury Severity Scores & Number of Regions Injured (#RI), TOTAL COHOR

Group A (Paediatric, AGE ≤ 18 years) Data Analysis

The 181 paediatric patients admitted with the youngest being only 5 months old, made up 19.1% of the admission in total and had a mortality rate of 17% The NISS (AUC 0.819, SD 15.871) was better a predictor of outcome in comparison to Age (AUC 0.495, SD 4.937) ,ISS (AUC 0.789, SD 15.127) and MISS (AUC 0.789, SD 23.100). The H-L X^2 statistic of 19.807 (p= 0.011) also showed that this model was not well calibrated.
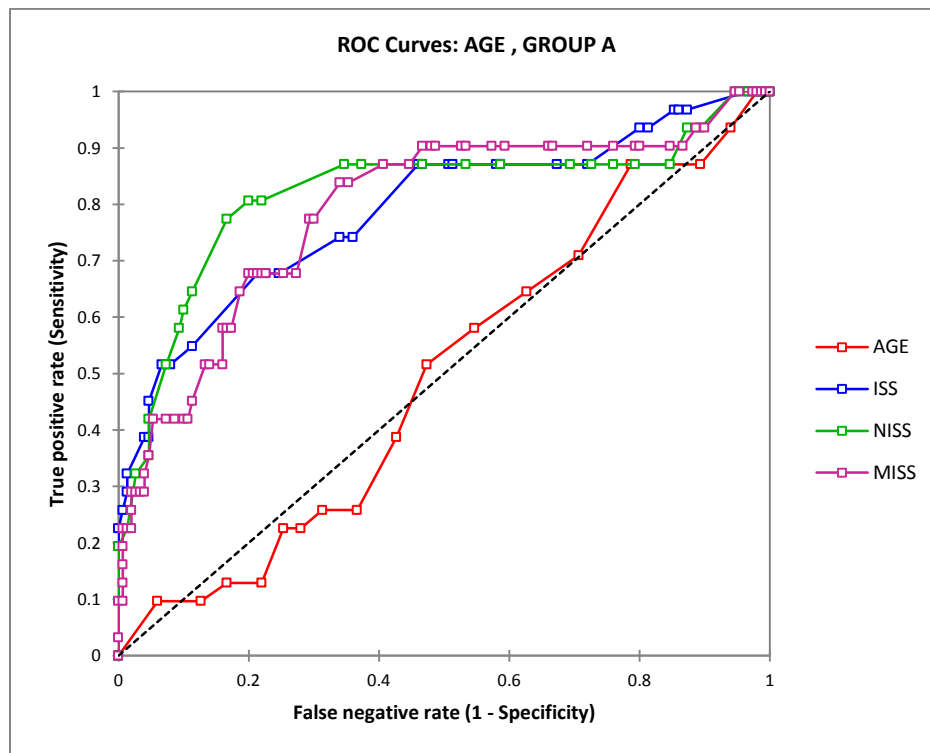
Figure 7 ROC Curves: AGE, GROUP A

	COMPARISON OF INJURY SEVERITY SCORES											
	GROUP A											
SCORE	**Area Under Curve (AUC)**	**95% CI**	**p- Value**	**Threshold**	**MIN**	**MAX**	**MEAN**	**Standard Deviation (SD)**	**ALIVE**		**DEAD**	
									N =	**%**	**N =**	**%**
AGE	0.495	]0.384,0.607[	0.935	4	0.5	18	9.124	4.937	150	83	31	17
ISS	0.789	]0.690,0.889[	< 0.0001	33	2	75	26.729	15.127				
NISS	0.819	]0.724,0.913[	< 0.0001	38	2	75	31.669	15.871				
MISS	0.789	]0.690,0.889[	< 0.0001	36	2	150	38.182	23.100				
	Chi-square , X^2			**Degrees of Freedom**			**Pr > X^2**					
Hosmer-Lemeshow (H-L) X^2 statistic	19.807			8			0.011					
Test is positive if LOS, ISS or NISS or MISS > threshold value **95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)**												

Table 8 Comparison of Injury Severity Scores and Age to predict mortality, GROUP A

Transport-related injuries made up 78.4% (142 patients) of mechanism of injury in this group with 102 (56.4%) due to MVC-pedestrian and 32(17.7%) due to MVC- passenger accidents. The third and fourth notable groups were GSW 19 (10.5%) and blunt trauma 14(7.7%) respectively.
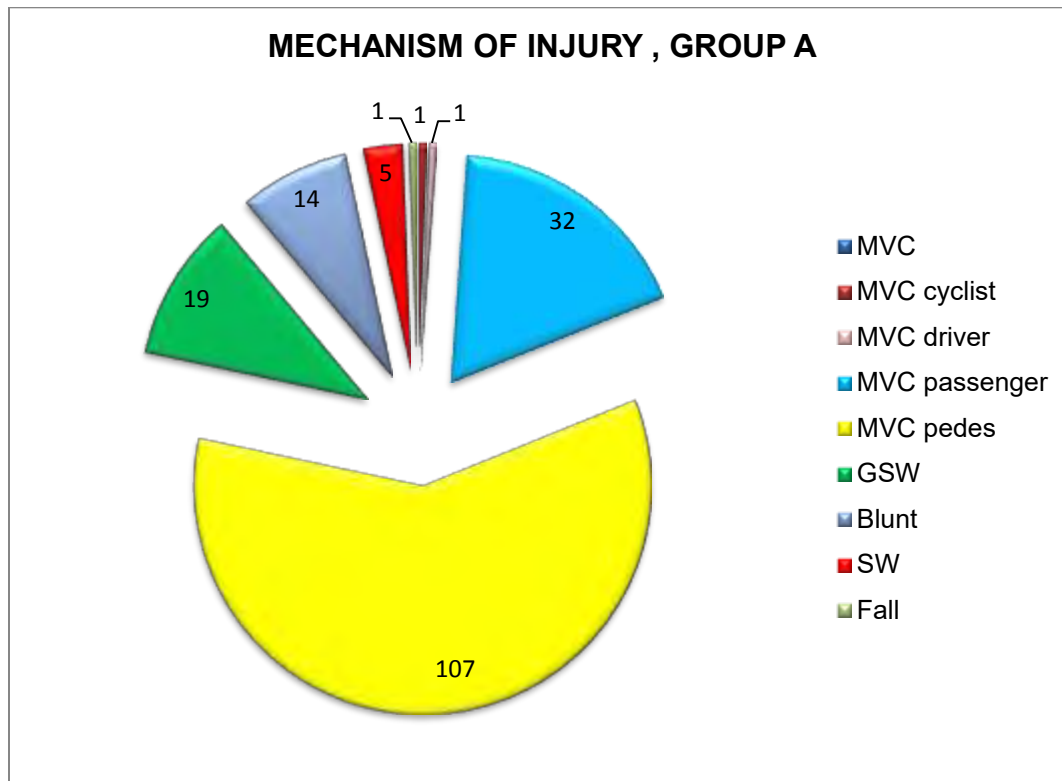
Figure 8 Mechanism of Injury, GROUP A

A total of 94 male (51.9%) paediatric patients versus 87 female patients (48.1%) were noted in this paediatric group with ratio of 1.1:1.0. NISS (AUC 0.757, SD 14.963) predicted mortality better than ISS (AUC 0.714, SD 13.682) or MISS (AUC 0.740, SD 21.425). The low H-L X^2 statistic of 10.169 (p= 0.253) showed that this model was well calibrated. These findings were mirrored in the female group but with better statistical values: NISS (AUC 0.872, SD 16.729), ISS (AUC 0.855, SD 16.317), MISS (0.825, SD 24.789) and H-L X^2 statistic of 7.115 (p= 0.524).
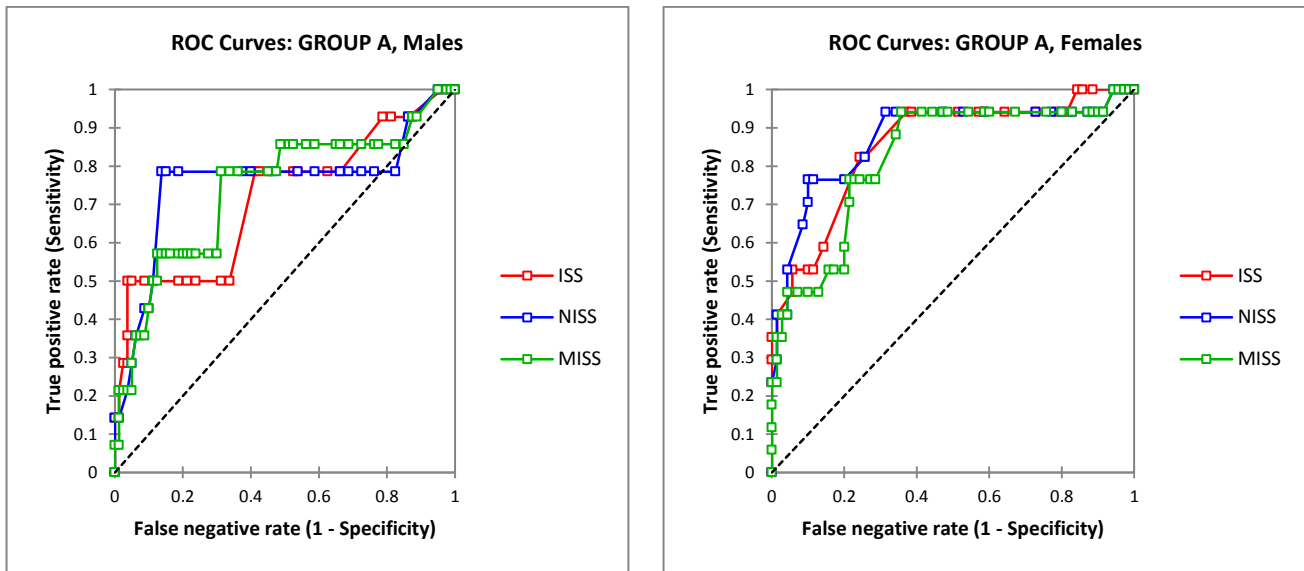
Figure 9 Gender ROC Curves: GROUP A

COMPARISON OF INJURY SEVERITY SCORES: Males												
GROUP A , Males												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.714	]0.553,0.874[	0.009	38	2	75	24.606	13.682				
NISS	0.757	]0.603,0.911[	0.001	38	2.	75	30.149	14.963	80	85	14	15
MISS	0.740	]0.583,0.897[	0.003	38	2.	116	36.553	21.425				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			10.169		8		0.253					
COMPARISON OF INJURY SEVERITY SCORES: Females												
GROUP A , Females												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.855	]0.737, 0.973[	< 0.0001	32	3	75	29.023	16.317				
NISS	0.872	]0.760, 0.984[	< 0.0001	43	3	75	33.310	16.729	70	80	17	20
MISS	0.825	]0.698,0.952[	< 0.0001	33	3	150	39.943	24.789				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			7.115		8		0.524					
Test is positive if ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 9 Comparison of Severity Injury Severity Scores and Gender: GROUP A

