Preventable Deaths Presenting to a Level 1 Trauma Centre in South Africa: A Panel Study

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DECLARATION

I, Megan Frost (FRSMEG003), hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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THESIS ABSTRACT

Background: Violence and injuries are one of the leading health threats to South Africans and create a large burden on the country's trauma system. This excessive rate of trauma means it is realistic that preventable trauma deaths can be identified, as well as the errors contributing to them.

Panel studies and the TRauma Score-Injury Severity Score (TRISS) method are two approaches to evaluating preventable trauma deaths. Panel studies use a panel that subjectively determines whether a death could have been prevented in terms of the care provided within the trauma system. MacKenzie et al. (1992) has created guidelines for increasing the reliability of panel studies. The TRISS method uses more objective measures including the patient's physiological condition and severity of injuries to determine whether a death may have been prevented.

The aim of our study was to identify areas for quality improvement in regards to preventable trauma deaths at Groote Schuur Hospital Trauma Centre (GSHTC)

Methods: A review of the literature regarding the use of panel studies to evaluate preventable deaths in trauma systems was performed. Twelve studies were identified and each was assessed using criteria outlined by MacKenzie et al. (1992).

A prospective audit was performed of all trauma patients that were admitted to GSHTC and subsequently died. Each case was reviewed by a panel of four trauma surgeons and one researcher. An assignment of non-preventable (NP), potentially preventable (PP), and preventable (P) was made by the panel and any errors contributing to a PP or P death were identified. A probability of survival (Ps) score was calculated for each patient using the TRISS method and this score was used to stratify patients into NP, PP, and P categories. The agreement between the panel method and TRISS method was assessed using kappa statistics.

Results: The panel method found 84 (76%) cases to be NP, 19 (17%) PP, and 8 (7%) P. The preventable death rate (PDR) was 24%. The TRISS method found 17 (17%) cases to be NP, 10 (10%) PP, and 72 (73%) P. The PDR using the TRISS method was 83%. Kappa statistics showed very poor agreement between the panel and TRISS method.

Conclusion: The studies identified in the review of the literature varied greatly in their approach to the methods for a panel review and their adherence to the guidelines set forth by MacKenzie et al. (1992).

The data from our study show a major discrepancy between PDRs based on panel versus TRISS methods. The difference may be explained by methodological issues and the unique characteristics of the trauma population and GSHTC. More importantly, GSHTC identified areas for quality improvement to decrease the true PDR.

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Co-Investigators:
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Dr. Sorin Edu, Dr. Wanda Bekker, and Dr. Anders Grotte, all trauma surgeons, were panel members.

Dr. Linda Liebenberg, a pathologist, collected autopsy information and attended panel sessions to review autopsies with the panel.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PROTOCOL

Preventable Deaths Presenting to a Level 1 Trauma Centre in South Africa: A Panel Study

PROBLEM STATEMENT

Groote Schuur Hospital has a high rate of trauma admissions and a limited staff with restricted resources; therefore the idea that the amount of preventable trauma deaths can be identified and then decreased is realistic.

RESEARCH JUSTIFICATION

Background

Violence and injuries have become one of the leading health threats to South Africans. In 2000, violence was the second leading cause of years of life lost while road traffic injuries was the fourth.[1] In addition, the death rate in South Africa due to injury was 157.8 per 100,000 which is nearly twice the global average of 86.9 per 100,000.[2,3] In 2007, the National Injury Mortality Surveillance System[4] estimated that injury mortality represents 11.5 to 13.4% of deaths every year.[5] Violence accounted for 36% of these deaths, road traffic accidents accounted for 32% of deaths, and the rest were due to unintentional injuries or suicides. In 2007, Cape Town had the highest injury mortality rate in the country at 144 per 100,000.[4] Groote Schuur Hospital Trauma Centre (GSHTC) in Cape Town currently admits approximately 1000 trauma patients per month with between 15 and 25 mortalities. The combination of a high burden of traumatic injuries, a

limited staff and restricted resources, requires an assessment of the quality of care provided at GSHTC.

The analysis of preventable trauma deaths has been widely used to assess trauma and non-trauma centres, and then to generate new standards for care within an institution. However, very few of these studies have been completed in low and middle income countries. In any area of the world, trauma centres are susceptible to errors due to the instability of the patients and the need for prompt decision making without complete knowledge of a patient's medical history. Low and middle income countries often face additional strains including a higher rate of trauma and fewer resources than their developed counterparts. A study at GSHTC is needed to illuminate areas for improvement in a middle income country with an extremely high burden of trauma.