The LOS for this group was not a good predictor of outcome (AUC 0.191, SD 14.428) and the high H-L X^2 statistic of 18.478 (p= 0.030). NISS predicted outcome better when compared to LOS, ISS and MISS. A threshold of > 97 days was required for a positive test (mortality).
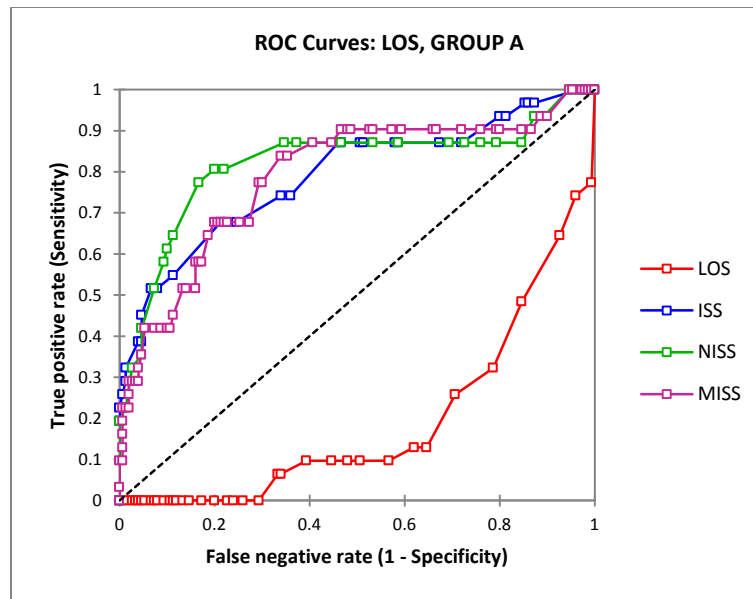
Figure 10 ROC Curves: LOS, GROUP A

									ALIVE		DEAD	
COMPARISON OF INJURY SEVERITY SCORES												
GROUP A												
SCORE	**Area Under Curve (AUC)**	**95% CI**	**p- Value**	**Threshold**	**MIN**	**MAX**	**MEAN**	**Standard Deviation (SD)**	**N =**	**%**	**N =**	**%**
LOS	0.191	]0.121,0.261[	< 0.0001	97	0	97	12.431	14.428				
ISS	0.789	]0.690,0.889[	< 0.0001	33	2	75	26.729	15.127	150	83	31	17
NISS	0.819	]0.724,0.913[	< 0.0001	38	2	75	31.669	15.871				
MISS	0.789	]0.690,0.889[	< 0.0001	36	2	150	38.182	23.100				
	Chi-square , X^2			**Degrees of Freedom**			**Pr > X^2**					
Hosmer-Lemeshow (H-L) X^2 statistic	18.478			9			0.030					
Test is positive if LOS, ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 10 Comparison of Injury Severity Scores and LOS, GROUP A

The distribution of the 409 (19.8%) injuries in this group was as follows: Head/Neck (113), Extremity (101), Abdomen (85), Chest (76), Face (18) a lastly External (16), (see Figure 5). As most of the paediatric injuries are transport related, especially MVC-pedestrian, this can be explained by the fact the children are shorter, with a more pliable thoracic cage than adults. When hit by a vehicle, they are more likely to sustain Head/ Neck and Extremity injuries, as this cartilaginous thoracic cage absorbs a portion of the impact.

When the total # RI was compared to ISS, NISS and MISS, NISS (AUC 0.819, SD 15.871) predicted mortality better. The high H-L X^2 statistic of 14.003 (p= 0.082) implied the model was barely a good fit. A threshold of >6 Total #RI was required for positive test (mortality).
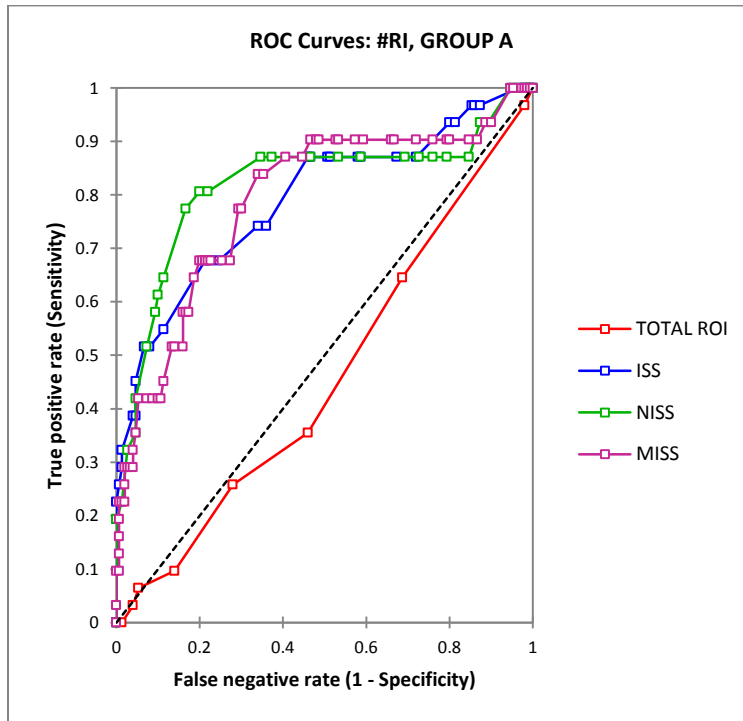
Figure 11 ROC Curves: Number of Regions Injured (#RI), GROUP A

COMPARISON OF INJURY SEVERITY SCORES												
GROUP A												
SCORE	Area Under Curve (AUC)	95% CI	p- Value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
TOTAL # RI	0.458	]0.348,0.567[	0.448	6	2	1	9	3.613				
ISS	0.789	]0.690,0.889[	< 0.0001	33	2	75	26.729	15.127	150	83	31	17
NISS	0.819	]0.724,0.913[	< 0.0001	38	2	75	31.669	15.871				
MISS	0.789	]0.690,0.889[	< 0.0001	36		150	38.182	23.100				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			14.003		8		0.082					
Test is positive if LOS, ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 11 Comparison of Injury Severity Scores and Total Number of Regions Injured (#RI), GROUP A

Group B (Adult, 19 years ≥ AGE ≤ 54 years) Data Analysis

The adult group (699, 74%) of patients was the largest of the three but had a mortality rate of 24% (167 patients). Age was not a good predictor of outcome (AUC 0.544, SD 8.954) .The low H-L X^2 statistic of 3.780 (p= 0.876) suggested the model was well calibrated. NISS (AUC 0.761, SD 15.428) predicted mortality better than ISS or MISS.
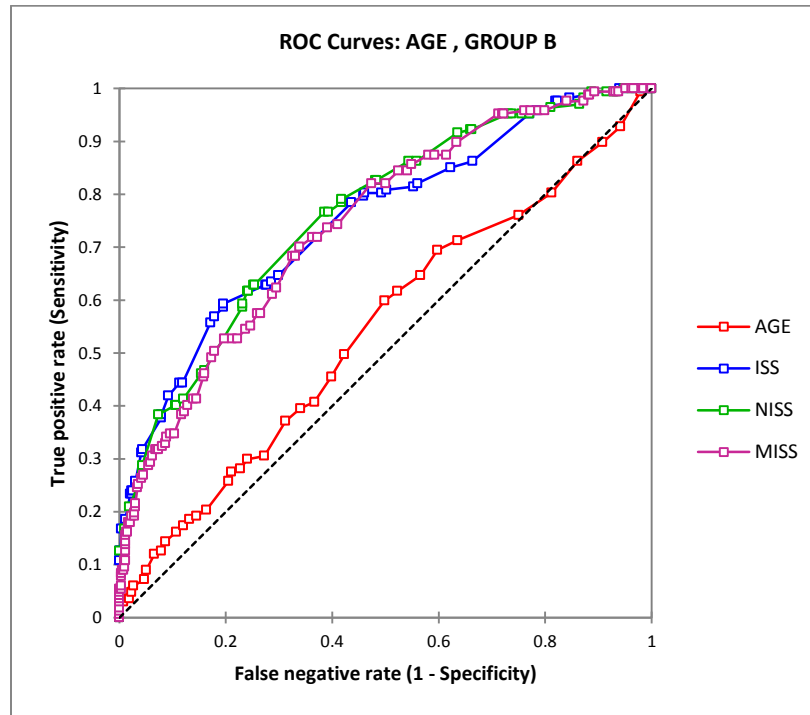
Figure 12 ROC Curves: AGE, GROUP B

COMPARISON OF INJURY SEVERITY SCORES											
GROUP B											
SCORE	Area Under Curve (AUC)	95% CI	p- Value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
AGE	0.544	]0.493,0.594[	0.093	29	19	54	31.512	8.954				
ISS	0.752	]0.706,0.798[	< 0.0001	29	1	75	25.757	14.531	532	76	167	24
NISS	0.761	]0.715,0.806[	< 0.0001	33	1	75	32.627	15.428				
MISS	0.744	]0.697,0.790[	< 0.0001	38	1	210	40.435	25.583				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			3.780		8		0.876					
Test is positive if LOS, ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 12 Comparison of Injury Severity Scores and AGE to predict mortality, GROUP B

As much as 443 (63.4%) patients sustained transport-related injuries with the 27.3% from MVC-pedestrian (191) then MVC-passenger 145 (20.7%) collisions. Interpersonal violence was responsible for 36.3% (254 patients) and GSW (133) was responsible for 52.4% of those injuries.
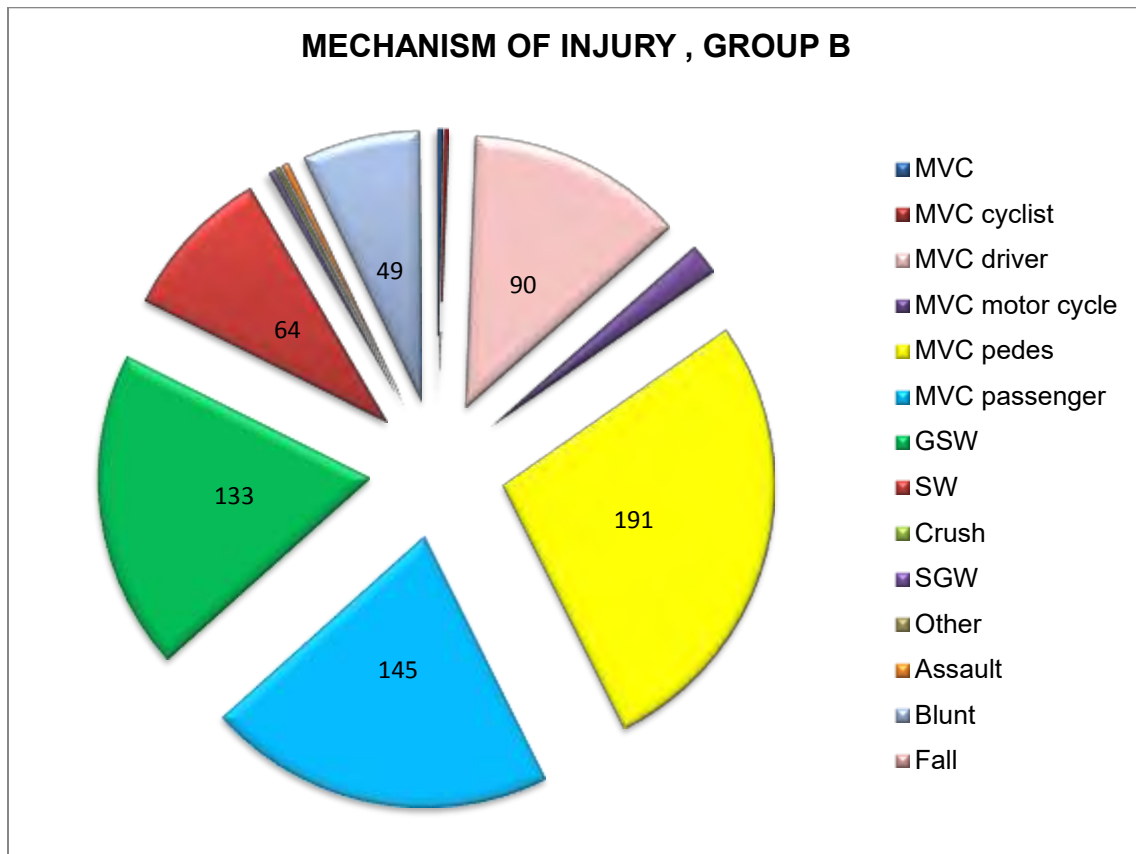
Figure 13 Mechanism of Injury, GROUP B

The ratio of males to females in this group was 1:3.69 (149 females, 550 males). In the male group, NISS (AUC 0.750, SD 14.908) was marginally better at predicting mortality versus ISS and MISS with a H-L X^2 statistic of 5.491 (p= 0.704). Whilst the findings were similar in the female group, the AUC values for NISS (AUC 0.800, SD 17.235) , ISS (AUC 0.807, SD 15.640) , MISS (AUC 0.796, SD 25.517) were higher and the H-L X^2 statistic of 7.445 (p= 0.489) corroborated the finding that the model was well calibrated. However, in the female group, ISS was the better predictor of mortality by a fractional increment.
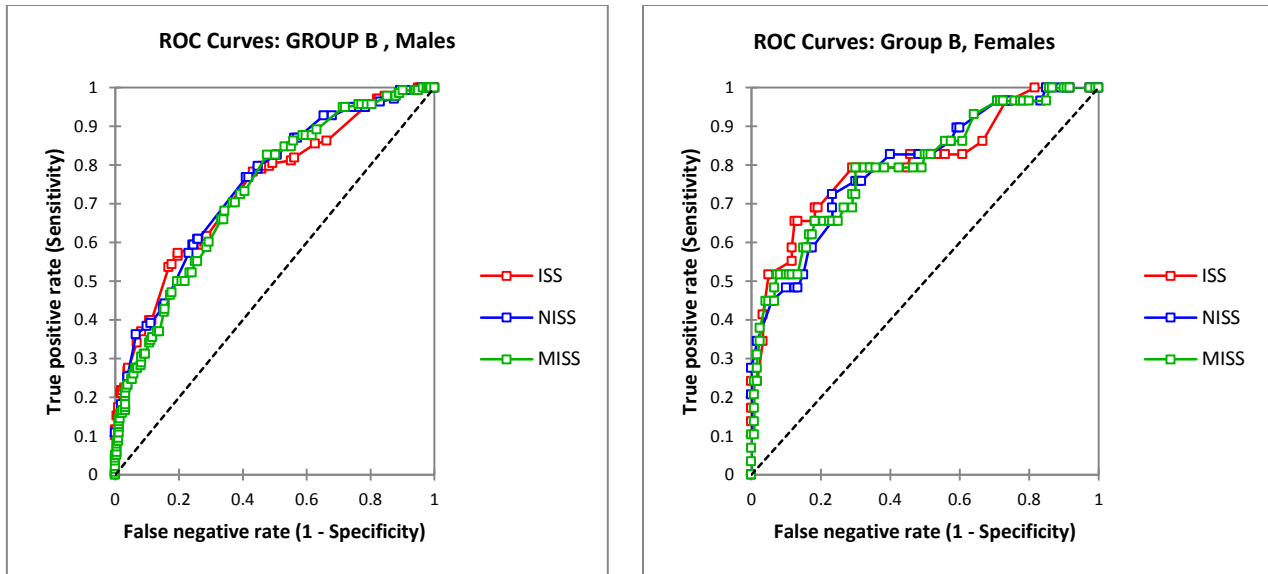
Figure 14 Gender ROC Curves: GROUP B

COMPARISON OF INJURY SEVERITY SCORES: Males											
GROUP B , Males											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.742	]0.690,0.793[	< 0.0001	29	1	75	25.613	14.228	412	75	138	25
NISS	0.750	]0.699,0.801[	< 0.0001	33	2	75	32.876	14.908				
MISS	0.733	]0.681,0.785[	< 0.0001	33	2	210	40.422	25.624				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom			Pr > X^2				
			5.491		8			0.704				
COMPARISON OF INJURY SEVERITY SCORES: Females												
GROUP B , Females												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.807	]0.707,0.908[	< 0.0001	36	1	75	26.289	15.640	120	81	29	19
NISS	0.800	]0.698, 0.902[	< 0.0001	34	1	75	31.705	17.235				
MISS	0.796	]0.694,0.899[	< 0.0001	39	1	142	40.483	25.517				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom			Pr > X^2				
			7.445		8			0.489				
Test is positive if ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 13 Comparison of Severity Scores and Gender: GROUP B

A threshold of > 102 days was required for positive test (mortality). LOS (AUC 0.281, SD 17.984) did not predict the outcome well, as also evidenced by high H-L X^2 statistic of 23.982 (p= 0.002). When LOS was compared to ISS, NISS and MISS, NISS was the better predictor of outcome.
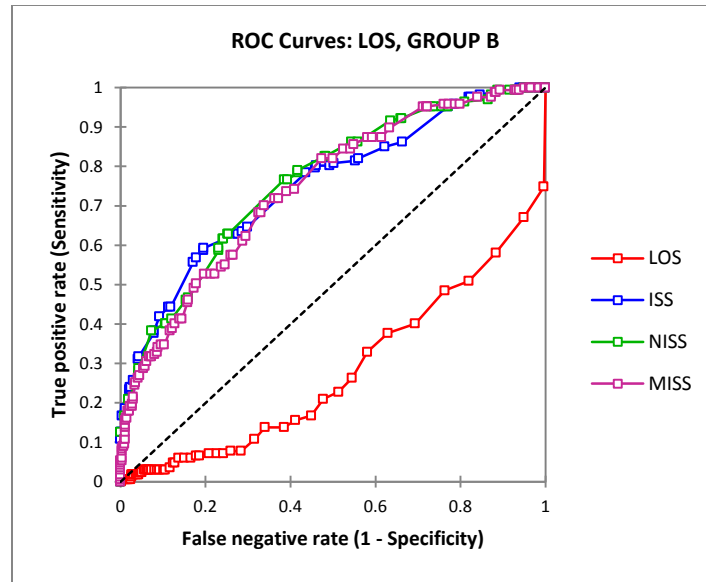
Figure 15 ROC Curves: LOS, GROUP B

COMPARISON OF INJURY SEVERITY SCORES											
	GROUP B										
SCORE	Area Under Curve (AUC)	95% CI	p- Value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
LOS	0.281	]0.241, 0.321[	< 0.0001	102	0	312	12.785	17.984	532	76	167	24
ISS	0.752	[0.706, 0.798[	< 0.0001	29	1	75	25.757	14.531				
NISS	0.761	[0.715, 0.806[	< 0.0001	33	1	75	32.627	15.428				
MISS	0.744	]0.697, 0.790[	< 0.0001	38	1	210	40.435	25.583				
	Chi-square , X^2		Degrees of Freedom			Pr > X^2						
Hosmer-Lemeshow (H-L) X^2 statistic	23.982		8			0.002						
Test is positive if LOS, ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 14 Comparison of Severity Scores and LOS: GROUP B

Of a total of 1517 (73.6%) injuries sustained in this group the four largest anatomical regions had almost similar numbers: Extremity (366), Chest (365), Head/Neck (331) and Abdomen (291) followed by Face (94) and External (70) (see Figure 5). This is congruent with the finding that adults are more likely to partake in acts of violence, drive motor vehicles but lack the pliable thoracic cavity that children have and hence the high number of chest injuries.

NISS (AUC 0.761, SD 15.428) predicted mortality better when compared to Total #RI, ISS and MISS. This model was well calibrated as implied by a low H-L X^2 statistic of 8.601 (p= 0.377). The adult group had the lowest threshold > 3 Total #RI for positive test (mortality).
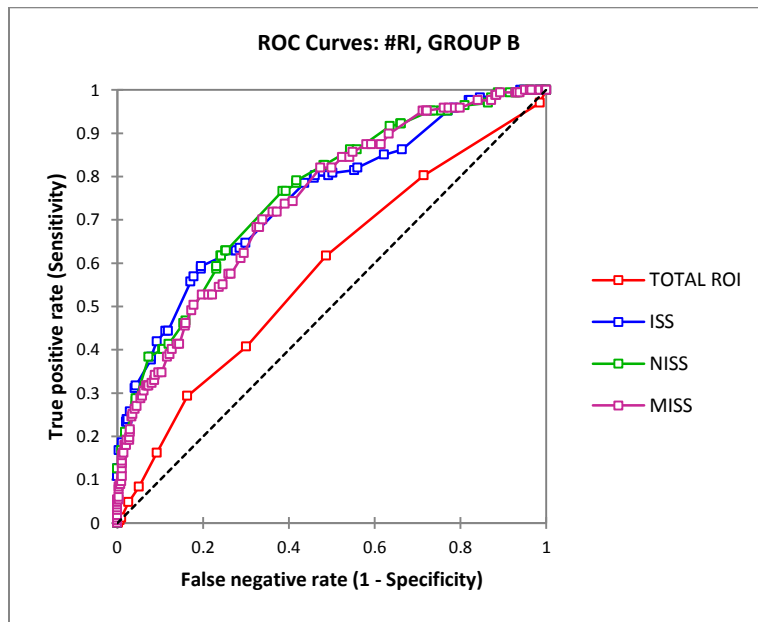
Figure 16 ROC Curves: Total Number of Regions Injured (#RI), GROUP B

COMPARISON OF INJURY SEVERITY SCORES												
GROUP B												
SCORE	Area Under Curve (AUC)	95% CI	p- Value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
TOTAL # RI	0.583	]0.532,0.633[	0.001	3	1	18	3.989	2.002				
ISS	0.752	]0.706,0.798[	< 0.0001	29	1	75	25.757	14.531	532	76	167	24
NISS	0.761	]0.715,0.806[	< 0.0001	33	1	75	32.627	15.428				
MISS	0.744	]0.697,0.790[	< 0.0001	38	1	21	40.435	25.583				
	Chi-square , X^2			Degrees of Freedom			Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic	8.601			8			0.377					
Test is positive if LOS, ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 15 Comparison of Injury Severity Scores and Total Number of Regions Injured (#RI): GROUP B

Group C (Geriatric, AGE ≥ 55 years) Data Analysis

The geriatric group represented 9.1% (64) of the total patients but had the highest mortality rate of 45% and the oldest patient was 90 years old. The Age (AUC 0.537, SD 8.954) of the patient, ISS, NISS and MISS were poor predictors of mortality. ISS (AUC 0.660, SD 16. 16.283) was the most accurate. The low H-L X^2 statistic of 4.481 (p= 0.877) suggested the model was well calibrated.
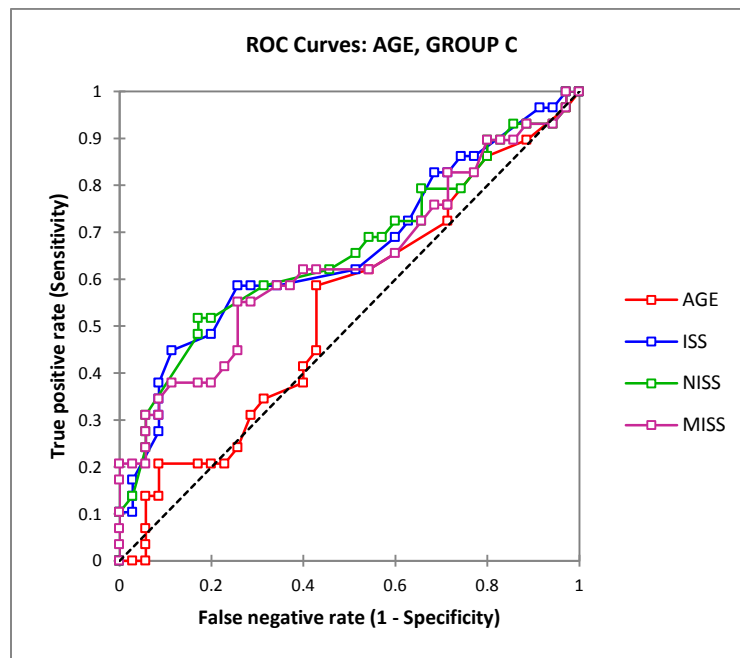
Figure 17 ROC Curves: AGE, GROUP C