Methods for evaluating preventable deaths

The modern trauma system has evolved over the past five decades due to studies illustrating major deficiencies in the care of trauma patients. Since that time, trauma has been a leader in assessing quality of care and improvements have been made based on these assessments. One method employed is to evaluate preventable mortalities as a proxy for evaluating quality. Extensive research has been completed estimating the preventable death rates (PDR) of institutions and reviewing what factors may have contributed to the deaths. The analysis of early phase preventable trauma mortalities has often resulted in the implementation of protocols directed at human errors and system changes in many trauma centres around the world.[6,7]

Panel studies, one form of analyzing preventable trauma deaths, have been used extensively to evaluate outcomes of trauma care. A panel of professionals reviews the trauma mortalities that have occurred at an institution and makes a decision as to whether the death was preventable in terms of the care provided. A preventable death is defined as "any death that may have been prevented if optimal care had been delivered,"[7] and must meet the following three criteria: "the injury or sequelae of the injury must be survivable; the care delivered must be judged suboptimal; and identified errors in the delivery of care must be directly or indirectly implicated in the demise of the patient."[7] A PDR, which is the proportion of deaths that are considered preventable or potentially preventable divided by the total number of deaths, can then be calculated.[7]

In regards to the validity and reliability of panel studies, the concern is the reproducibility of the subjective judgments that are made by different groups of professionals.[8] The methodology employed in these studies is varied, but guidelines have been introduced to increase the rigour of the panels by MacKenzie et al. (1992) after reviewing over 30 panel studies and analyzing the inter-rater reliability.[8]

First, the review process should be chosen carefully as the methodology can impact the PDR. There are three main ways to carry out the review: independent review, panel consensus, and unanimous decision. An independent review consists of each panelist independently reviewing records and casting a vote on the preventability status. The preventability assignment is made by the majority vote. A panel consensus consists of an

independent review of records by each panelist, a vote, and then a panel discussion for each case when at least one person voted the death as preventable. After discussion, the panel's consensus assigns the preventability status. The unanimous decision rule requires an independent review of records, a vote, and then a preventability assignment is made only in cases when the vote is unanimous. An independent review and the unanimous decision rule provide an estimate of the lower bounds of the true PDR, while the panel consensus estimates the upper bounds.[8,9]

Additionally, to increase reliability the composition of the review panel should take a multidisciplinary approach consisting of trauma surgeons, nurses, anesthesiologists, emergency room physicians, pathologists, pre-hospital care givers, and others. Although original studies included only trauma surgeons, by incorporating other disciplines with clinical expertise and acquiring different perspectives, a more comprehensive view of the patient's care can be obtained. It is important with a multidisciplinary approach that there is time for discussion and not a simple vote.[8,9] Moreover, the information available to the panel for review should be thorough and include pre-hospital reports, hospital records, and autopsy reports.[8,9] When making the preventability decision, the use of a three point classification system (non-preventable (NP), potentially preventable (PP), preventable (P)), as opposed to a two point classification system (NP, P) decreases confusion and increases reliability amongst the panel members.[8]

In addition to the recommendations set forth by MacKenzie et al. (1992), multiple studies use the TRauma Score-Injury Severity Score (TRISS) method to correlate the panel

decision with a more objective measurement.[9] The TRISS calculation is derived from the Injury Severity Score (ISS) and the Revised Trauma Score (RTS) plus the patient's age and mechanism of trauma, whether blunt or penetrating. The ISS is calculated based on the anatomical location and severity of the person's injuries, and the RTS is calculated using the admission systolic blood pressure, the respiratory rate, and the Glascow Coma Score (GCS).[10] These numbers are used to calculate a person's probability of survival (Ps) which can then be stratified as NP, PP, and P. A P death occurs when the Ps is greater than 0.5; a PP death occurs when the Ps is between 0.25 and 0.5; a NP death occurs when the Ps is lower than 0.25.[9,11]

Figure 1. Probability of survival formula[10]

$$Ps = \frac{1}{1+e^{-B}}, \quad \text{where } B = B_0 + B_1(RTS) + B_2(ISS) + B_3(age)$$

Although panel reviews are classified as Class III evidence,[12] by using MacKenzie et al.'s guidelines and the TRISS method, the reliability of the study can be greatly increased. The true significance of a panel review in evaluating preventable deaths is not the statistics that will be available for publishing, but the fact that those within a trauma system are making a concerted, systematic effort to identify areas that can be improved to prevent future deaths. Regardless of the actual value of the PDR, the recognition of errors or the contribution of lack of resources to preventable deaths is a major step for a trauma system to take responsibility for ensuring its own quality.