COMPARISON OF INJURY SEVERITY SCORES											
GROUP C											
SCORE	Area Under Curve (AUC)	95% CI	p- Value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
AGE	0.537	]0.394,0.680[	0.608	61	55	90	64.484	8.244				
ISS	0.660	]0.524,0.795[	0.021	29	1	75	24.563	16.283	35	55	29	45
NISS	0.658	]0.522,0.793[	0.023	36	1	75	30.703	16.499				
MISS	0.635	]0.497, 0.773[	0.055	39	2	117	36.875	23.117				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			4.481		9		0.877					
Test is positive if LOS, ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 16 Comparison of Injury Severity Scores and AGE to predict mortality: GROUP C

In this small group, transport-related injuries 51(79.7%) was the commonest mechanism with MVC-pedestrian accounting for 24(37.5%). Interpersonal violence represented only 18.8% (12) of injuries. It is most likely that the patients were victims of violence rather than the perpetrators of violent acts.
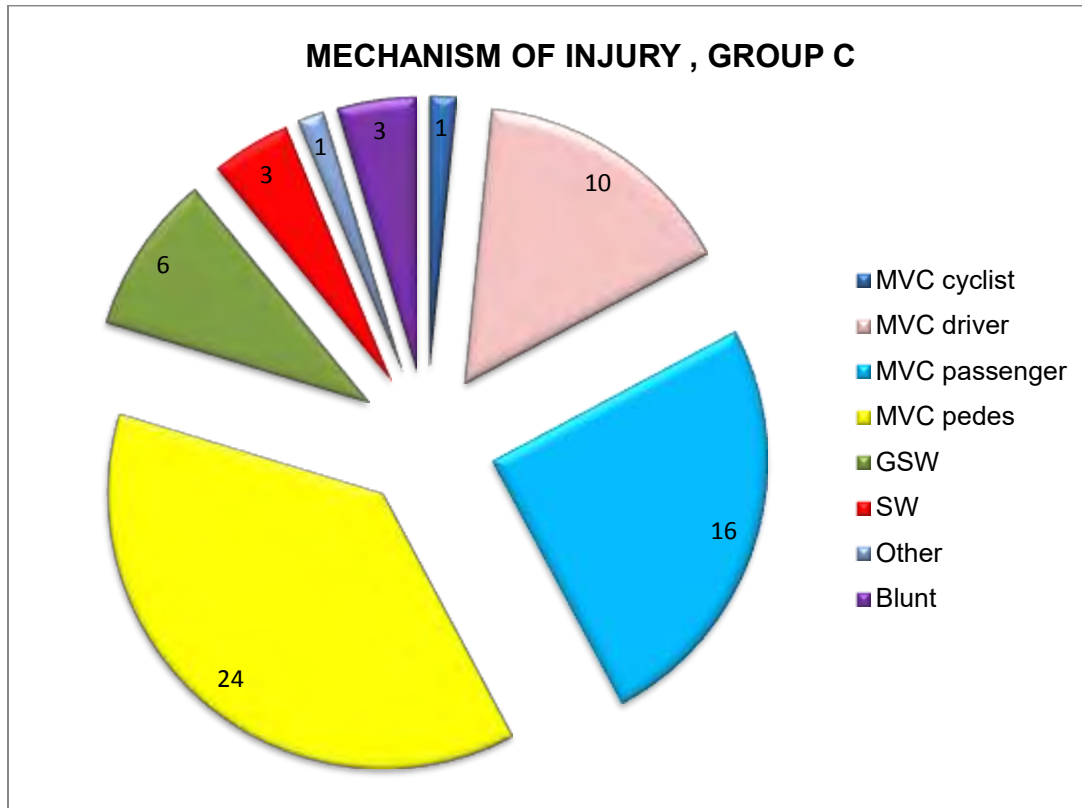
Figure 18 Mechanism of Injury, GROUP C

 A total of 46 males were admitted versus 18 females, making the ratio of 2.56:1. In the male group, ISS, NISS and MISS were poor predictors of outcome, with NISS having highest AUC 0.654(SD 16.276). The low H-L X2 statistic of 9.034 (p= 0.339) suggested the model was well calibrated. The findings in the female group were comparatively similar, but ISS (AUC 0.675, SD 17.037) had better calculated values compared to NISS and MISS.
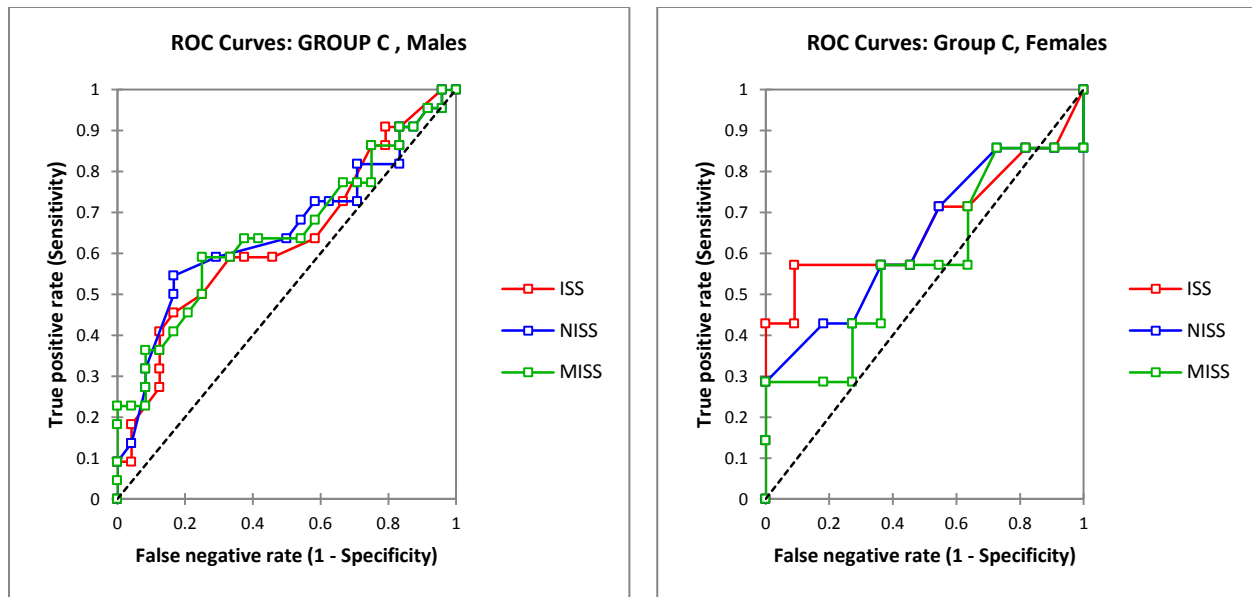
Figure 19 Gender ROC Curves: GROUP C

COMPARISON OF INJURY SEVERITY SCORES: Males											
GROUP C , Males											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.634	]0.472,0.796[	0.104	29	1	75	26.152	15.886	24	52	22	48
NISS	0.654	]0.495,0.814[	0.058	34	1	75	31.804	16.276				
MISS	0.652	]0.492,0.812[	0.063	38	2	101	37.891	22.317				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			9.034		8		0.339					
COMPARISON OF INJURY SEVERITY SCORES: Females												
GROUP C , Females												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.675	]0.409,0.942[	0.198	20	4	75	20.500	17.037	11	61	7	39
NISS	0.636	]0.363,0.910[	0.329	41	4	75	27.889	17.201				
MISS	0.578	]0.298,0.858[	0.585	49	4	117	34.278	25.536				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			12.360		8		0.136					
Test is positive if ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 17 Comparison of Injury Severity Scores and Gender: GROUP C

The LOS, ISS, NISS and MISS were all poor predictors of mortality in this group. The low H-L X^2 statistic of 9.626 (p= 0.382) implied the model was well calibrated. Here ISS had the higher calculated values of AUC 0.660 (SD 16.283). A threshold of > 229 days resulted in positive test (mortality).
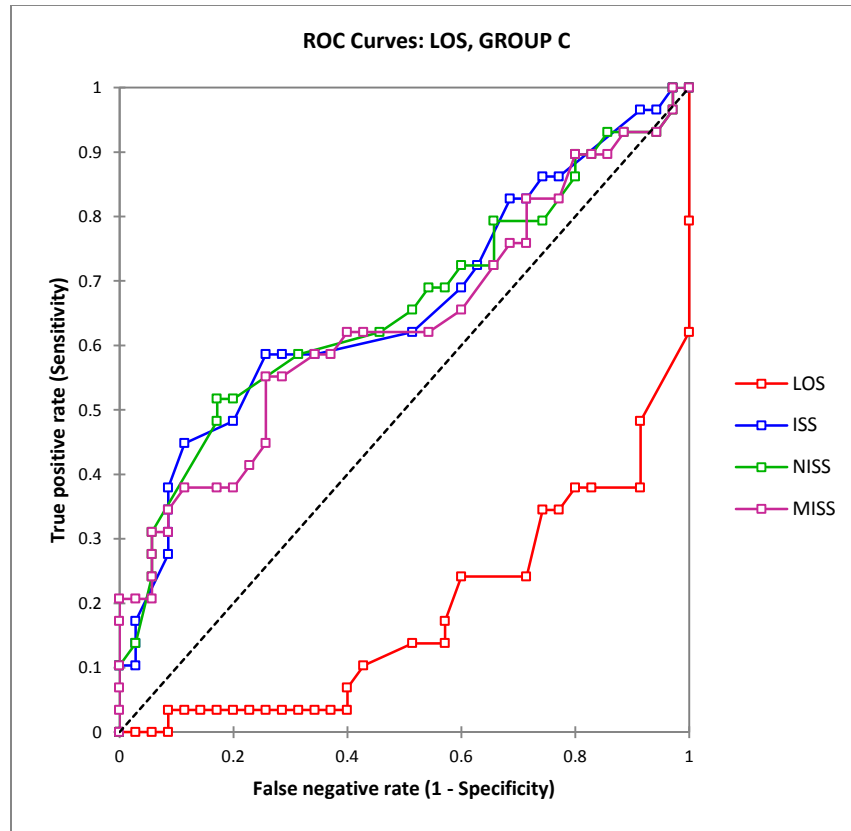
Figure 20 ROC Curves: LOS, GROUP C

	COMPARISON OF INJURY SEVERITY SCORES											
	GROUP C											
SCORE	Area Under Curve (AUC)	95% CI	p- Value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
LOS	0.184	]0.081,0.288[	< 0.0001	229	0	229	18.109	33.563				
ISS	0.660	]0.524, 0.795[	0.021	29	1	75	24.563	16.283	35	55	29	45
NISS	0.658	]0.522,0.793[	0.023	36	1	75	30.703	16.499				
MISS	0.635	]0.497, 0.773[	0.055	39	2	117	36.875	23.117				
	Chi-square , X^2			Degrees of Freedom			Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic	9.626			9			0.382					
Test is positive if LOS, ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 18 Comparison of Injury Severity Scores and LOS, GROUP C

The total number of regions injured 132 (6.40%) in this group was similar to that of the younger adult group but to a smaller proportion as noted by: Extremity (40), Chest (35), Head/Neck (24), External (6) and Face (4) (see Figure 5). The elderly group have many reasons why they would represent the smallest group e.g. the geriatric population is small and their lack of physiological reserve compounded by presence of several co-morbidities may contribute to an inability to survive polytrauma prior to admission. The comparative model was well calibrated with H-L X^2 statistic of 11.687 (p= 0.232).