AIM OF STUDY

To identify areas for quality improvement in regards to preventable trauma deaths at GSHTC.

OBJECTIVES OF STUDY

1. To use a panel review to analyze trauma deaths presenting to GSHTC with respect to preventability and any factors that contributed to the poor outcome.

2. To analyze the reliability of the panel review in determining whether deaths are preventable by correlating the results with the Trauma Score-Injury Severity Score (TRISS)

METHODS

A prospective audit will be performed on patients that are admitted to Groote Schuur Hospital's trauma system and subsequently expire during their initial hospital stay over a seven-month period.

Patients will be identified upon expiration and a GSHTC Mortality Data form (See Appendix) will be filled out including the basic demographics, time and date of death, and mechanism of trauma.

Once a month, a panel discussion amongst the Trauma Mortality Review Team will be held to review all traumatic mortalities. The Trauma Mortality Review Team will include trauma surgeons, the forensic pathologists, registrars and members of the research team with experience in trauma research. The panel members responsible for the preventability assignment will be restricted to four trauma surgeons and a researcher with experience in trauma care. The pathologists and the registrars that took care of the patients will be

available to fill in missing information that has not been documented in the patient folder. Prior to the discussion, each panel member will receive a summary of each patient's prehospital notes, hospital records, and autopsy. Each member will be asked to decide individually whether the death is NP, PP, P and to fill out the Mortality Data form. A modified panel consensus review will be used. The panel will convene, all cases will be discussed, and a vote will be held on the preventability status for each patient. For all patients, a discussion will be held regarding the nature of the death (trauma related, provider related, or systems related) and the status of the care (acceptable, acceptable with reservations, unacceptable). If the mortality is found to be P or PP, the review team will discuss and determine by consensus where the delay, error, or lack of resources contributed to the mortality.

All forms will be collected and inter-rater reliability between individual panelists and the consensus will be assessed at the end of the study using kappa statistics.

Two separate ISSs will be calculated. One based on clinical data (medical records, imaging, etc) and the other by autopsy report. Clinical and autopsy TRISS and Ps scores will be calculated for each patient, and this information will be used to evaluate the correlation between preventable deaths and probability of survival. Kappa statistics will be used for comparison. The ISS and TRISS will not be available to panel members during their decision making, but the autopsy results will be available.

A practice session will be held before the commencement of the study. All panel members will receive training regarding the definitions of the terms used on the form (Table 1). In addition, written definitions will be available at each panel discussion. At the practice session, the panel will review seven real cases and individuals will have the chance to ask questions and clarify definitions.

STUDY POPULATION

The study population will include any patient who is admitted to the GSHTC and subsequently expires during their initial hospital stay.

Inclusion criteria:

1) Patients admitted to the GSHTC who subsequently expire

Exclusion criteria:

1) Deaths caused by non-traumatic means including drowning, suffocating, inhalation, and drug overdoses
2) Patients dead on arrival and no resuscitation is performed
3) Patients that are admitted to the trauma team and care is subsequently transferred to an independent team

Table 1. Definitions of Terms for Preventability Decision

Non-preventable death (NP): when injuries are not survivable and not currently curable or reversible
Possible preventable death (PP): when injuries are severe, but currently curable or reversible under optimal circumstances
Preventable death (P): when injuries are curable or reversible under the existing facilities
Delay in transfer: transfer of patient from one care centre to GSHTC takes longer than expected transfer times
Delay in doctor response: greater than 5 minutes from arrival of patient
Delay to ICU: the patient is not admitted to the ICU in a timely manner when they require ICU care
Delay to theatre: greater than two hours for life-threatening injury from time of patient arrival
Delay in obtaining consultation: consultant has not arrived at greater than 30 minutes from arrival of patient
Delay in diagnosis: diagnosis not made in timely fashion when considered in context of patients overall condition
Error in judgment: therapeutic or diagnostic decision made contrary to available data
Error in technique: technical error occurring during the performance of a diagnostic or therapeutic procedure
Error in diagnosis: injury missed because of misinterpretation or inadequacy of physical examination or diagnostic procedures
Error in communication: information was either incorrectly given or incorrectly received

RISKS

Due to the nature of the study, there will be little to no risk of physical, psychological, social, or economic harm to the patients or patients' family and friends secondary to the study. One possible risk would be for the loss of confidentiality about the cause of a patient's death. Patients will be included in the study only after their time of death; therefore the study will not affect the treatment they receive in the hospital.

BENEFITS

This study will help to evaluate the quality of trauma care at GSHTC. It will elucidate whether there are areas where common errors contribute to mortalities. The study will benefit future patients that enter the hospital's trauma system by increasing the quality of care provided

LIMITATIONS

An attempt will be made to follow MacKenzie et al.'s (1992) recommendations[8] to increase reliability, but there are limitations that this study will face. The first limitation is that this study will not use a multidisciplinary panel to make decisions. Only trauma surgeons and a researcher with experience in trauma care will be used. This is due to the unique structure of trauma care at GSHTC. Many trauma centres incorporate emergency room physicians and anesthesiologists in the initial care of trauma patients, but at GSHTC the patients bypass the emergency room and go directly to the trauma bay. Anesthesiologists are not routinely available unless requested. Additionally, other surgical subspecialties that are often included in reviews (e.g. neurosurgeons), are only consulted after initial resuscitation and imaging have been completed. Because the trauma surgeons are the only people involved in the care of the patients, they have been the only people included in the panel review. The pathologist will be present at the meeting and will provide autopsy details, but because of a lack of clinical experience with trauma patients, will not be included in the panel decision.

Another limitation is that the panel review is done by internal reviewers who may hold bias. An internal review is necessary at GSHTC because documentation is often incomplete. The benefit of an internal review team is that it is familiar with the cases being discussed. Therefore, no attempt will be made to anonymize the cases so those that contribute to a patient's care can assist in completing missing information. This method may introduce bias, but will assist in providing comprehensive information for the panel review.

PRIVACY

All medical records will be kept locked in the trauma office. Once the panel discussion is completed regarding a particular patient, the patient will be given a unique identification code and all further materials and analyses will use that code.

RESEARCH TEAM

Principal Investigator: Professor Andrew Nicol, head of the trauma department at GSHTC, has contributed greatly to the study design. He will assist in data collection, analysis, write up and dissemination. He will be available for questions regarding the study at all times.

Co-Investigators:

Dr. Megan Frost, a visiting surgical registrar and Master's of Public Health student, has contributed to study design. She will be a member of the panel and will assist with data collection, data analysis, write up and dissemination. In addition, she will summarize patient information for distribution to other panel members to review prior to the panel. She will calculate the ISS, TRISS, and Ps for each patient. She will be responsible for storing collected data confidentially. She will be available for questions regarding the study at all times.

Professor Pradeep Navsaria, Dr. Sorin Edu, Dr. Wanda Bekker, and Dr. Anders Grotte, all trauma surgeons, will be panel members and assist with data collection and analyses.

Dr. Linda Liebenberg, a pathologist, will attend panel sessions to review autopsies with the panel.

BUDGET

No budget will be required for this study.

DISSEMINATION

During the study, information collected regarding errors, time delays, or lack of resources will be presented at surgical morbidity and mortality conferences, presented for peer review amongst surgical faculty, and presented at GSHTC management review. If areas of improvement can be identified based on these presentations and discussions, then new guidelines and protocols for the GSHTC will be devised. If new guidelines or protocols are implemented during the study, then a comparison will be made before and after the implementation. A guideline or protocol will not be withheld for the duration of the study if it is deemed needed in the interest of providing the best quality of care. After the study, this data will be submitted for publication in a peer-reviewed journal and submitted for presentation at both local and international trauma meetings.

The stakeholders in this research are any healthcare personnel working within the trauma centre (emergency services personnel, nursing staff, physicians, etc), hospital administration, the community served by GSHTC, and the South African Ministry of Health. Any parties interested in expressing their views regarding this research will be

welcome to contact Professor Andrew Nicol or Dr. Megan Frost. Healthcare workers and hospital administration will be welcome to attend morbidity and mortality meetings, peer review presentation, and GSHTC management review meetings.