The ability to predict mortality was poor for Total # RI, ISS, NISS and MISS. ISS had the higher calculated values of AUC 0.660 and SD 16.283. The threshold for positive test (mortality) was when > 7 Total #RI was present.
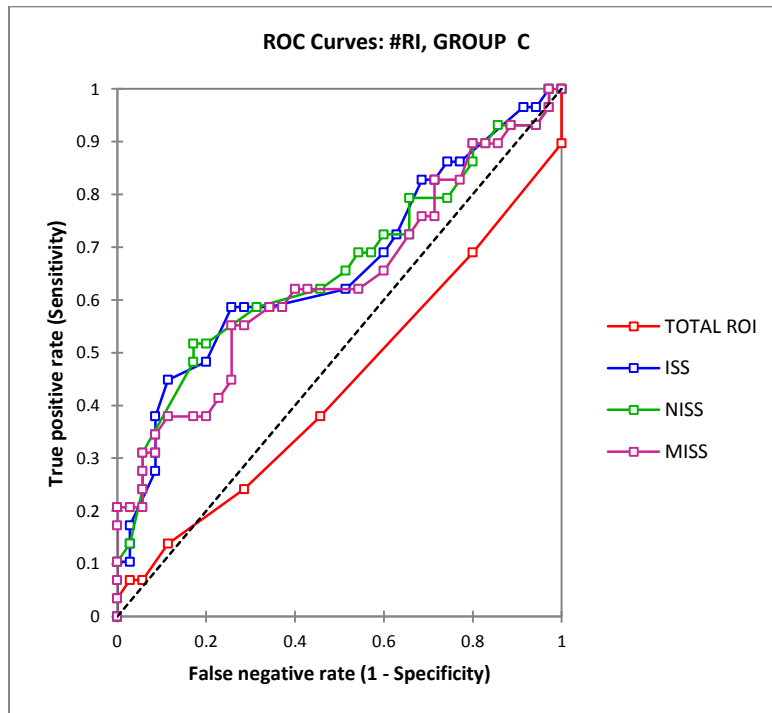

Figure 21 ROC Curves: Total Number of Regions Injured (#RI), GROUP C

COMPARISON OF INJURY SEVERITY SCORES											
	GROUP C										
SCORE	Area Under Curve (AUC)	95% CI	p- Value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
TOTAL # RI	0.437	]0.296,0.578[	0.382	7	1	9	3.641	1.703				
ISS	0.660	]0.524,0.795[	0.021	29	1	75	24.563	16.283	35	55	29	45
NISS	0.658	]0.522,0.793[	0.023	36	1	75	30.703	16.499				
MISS	0.635	]0.497,0.773[	0.055	39	2	117	36.875	23.117				
	Chi-square , X^2			Degrees of Freedom			Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic	11.687			9			0.232					
Test is positive if LOS, ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 19 Comparison of Injury Severity Scores and Total Number of Regions Injured (#RI), GROUP C

Conclusion

In Section 5, I look to conclude the findings made in this study and hopefully draw recommendations as well.

SECTION FIVE: **CONCLUSION**

Conclusion

The resource-constrained milieu in which we work, coupled with a high burden of disease associated with transport-related and interpersonal violence injuries and the paucity of local data, is what initiated this study. Could the current situation be better understood and improved upon? Was intended improvement based on the analysis of a reliable data base providing adequate evidence of the task at hand?

This short 57 month retrospective analysis provided a glimpse of our everyday reality.

The total of 944 patients eligible for this research contributed towards the following conclusions:

1. In this cohort based on the collected data and irrespective of age, the NISS was superior to the ISS at predicting outcome. This finding is in line with current literature views as discussed previously. It also further supports the finding that NISS is a more robust purely anatomical injury severity scoring system as it identifies the three most severe injuries, regardless of body zone injured.

2. The MISS, although comparable to both ISS and NISS at predicting mortality, was not a better predictor of outcome.

3. The mechanism of injury distribution was in accordance with South Africa national trends with transport-related and Inter-personal violence being most common.

4. Gender of the patient did not have a major effect on outcome.

5. The total number of regions injured did not have a major effect on outcome. This may suggest that perchance, it does not matter how many injuries a patient sustains but more how severe are the highest three AIS scoring injuries. The consistent advantage of the NISS demonstrated in this study underscores this concept whereby the three worst injuries, regardless of location are summated. To expound even further, the lower AIS scoring injuries, however many, may not contribute towards the overall outcome of the patient, but rather add to the potential morbidity that patient may be at risk of. In patients with multiple trauma there may well be a limit to the physiological reserve and

compensation which may be governed by age, co-morbidities and number of injuries. Beyond a certain number of injuries the ability to survive will not change. That may explain why, although MISS is comparable to both NISS and ISS for this cohort in terms of predicting outcome, a higher MISS does not always equate to mortality. The magnitude of physiological rather than anatomical disruption may well be the deciding factor. In patients with lesser injuries anatomical scores alone may suffice but in those suffering critical injury a composite anatomical and physiological score would appear to be more relevant.

5. The length of stay was longer on the whole and did not affect the outcome of a patient. This can be explained by two logistical reasons defined by the resource constrained environment of our trauma practice. Firstly, once the patient is ready for transfer back to referral hospital, the repatriation process can take up to two weeks depending on far the patient has to travel. Secondly, ideally our patients are expected to be transferred back to at least a high definition unit in the referring hospital. With the vast disparities in the capacities of the referring hospitals that lie within our catchment area, this is not always possible. Thus our patients are hospitalized for a prolonged period until they are in condition that their referring hospital can manage.

6. This study specifically looked at anatomical scoring of trauma patients. As such, whilst other injury severity scores like the Kampala Trauma Score and APACHE IV Score have gained some acceptance in recent publications, it is important to be cognizant of their applicability in the context of predicting outcomes of trauma patients in our local environment. Systems designed in one location with specific groups of patients require validation by independent observers in other locales.

Recommendations:

 To begin with, understanding the problem is only one arm of a two handed approach towards improvement of service delivery. The existing strict legislation surrounding traffic violations, and enforcement thereof should continue. More important than that however, are injury prevention programs with education of traffic safety both inside and outside the vehicle. Abating rampant crime, which contributes to the violent injuries

managed at this hospital, is a huge task which would require collaborative efforts to improve upon by all interested parties.

Standardising data collection and accurate record keeping can enable a better understanding and contribute towards improved service delivery in the future. This would be a starting point towards having a centralized data set that is representative first at a provincial level then expanded to a national level. This not only contributes to improving our capacity to constructively assess the problem at hand, but also promotes inter-departmental communique and builds stronger ties between the provincial departments enabling one to learn from both success and failures of strategy implementation.

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SECTION SEVEN: **APPENDICES**

APPENDIX A. Protocol for Ethics Approval

Title of study

Injury Severity Score (ISS) versus and New Injury Severity Score (NISS) at a Level One Trauma Unit in South Africa. Are we M.I.S.S. (Maximal Injury Severity Score) ing the point?

Aim of study

To demonstrate whether the MISS for patients admitted to Level 1 Trauma unit has a better predictive value in comparison to the ISS versus NISS for same subset of patients.

Specific objectives

1. To evaluate the predictive value ISS vs NISS in polytrauma patients admitted to a Level 1 Trauma Unit in South Africa.

2. To evaluate and assess the predictive value of a MAXIMAL Injury Severity Score (MISS) in polytrauma patients admitted to Level 1 Trauma Unit in South Africa.

Background and Literature

Polytrauma patients comprise a disease burden on the Health Care system of South Africa. Injury Severity Scoring (ISS) was developed to predict the mortality and morbidity of these trauma patients. The ISS sums the severity score for the three most severe injuries, but it only considers one injury per body region. Thus one can infer that ISS underscores the severity in trauma victims with multiple injuries confined to one body region. The NISS sums the severity score for the three most severe injuries, regardless of body region. Therefore, the NISS will be equal to or higher than the ISS.

Values of NISS higher than the ISS indicate multiple injuries in at least one body region. Early comparison of ISS vs NISS were based on patients who sustained blunt trauma. However, it is important to note that penetrating injuries do differ from blunt: the nature of tissue damage differs, the physiological responses differ, and the primary treatment differs. The subsequent modification to ISS, the New Injury Severity Score (NISS) was put forward, not widely used. In developing country like South Africa, epidemiological research forms the basis from which health care can be improved upon. The Maximal Injury Severity Score (MISS) has not been investigated and will be evaluated with a view to improving the current predictive value when assessed in comparison to ISS and NISS at a Level 1 Trauma Unit in Durban, South Africa.

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Study design:

This is retrospective, non-randomised, uncontrolled qualitative study

Study population:

All patients on the IALCH major trauma database (Class approval BE207/09)

Sampling strategy

Statistical planning (variables / confounders):

Simple statistical analysis with Student's t-test, for continuous variables and Chi-squared tests or Fisher's exact test for non-continuous data variables. The supervisor (Prof DJJ Muckart has extensive statistical experience)

Sample size: All patients included – N/A

Inclusion criteria

1. All patients regardless of injury mechanism admitted to Trauma Unit, IALCH.
2. Polytrauma patients transferred from outside hospitals for post-operative ventilation.
3. Polytrauma patients who were certified dead on arrival.

Exclusion criteria:

Any patient found to be in the data-base but not a polytrauma patient (e.g. snakebite or sjambok injury admitted purely for renal failure treatment)

Data collection methods and tools:

- The data will be obtained from computerised patient records admitted during the period March 2007 to December 2011. The database is approved by BREC BE207/09.
- Each subject data will be collected under the following subheadings

1. General Patient Details
2. Demographics
3. Clinical Presentation

- Data Collection Proforma : See Appendix 6a

Data analysis techniques:

1. Comparison of means between the ISS and NISS scores.
2. Analysis using a paired Student's T-test for continuous data.
3. Categorical data will be analysed using either Fishers or Chi squared.
4. P value was accepted as > 0.05

Statistical analysis:

Study location:

Level 1 Trauma Unit, Inkosi Albert Luthuli Central Hospital, Durban, South Africa

Study period:

March 2007 to December 2011

Limitations to the study:

Single centre, mainly severe trauma, retrospective data – thus risk of bias from inaccurate notes, but unlikely due to consultant-led unit with regular audit and good clinical governance.

Ethical considerations:

Ethical approval will be obtained from the Research and Ethics Committee of the Faculty of Medicine. Since this is retrospective chart review it is unlikely that patient confidentiality will be breached.

All study participants will be identified by their hospital subject number only – KZ numbers will be kept in a secure password protected database.

Data Acquisition Form: Proforma

GENERAL:

SUBJECT NUMBER: _____

HOSPITAL KZ NUMBER: KZ __ ___ ___ (PASSWORD PROTECTED)

DATE OF ADMISSION: __ / __ / 20__   DATE OF DISCHARGE: __ / __ / 20__

STATUS ON ADMISSION Alive ( ) Dead ( ) STATUS ON DISCHARGE: Alive ( ) Dead ( )

DEMOGRAPHICS:

AGE: DATE OF BIRTH:

SEX: MALE ( )   FEMALE ( )

RACE : AFRICAN ( )   ASIAN ( )   CAUCASIAN ( )   OTHER (Please specify)

CLINICAL PRESENTATION:

Region	Injury	AIS	AIS^2 (ISS)	AIS^2 (NISS)	AIS^2 (MISS)
Head/Neck					
Face					
Chest					
Abdomen					
Extremity					
External					
TOTAL			ISS=	NISS=	MISS=

APPENDIX B. Ethical Certificate

University of KwaZulu-Natal

HEREBY ACKNOWLEDGES THAT

Dr Anjana Bairagi

HAS COMPLETED A COURSE IN

RESEARCH POLICY V: RESEARCH ETHICS

Valid Until
2 - 2014

THE FOLLOWING SUBJECTS WERE COMPLETED IN THIS COURSE

- RESEARCH ETHICS POLICY

-CODE OF CONDUCT FOR RESEARCH

Completed On
9 - 2 - 2011

APPENDIX C. BREC Letter

UNIVERSITY OF
KWAZULU-NATAL

INYUVESI
YAKWAZULU-NATALI

20 December 2013

Dr. A Bairagi
Department of General Surgery
Nelson R Mandela School of Medicine
University of KwaZulu-Natal

PROTOCOL: Injury severity score (I.S.S) versus new injury severity score (N.I.S.S) at a level one Trauma Unit in South Africa. Are we M.I.S.Sing (Maximal injury severity score) the point? REF: BE302/12.

EXPEDITED APPLICATION

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application received on 23 November 2012.

The study was provisionally approved pending appropriate responses to queries raised. Your responses received on 19 December 2013 to queries raised on 11 December 2013 have been noted by a sub-committee of the Biomedical Research Ethics Committee. The conditions have now been met and the study is given full ethics approval and may begin as from 20 December 2013.