CONFLICT OF INTEREST

No person involved with the study has any proprietary interest involving the research.

ETHICS

This protocol complies with the Declaration of Helsinki 2008 and The Department of Health: Ethics in Health Research: Principles Structures and Processes, 2004.

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LITERATURE REVIEW

BACKGROUND

Since 1955, when Robert Zollinger first examined the quality of care for motor vehicle crash victims, trauma systems have made a concerted effort to improve the quality of care provided in response to the alarming morbidity and mortality rates associated with injuries.[1] Over the following decades, a multitude of studies were performed to assess the quality of trauma systems by evaluating the nature of preventable deaths and the contributing errors and delays in care.[2,3] The analysis of preventable trauma mortalities has resulted in the implementation of protocols and system changes in many trauma centres around the world[4].

Early phase trauma deaths, those that occur within the first 6 hours from injury, are often considered preventable since they are due to evolving conditions where an intervention is likely to be successful.[5,6] Panel studies, one form of analyzing preventable trauma deaths, are often used to evaluate the care of those patients whose deaths occurred in the early phase. A group of healthcare providers with experience in trauma care convenes to review the mortalities and assign the death a preventability status. A death is defined as preventable if it could have been prevented assuming optimal care.[7] Additionally, the panel identifies the errors or delays that contributed to the death. Ultimately a preventable death rate (PDR), which is the proportion of deaths that are considered preventable or potentially preventable divided by the total number of deaths, can then be calculated.[9]

The reliability of panel studies is often questioned and the studies are classified as Class III evidence.[8] Frequently the agreement both within and between panels is low.[6,7,8] MacKenzie et al. (1992) reviewed over 30 preventable death studies and subsequently made recommendations, which are summarized below, to increase panel study reliability.[7] Some studies also use the TRauma Score-Injury Severity Score (TRISS) method to correlate the panel decision with a more objective measure.[6] When properly designed using the guidelines set forth by MacKenzie et al. (1992) or the TRISS method, panel studies can generate important information regarding the quality of care within a trauma system.

OBJECTIVES

1. To review the recently published literature regarding the use of panel studies which calculate a preventable death rate in trauma centres.
2. To assess methods to optimize the reliability of panel studies in evaluating preventable deaths.
    a. To evaluate whether panel studies have used recommendations made by MacKenzie et al. (1992) to increase reliability, and how the results have been affected.
3. To review the recently published literature regarding the use of the TRISS scoring system and its correlation with panel studies to increase validity in evaluating preventable deaths.

METHODS

Criteria for considering studies for this review

Panel studies evaluating preventable deaths in trauma centres and those also using the TRISS method were included in this review. Studies were excluded if they only studied the pediatric population, if the preventable death panel review was only a portion of a larger study, and if the study did not include all trauma deaths entering the system. The last criteria includes studies that are restricted to a certain type of injury, such as a gun shot wound, or a wound confined to one anatomical area, such as abdominal injuries. The review was restricted to articles published in English and after 1994. Additionally, any articles that fit the inclusion criteria that were not found in the initial search, but were referenced in articles that were found, were also included.

Literature search strategy

The published literature assessing the use of panel studies to evaluate preventable deaths in trauma centres was identified using an electronic search of MEDLINE. The keyword terms used to identify the appropriate literature were "preventable," "trauma," "mortality," "panel," "TRISS," "death," and "review."

Assessment of methodological quality

To assess the methodological quality of each study, the criteria outlined in the landmark article by MacKenzie et al. (1992) were used.[7] To increase the reliability of panel studies, the article asserts that each study must address the following guidelines. The method used

by the panel to make a decision regarding preventability must be clearly delineated. There are a range of methods providing varying estimates of the PDR. A unanimous decision rule, in which each panel member makes an independent decision and an assignment of preventability is made only when there is unanimous agreement amongst panel members, provides an estimate of the lower bound of the true PDR. A panel consensus approach, in which there is a discussion among panel members if at least one person judges the death preventable, provides an estimate of the upper bound of the PDR.[7,9] In an independent review the panel members each make a private decision and then the final judgment is made by majority opinion. A modified independent review includes a discussion of all cases where there is no majority opinion decision.[7,9] None of the methods are considered to be the best, but an explanation of why the method is chosen in correlation with the objectives and circumstances of the study is prudent.[7]