This approval is valid for one year from **20 December 2013.** To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.
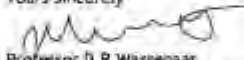
Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2004), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be RATIFIED by a full Committee at its next meeting taking place on 11 February 2014.

We wish you well with this study. We would appreciate receiving copies of all publications arising out of this study.

Yours sincerely

Professor D.R Wassenaar
Chair: Biomedical Research Ethics Committee

Professor D Wassenaar (Chair)
Biomedical Research Ethics Committee
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban, 4000, South Africa
Telephone: +27 (0)31 260 2384 Facsimile: +27 (0)31 260 4609 Email: brec@ukzn.ac.za
Website: http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx
Founding Campuses: ▪ Edgewood ▪ Howard College ▪ Medical School ▪ Pietermaritzburg ▪ Westville

INSPIRING GREATNESS

**UNIVERSITY OF
KWAZULU-NATAL**

INYUVESI
YAKWAZULU-NATALI

RESEARCH OFFICE
Biomedical Research Ethics Administration
Westville Campus, Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604769 · Fax: 27 31 2604609
Email: BREC@ukzn.ac.za
Website http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

01 December 2015

Dr. A Bairagi
Department of General Surgery
Nelson R Mandela School of Medicine
University of KwaZulu-Natal

PROTOCOL: Injury severity score (I.S.S) versus new injury severity score (N.I.S.S) at a level one Trauma Unit in South Africa. Are we M.I.S.Sing (Maximal injury severity score) the point? REF: BE302/12.

RECERTIFICATION APPLICATION APPROVAL NOTICE

Approved: 20 December 2014
Expiration of Ethical Approval: 19 December 2015

I wish to advise you that your application for Recertification received 18 November 2015 for the above protocol has been noted and approved by a sub-committee of the Biomedical Research Ethics Committee (BREC) for another approval period. The start and end dates of this period are indicated above.

If any modifications or adverse events occur in the project before your next scheduled review, you must submit them to BREC for review. Except in emergency situations, no change to the protocol may be implemented until you have received written BREC approval for the change.

This approval will be **ratified** by a full Committee at its next meeting taking place on **08 December 2015.**

Yours sincerely

Mrs A Marimuthu
Senior Administrator: Biomedical Research Ethics

UNIVERSITY OF KWAZULU-NATAL

INYUVESI YAKWAZULU-NATALI

RESEARCH OFFICE
Biomedical Research Ethics Administration
Westville Campus, Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604769 - Fax: 27 31 2604609
Email: BREC@ukzn.ac.za
Website: http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

15 December 2015

Dr. A Bairagi
Department of General Surgery
Nelson R Mandela School of Medicine
University of KwaZulu-Natal

PROTOCOL: Injury severity score (I.S.S) versus new injury severity score (N.I.S.S) at a level one Trauma Unit in South Africa. Are we M.I.S.Sing (Maximal injury severity score) the point? REF: BE302/12.

RECERTIFICATION APPLICATION APPROVAL NOTICE

Approved: 20 December 2015
Expiration of Ethical Approval: 19 December 2016

I wish to advise you that your application for Recertification received 09 December 2015 for the above protocol has been noted and approved by a sub-committee of the Biomedical Research Ethics Committee (BREC) for another approval period. The start and end dates of this period are indicated above.

If any modifications or adverse events occur in the project before your next scheduled review, you must submit them to BREC for review. Except in emergency situations, no change to the protocol may be implemented until you have received written BREC approval for the change.

This approval will be **ratified** by a full Committee at its next meeting taking place on **09 February 2016.**

Yours sincerely

Mrs A Marimuthu
Senior Administrator: Biomedical Research Ethics

APPENDIX D. DOH Letter of approval

health

Department:
Health
PROVINCE OF KWAZULU-NATAL

Health Research & Knowledge Management sub-component
10 – 103 Natalia Building, 330 Langalibalele Street
Private Bag x9051
Pietermaritzburg
3200
Tel.: 033 – 3953189
Fax.: 033 – 394 3782
Email.: hrkm@kznhealth.gov.za
www.kznhealth.gov.za

Reference   : HRKM342 /13
Enquiries: Mrs G Khumalo
Telephone : 033 – 395 3189

02/01/2014

Dear Dr A Bairagi

Subject: Approval of a Research Proposal
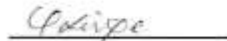
1. The research proposal titled 'Injury Severity Score (I.S.S.) versus New Injury Severity Score (N.I.S.S.) at a level one Trauma Unit in South Africa. Are we M.I.S. Sing (Maximal Injury Severity Score) the point?' was reviewed by the KwaZulu-Natal Department of Health (KZN-DoH).

The proposal is hereby **approved** for research to be undertaken at Inkosi Albert Luthuli Central Hospital.

2. You are requested to take note of the following:
    a. Make the necessary arrangement with the identified facility before commencing with your research project.
    b. Provide an interim progress report and final report (electronic and hard copies) when your research is complete.

3. Your final report must be posted to **HEALTH RESEARCH AND KNOWLEDGE MANAGEMENT, 10-102, PRIVATE BAG X9051, PIETERMARITZBURG, 3200** and e-mail an electronic copy to hrkm@kznhealth.gov.za

For any additional information please contact Mrs G Khumalo on 033-395 3189.

Yours Sincerely

Dr. E Lutge
Chairperson, KwaZulu-Natal Health Research Committee
Date: 02/01/2014 .

uMnyango Wezempilo. Departement van Gesondheid

Fighting Disease, Fighting Poverty, Giving Hope

APPENDIX E: Graphs, Tables, Figures

E 1.0 Age Group
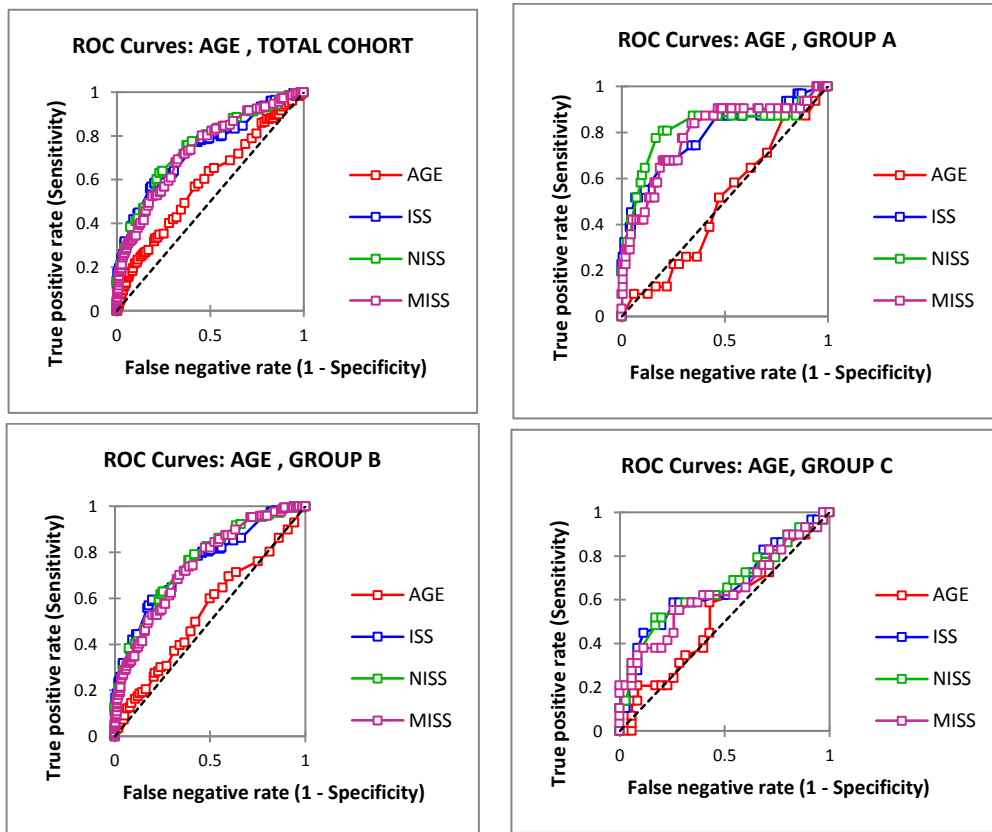
Figure 22.ROC Curves: AGE Group

COMPARISON OF INJURY SEVERITY SCORES											
TOTAL COHORT											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
AGE	0.590	]0.546, 0.633[	< 0.0001	29	0.5	90	29.455	15.306	717	76	227	24
ISS	0.740	]0.700, 0.780[	< 0.0001	29	1	75	25.862	14.763				
NISS	0.754	]0.715,0.793[	< 0.0001	37	1	75	32.313	15.581				
MISS	0.735	]0.694,0.775[	< 0.0001	38	1	210	39.762	24.968				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			15.333		9		0.082					
GROUP A											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
AGE	0.495	]0.384,0.607[	0.935	4	0.5	18	9.124	4.937	150	83	31	17
ISS	0.789	]0.690,0.889[	< 0.0001	33	2	75	26.729	15.127				
NISS	0.819	]0.724,0.913[	< 0.0001	38	2	75	31.669	15.871				
MISS	0.789	]0.690,0.889[	< 0.0001	36	2	150	38.182	23.100				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			19.807		8		0.011					
GROUP B											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
AGE	0.544	]0.493,0.594[	0.093	29	19	54	31.512	8.954	532	76	167	24
ISS	0.752	]0.706,0.798[	< 0.0001	29	1	75	25.757	14.531				
NISS	0.761	]0.715,0.806[	< 0.0001	33	1	75	32.627	15.428				
MISS	0.744	]0.697,0.790[	< 0.0001	38	1	210	40.435	25.583				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			3.780		8		0.876					
GROUP C											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
AGE	0.537	]0.394,0.680[	0.608	61	55	90	64.484	8.244	35	55	29	45
ISS	0.660	]0.524,0.795[	0.021	29	1	75	24.563	16.283				
NISS	0.658	]0.522,0.793[	0.023	36	1	75	30.703	16.499				
MISS	0.635	]0.497, 0.773[	0.055	39	2	117	36.875	23.117				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			4.481		9		0.877					
Test is positive if AGE or ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table20. Comparison of Injury Severity Scores and Age to predict mortality