Next, reliability is increased when the panel is composed of a multidisciplinary team. The range of clinical expertise that multiple disciplines provide is key to evaluating all aspects of the patient's care. Disciplines that are often included are trauma surgeons, general surgeons, neurosurgeons, orthopedic surgeons, nursing staff, emergency room physicians, anesthesiologists, and pre-hospital care providers. This multidisciplinary approach is most useful when panel members have the opportunity to discuss cases in which there is disagreement.[7]

The most comprehensive review of each case must be made available to the panel for a decision to be made. This includes pre-hospital reports, hospital data, and autopsy

reports. Moreover, the completeness of this information is important and if incomplete, the impact on the preventability judgment must be noted.[7]

The use of a three point classification system (non-preventable (NP), potentially preventable (PP), and preventable(P)) provides more reliability than a two point classification system (NP and P).[7] Additionally, explicit guidelines for making preventability judgments must be followed and the use of those outlined by Shackford et al. (1987) is recommended (Table 1).[6,7,10]

Table 1. Guidelines for Judgment Concerning Mortality[10]

Non-Preventable	1. Anatomic injury or combination of injuries considered to be nonsurvivable with optimum care 2. Physiologic state at time of arrival of first responder important but not critical to judgment of nonpreventability 3. Evaluation and management appropriate to ACLS* and ATLS** guidelines; if care is suspect it is handled as a morbidity and does not effect judgment regarding death
Preventable	1. Anatomic injury or combination of injuries considered to be very severe but survivable under optimal conditions 2. Physiologic state at time of arrival of first responder critical to judgment of potential survivability; patient generally considered to be unstable; responds minimally to treatment 3. Evaluation and management generally appropriate to ACLS* and ATLS** guidelines; any suspect care directly or indirectly implicated in patient demise
Frankly preventable	1. Anatomic injury or combination of injuries considered survivable 2. Physiologic state at time of arrival of first responder critical to judgment of preventability; patient generally stable; if unstable, patient becomes stable with treatment 3. Evaluation and management suspect in any way

*Advanced cardiac life support; **Advanced trauma life support

In addition to MacKenzie et al.'s (1992) recommendations for reliability, this review also included whether the panels were external or internal, whether the study had a second panel to review the cases and then assessed inter-rater reliability between the panels, and whether the TRauma Score-Injury Severity Score (TRISS) was used to evaluate the

correlation between probability of survival (Ps) and the panel's preventability decision. The TRISS method calculates the Ps for a trauma patient using the Injury Severity Score (ISS) and the Revised Trauma Score (RTS). The location and severity of injuries are used to determine the ISS, and the RTS is based on the following physiological parameters: blood pressure, respiratory rate, and Glascow Coma Score. Also taken into account is the age and the mechanism of trauma.[6,11] A Ps value greater than 0.5 is considered a P death, a Ps value of 0.25 to 0.5 PP, and a Ps value of less than 0.25 is NP.[6,12] The TRISS can then be compared to the panel assignments.

RESULTS

Decision Rule

Twelve studies were identified that fit the inclusion criteria (Table 2). The studies were extremely varied in regards to their methods in assigning preventability. The decision rules outlined by MacKenzie et al. (1992) are rarely used in their purest forms.[7] None of the studies used a unanimous consensus or an independent review. Zafarghandi et al. (2003) reports that they use a modified independent review,[13] but it was not a true modified independent review by MacKenzie et al.'s (1992) definition.[7,9] A discussion