E2.0 Mechanism of Injury Distribution

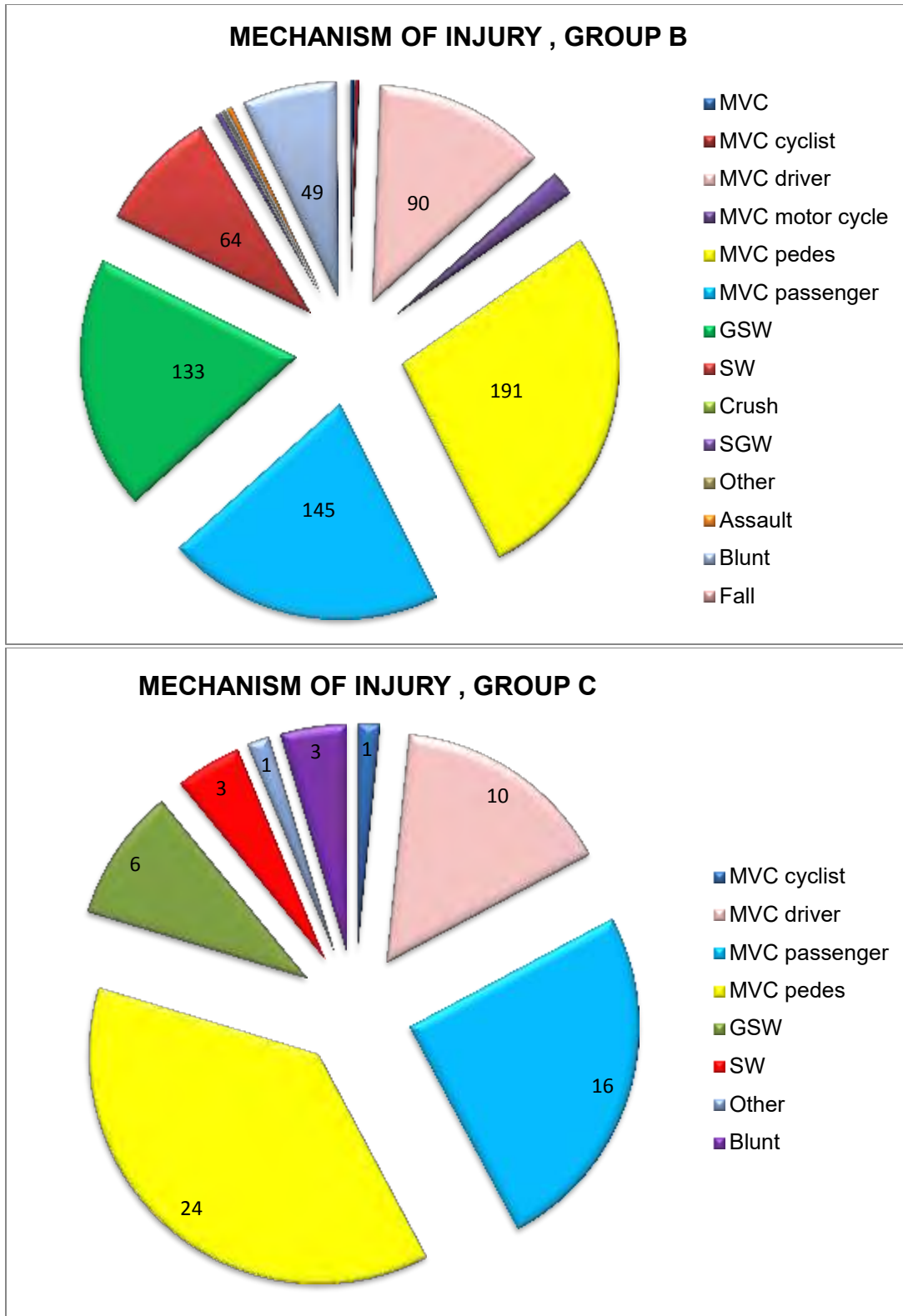Figure 23. Distribution of Mechanism of Injury

E3.0 Gender
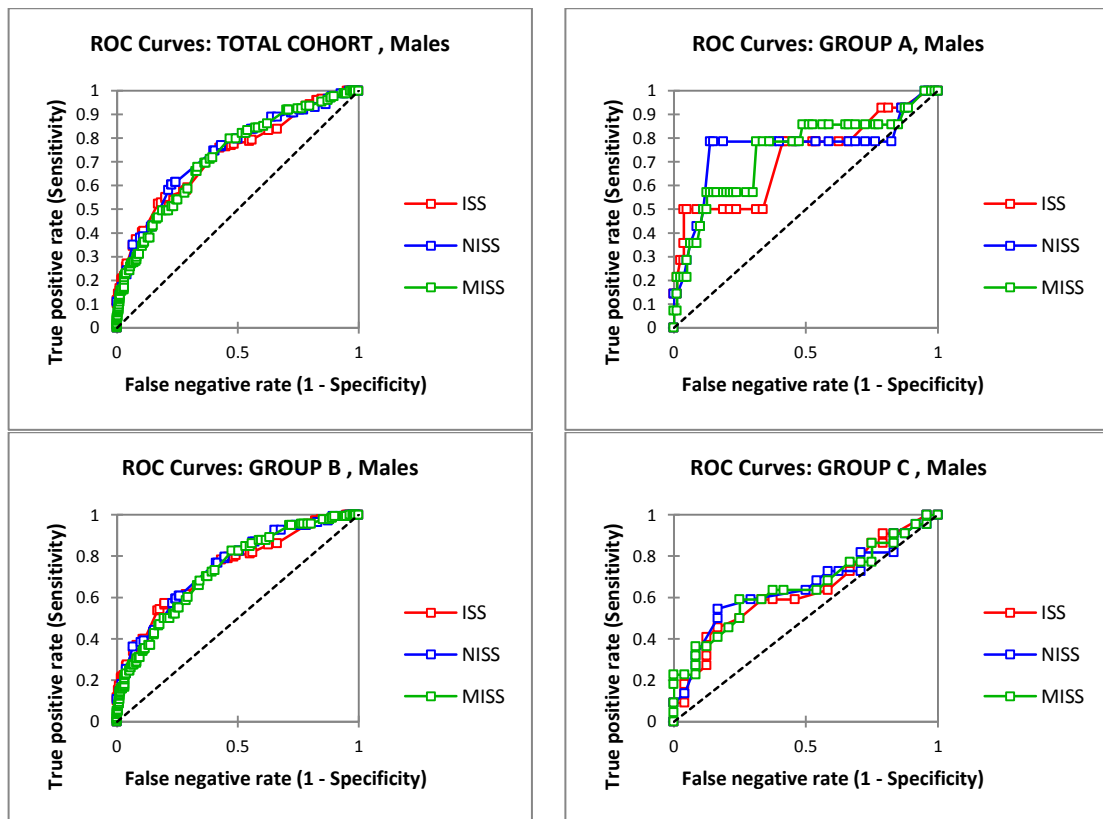
Figure 24. ROC Curves: Males

COMPARISON OF INJURY SEVERITY SCORES: Males											
TOTAL COHORT, Males											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.726	] 0.690 ,0.773[	< 0.0001	33	1	75	25.512	14.254				
NISS	0.739	]0.693,0.785[	< 0.0001	37	1	75	32.433	15.017	516	75	174	25
MISS	0.723	]0.676,0.770[	< 0.0001	38	2	210	39.726	24.893				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			4.495		8		0.810					
GROUP A, Males											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.714	]0.553,0.874[	0.009	38	2	75	24.606	13.682				
NISS	0.757	]0.603,0.911[	0.001	38	2.	75	30.149	14.963	80	85	14	15
MISS	0.740	]0.583,0.897[	0.003	38	2.	116	36.553	21.425				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			10.169		8		0.253					
GROUP B , Males											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.742	]0.690,0.793[	< 0.0001	29	1	75	25.613	14.228				
NISS	0.750	]0.699,0.801[	< 0.0001	33	2	75	32.876	14.908	412	75	138	25
MISS	0.733	]0.681,0.785[	< 0.0001	33	2	210	40.422	25.624				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			5.491		8		0.704					
GROUP C, Males											
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE		DEAD	
									N =	%	N =	%
ISS	0.634	]0.472,0.796[	0.104	29	1	75	26.152	15.886				
NISS	0.654	]0.495,0.814[	0.058	34	1	75	31.804	16.276	24	52	22	48
MISS	0.652	]0.492,0.812[	0.063	38	2	101	37.891	22.317				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			9.034		8		0.339					
Test is positive if ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 21. Comparison of Injury Severity Scores and Males to predict mortality
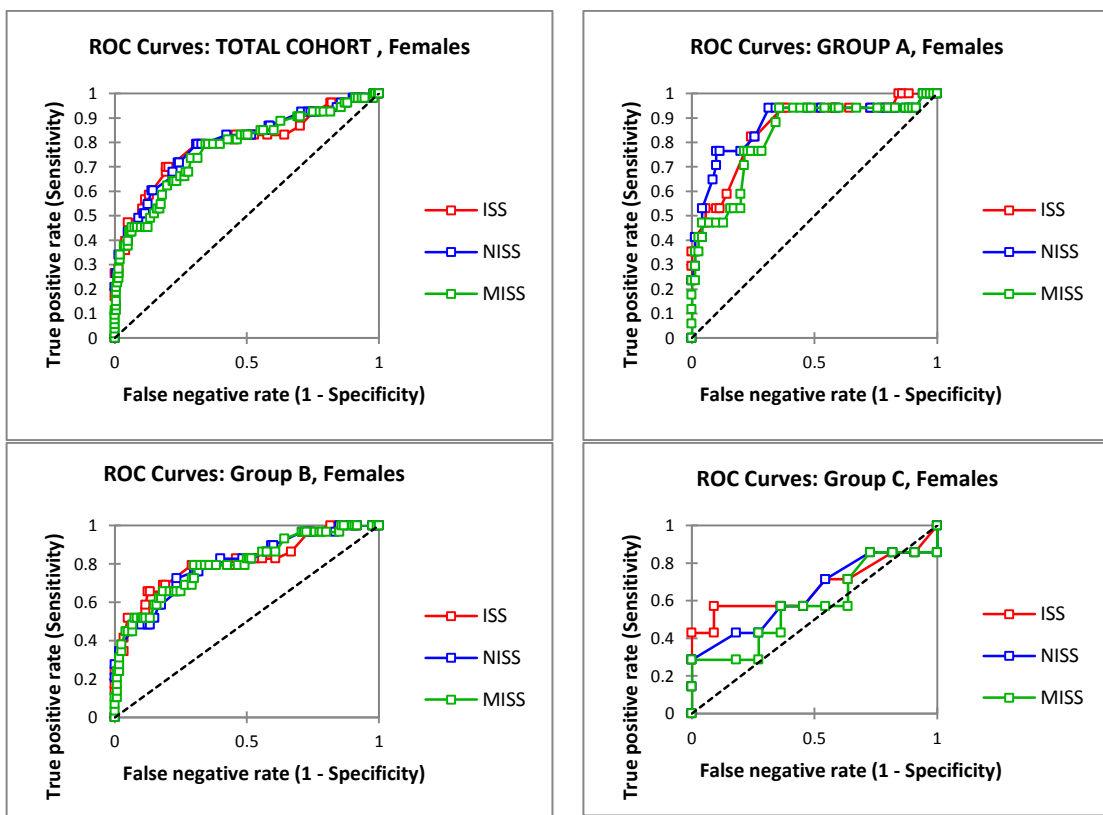
Figure 25. ROC Curves, Females

COMPARISON OF INJURY SEVERITY SCORES: Females												
TOTAL COHORT, Females												
SCORE	**Area Under Curve (AUC)**	**95% Confidence Interval (CI)**	**p- value**	**Threshold**	**MIN**	**MAX**	**MEAN**	**Standard Deviation (SD)**	**ALIVE**		**DEAD**	
									N =	**%**	**N =**	**%**
ISS	0.791	]0.714,0.886[	< 0.0001	32	1	75	26.815	16.056	201	79	53	21
NISS	0.795	]0.719,0.871[	< 0.0001	33	1	75	31.984	17.047				
MISS	0.773	]0.695,0.852[	< 0.0001	37	1	150	39.858	25.220				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			7.881		8		0.445					
GROUP A, Females												
SCORE	**Area Under Curve (AUC)**	**95% Confidence Interval (CI)**	**p- value**	**Threshold**	**MIN**	**MAX**	**MEAN**	**Standard Deviation (SD)**	**ALIVE**		**DEAD**	
									N =	**%**	**N =**	**%**
ISS	0.855	]0.737,0.973[	< 0.0001	32	3	75	29.023	16.317	70	80	17	20
NISS	0.872	]0.760, 0.984[	< 0.0001	43	3	75	33.310	16.729				
MISS	0.825	]0.698,0.952[	< 0.0001	33	3	150	39.943	24.789				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			7.115		8		0.524					
GROUP B , Females												
SCORE	**Area Under Curve (AUC)**	**95% Confidence Interval (CI)**	**p- value**	**Threshold**	**MIN**	**MAX**	**MEAN**	**Standard Deviation (SD)**	**ALIVE**		**DEAD**	
									N =	**%**	**N =**	**%**
ISS	0.807	]0.707,0.908[	< 0.0001	36	1	75	26.289	15.640	120	81	29	19
NISS	0.800	]0.698, 0.902[	< 0.0001	34	1	75	31.705	17.235				
MISS	0.796	]0.694,0.899[	< 0.0001	39	1	142	40.483	25.517				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			7.445		8		0.489					
GROUP C, Females												
SCORE	**Area Under Curve**	**95% Confidence Interval (CI)**	**p- value**	**Threshold**	**MIN**	**MAX**	**MEAN**	**Standard Deviation (SD)**	**ALIVE**		**DEAD**	
									N =	**%**	**N =**	**%**
ISS	0.675	]0.409,0.942[	0.198	20	4	75	20.500	17.037	11	61	7	39
NISS	0.636	]0.363,0.910[	0.329	41	4	75	27.889	17.201				
MISS	0.578	]0.298,0.858[	0.585	49	4	117	34.278	25.536				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			12.360		8		0.136					
Test is positive if ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 22. Comparison of Injury Severity Scores and Females to predict mortality

E 4.0 Length of Stay
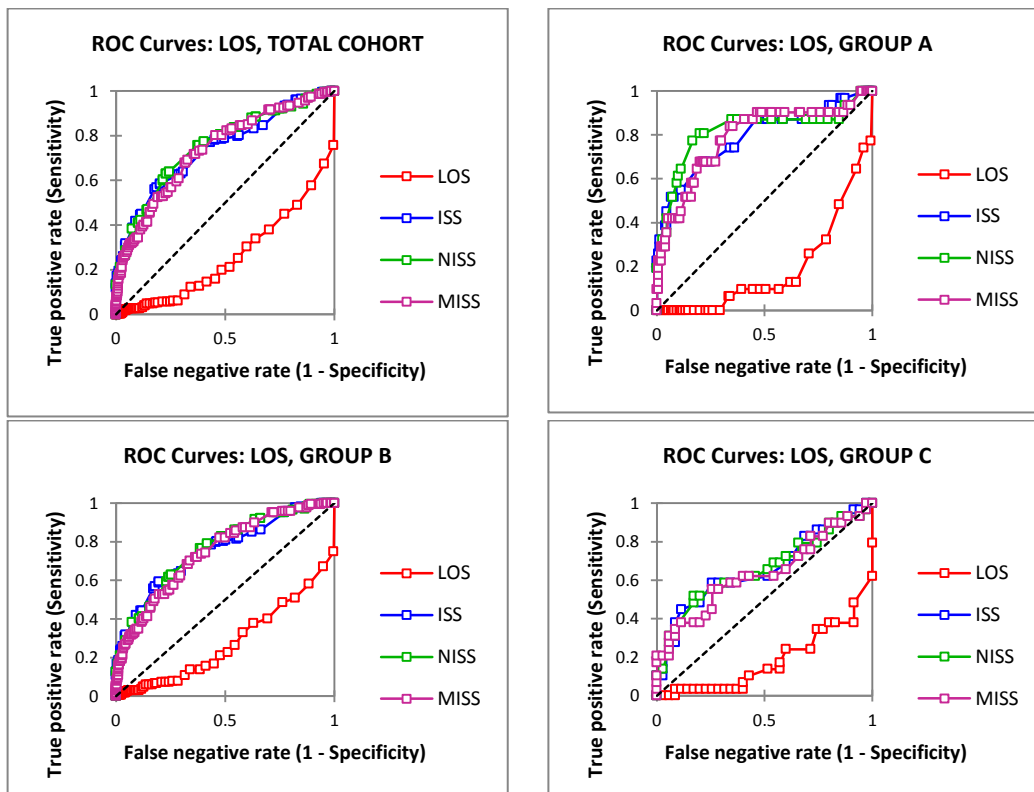
Figure 26. ROC Curves for Length of Stay (LOS)

COMPARISON OF INJURY SEVERITY SCORES												
TOTAL COHORT												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE N =	%	DEAD N =	%
LOS	0.261	]0.228, 0.295[	< 0.0001	102	0	312	13.078	18.874				
ISS	0.740	]0.700, 0.780[	< 0.0001	29	1	75	25.862	14.763	717	76	227	24
NISS	0.754	]0.715, 0.793[	< 0.0001	37	1	75	32.313	15.581				
MISS	0.735	]0.694, 0.775[	< 0.0001	38	1	210	39.762	24.968				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			32.414		9		0.000					
GROUP A												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE N =	%	DEAD N =	%
LOS	0.191	]0.121,0.261[	< 0.0001	97	0	97	12.431	14.428				
ISS	0.789	]0.690,0.889[	< 0.0001	33	2	75	26.729	15.127	150	83	31	17
NISS	0.819	]0.724,0.913[	< 0.0001	38	2	75	31.669	15.871				
MISS	0.789	]0.690,0.889[	< 0.0001	36	2	150	38.182	23.100				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			18.478		9		0.030					
GROUP B												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE N =	%	DEAD N =	%
LOS	0.281	]0.241, 0.321[	< 0.0001	102	0	312	12.785	17.984				
ISS	0.752	[0.706, 0.798[	< 0.0001	29	1	75	25.757	14.531	532	76	167	24
NISS	0.761	[0.715, 0.806[	< 0.0001	33	1	75	32.627	15.428				
MISS	0.744	[0.697, 0.790[	< 0.0001	38	1	210	40.435	25.583				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-Lemeshow (H-L) X^2 statistic			23.982		8		0.002					
GROUP C												
SCORE	Area Under Curve (AUC)	95% Confidence Interval (CI)	p- value	Threshold	MIN	MAX	MEAN	Standard Deviation (SD)	ALIVE N =	%	DEAD N =	%
LOS	0.184	]0.081,0.288[	< 0.0001	229	0	229	18.109	33.563				
ISS	0.660	]0.524, 0.795[	0.021	29	1	75	24.563	16.283	35	55	29	45
NISS	0.658	]0.522,0.793[	0.023	36	1	75	30.703	16.499				
MISS	0.635	]0.497,0.773[	0.055	39	2	117	36.875	23.117				
			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
Hosmer-**Lemeshow (H-L) X^2 statistic**			9.626		9		0.382					
Test is positive if ISS or NISS or MISS > threshold value **95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)**												

Table 23. Comparison of Injury Severity Scores and Length of Stay (LOS) to predict mortality

E5.Number of Regions Injured (#RI)

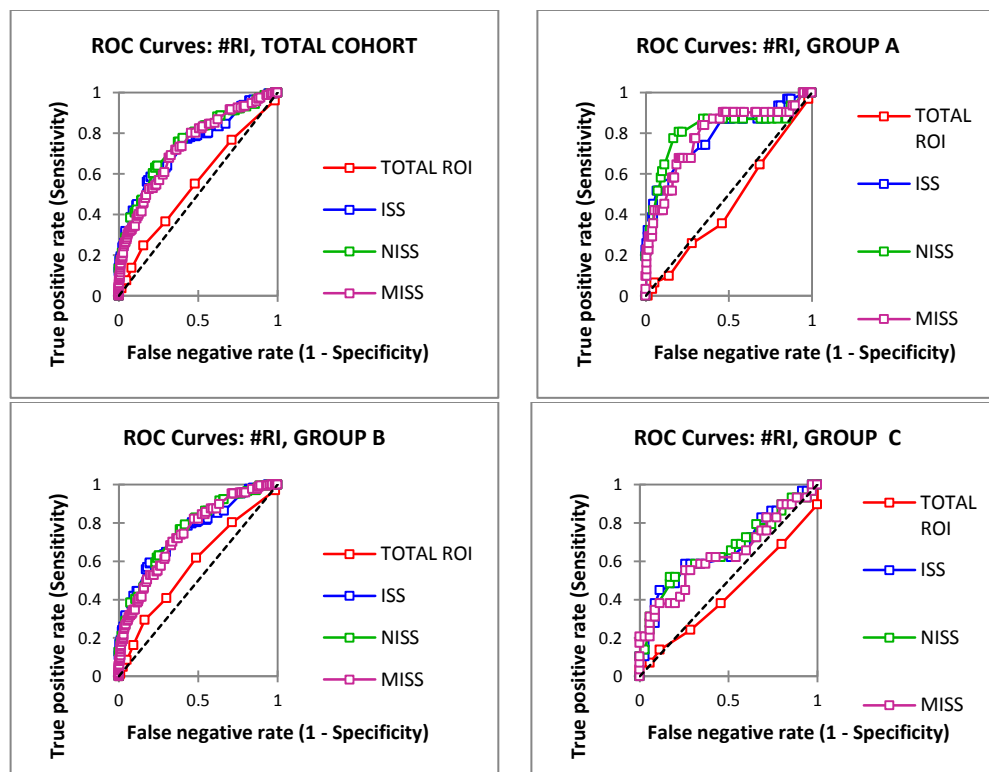**Figure 27.ROC Curves: Number of Regions Injured (#RI)**

COMPARISON OF INJURY SEVERITY SCORES											
TOTAL COHORT											
SCORE	**Area Under Curve (AUC)**	**95% Confidence Interval (CI)**	**p- value**	**Threshold**	**MIN**	**MAX**	**MEAN**	**Standard Deviation (SD)**	**ALIVE**		**DEAD**	
									N =	**%**	**N =**	**%**
TOTAL # RI	0.551	]0.507,0.595[	0.022	5	0	12	3.864	1.849				
ISS	0.740	]0.700,0.780[	< 0.0001	29	1	75	25.862	14.763	717	76	227	24
NISS	0.754	]0.715, 0.793[	< 0.0001	37	1	75	32.313	15.581				
MISS	0.735	]0.694,0.775[	< 0.0001	38	1	210	39.762	24.968				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			17.872		8		0.022					
GROUP A												
SCORE	**Area Under Curve (AUC)**	**95% Confidence Interval (CI)**	**p- value**	**Threshold**	**MIN**	**MAX**	**MEAN**	**Standard Deviation (SD)**	**ALIVE**		**DEAD**	
									N =	**%**	**N =**	**%**
TOTAL # RI	0.458	]0.348,0.567[	0.448	6	2	1	9	3.613				
ISS	0.789	]0.690,0.889[	< 0.0001	33	2	75	26.729	15.127	150	83	31	17
NISS	0.819	]0.724,0.913[	< 0.0001	38	2	75	31.669	15.871				
MISS	0.789	]0.690,0.889[	< 0.0001	36		150	38.182	23.100				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			14.003		8		0.082					
GROUP B												
SCORE	**Area Under Curve (AUC)**	**95% Confidence Interval (CI)**	**p- value**	**Threshold**	**MIN**	**MAX**	**MEAN**	**Standard Deviation (SD)**	**ALIVE**		**DEAD**	
									N =	**%**	**N =**	**%**
TOTAL # RI	0.583	]0.532,0.633[	0.001	3	1	18	3.989	2.002				
ISS	0.752	]0.706,0.798[	< 0.0001	29	1	75	25.757	14.531	532	76	167	24
NISS	0.761	]0.715,0.806[	< 0.0001	33	1	75	32.627	15.428				
MISS	0.744	]0.697,0.790[	< 0.0001	38	1	21	40.435	25.583				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X2					
			8.601		8		0.377					
GROUP C												
SCORE	**Area Under Curve (AUC)**	**95% Confidence Interval (CI)**	**p- value**	**Threshold**	**MIN**	**MAX**	**MEAN**	**Standard Deviation (SD)**	**ALIVE**		**DEAD**	
									N =	**%**	**N =**	**%**
TOTAL # RI	0.437	]0.296,0.578[	0.382	7	1	9	3.641	1.703				
ISS	0.660	]0.524,0.795[	0.021	29	1	75	24.563	16.283	35	55	29	45
NISS	0.658	]0.522,0.793[	0.023	36	1	75	30.703	16.499				
MISS	0.635	]0.497,0.773[	0.055	39	2	117	36.875	23.117				
Hosmer-Lemeshow (H-L) X^2 statistic			Chi-square , X^2		Degrees of Freedom		Pr > X^2					
			11.687		9		0.232					
Test is positive if ISS or NISS or MISS > threshold value 95% confidence interval on the difference between the AUC and 0.5 (Two-tailed test)												

Table 24. Comparison of Injury Severity Scores& Number of Regions Injured to predict mortality