Table 2. Comparison of Panel Study Methodology

Author	Year of Publication	Place of Study	# of deaths	Panel Size	Panel Compostion	# of Categories	IR	TRISS	Information Available	Decision Rule	Outcome	PDR (%)
Saltzherr et al.	2010	Amsterdam, Netherlands	62	4	Trauma, ICU, Anes,	3	Y	N	Pre, Hosp, Aut,	Panel Consensus	1P, 17PP, 44NP	44
Sanddal et al.	2010	Utah, USA	434	9	Trauma, ER, RN, PreCP,	3	Y	N	NS	Discussion Consensus	3P, 26PP, 405NP	7
Sugrue et al.	2008	Sydney, Australia	307	7	Trauma, ER, ICU, NSG, RN,	4	N	N	Pre, Hosp	NS	69P, 238NP	22
Teixeira et al.	2007	Los Angeles, USA	2081	NS	Trauma, Path, ER, NSG, RN,	3	N	N	Pre, Hosp, Aut,	Discussion Consensus	11P, 40PP, 2030NP	2.5
Ali Jat et al.	2004	Karachi, Pakistan	17	7	GS, NSG, Ortho, Anes, ER, Res	3	N	Y	Pre, Hosp,	Discussion Consensus	6P, 7PP, 4NP	76
Shanti et al.	2003	Detroit, USA	281	NS	Trauma, NSG, Ortho, Path,	3	N	Y	NS	NS	NS	NS
Stewart et al.	2003	San Antonio, USA	753	NS	Trauma	3	N	Y	Pre, Hosp, Aut,	NS	20P, 32PP, 701NP	7
Zafarghandi et al.	2003	Tehran, Iran	69	5	Trauma, NSG, ICU, Path,	2	N	N	Pre, Hosp, Aut,	Modified Independent Review	18P, 3PP, 48NP	30

Chiara et al.	2002	Milan, Italy	203	3,2*	Anes, Epi, NSG, Trauma, ICU	3	Y	Y	Pre, Hosp, Aut,	Panel Consensus	23P, 64PP, 116NP	43
Fallon et al.	1997	Cleveland, USA	104	NS	NS	3	N	Y	Pre, Hosp, Aut,	Trauma Director final decision	NS	NS
Maio et al.	1996	Michigan, USA	155	9	Trauma, ICU, ER, Path, RN, PreCP	3	Y	N	Pre, Hosp, Aut,	Discussion Consensus	4P, 16PP, 135NP	13
Esposito et al.	1995	Montana, USA	324	8,12*	GS, ER, Anes, Path, RN, PreCP	3	Y	Y	Pre, Hosp, Aut,	Discussion Consensus	5P, 36PP, 283NP	13

Abbreviations: IR = interrater reliability, PDR = preventable death rate, ICU = Intensivist, Anes = Anesthesiologist, ER = emergency room physician, RN = nurse, PreCP = prehospital care provider, NSG = neurosurgeon, Ortho = orthopedic surgeon, Path = Pathologist; GS = general surgeon, Epi = epidemiologist, Res = Research, Pre = preshospital notes, Hosp = hospital notes, Aut = Autopsy notes, P = preventable, PP = potentially preventable, NP = nonpreventable, NS = not specified;
*Two separate panels convened

was held of all cases and then panel members made their decisions on a two point scale of P versus NP. If four panelists voted for P, the case was assigned a P status. If only three voted for P, the case was assigned a PP status, and if two or less voted for P, the case was assigned a NP status.[13] This method is more of a modified panel consensus review and probably estimates a PDR close to the upper bounds of the true PDR.

Saltzherr et al. (2010) is the only study to use a true panel consensus technique.[14] The study done by Chiara et al. (2002) used two separate panels, each arriving at a decision using the panel consensus technique. The results from the two panels were sent to the coordinator of the study, and if both panels agreed, their consensus designated the preventability status. If the panels disagreed, the case was allocated to the less preventable category.[15] As stated above, a panel consensus will give the upper bound of the PDR. The technique used by Chiara et al. (2002) would estimate a PDR lower than the upper bound, but increases the reliability of the those cases determined to be "preventable" by requiring agreement amongst the two separate panels.

Five of the studies used a basic discussion technique where all cases were discussed and then a consensus decision was made.[4,16,17,18,19] This technique is comparable to the panel consensus technique by estimating the upper bounds of the PDR. There was great variability even amongst these techniques. One study discussed all cases at the monthly departmental Morbidity and Mortality (M&M) conference, where the preventability status was assigned. A separate internal committee reviewed the cases and the decision derived from the M&M meeting, and made the final preventability ruling.[4] Another study

used a discussion technique to review all cases and to come to a consensus on the preventability status, but then the trauma director made the final judgment.[20] It is difficult to assess where this study would lie in the bounds of the true PDR since it is not clear how often the trauma director overruled the consensus made at the multidisciplinary meeting.

Multidisciplinary team

With the exception of one study that did not specify their panel composition, but did mention that it was multidisciplinary,[20] and one study that only included trauma surgeons,[21] all of the studies used a multidisciplinary panel. In keeping with MacKenzie et al.'s (1992) recommendations,[7] all of the multidisciplinary panels had the opportunity to discuss contentious, if not all, cases. The range of disciplines included was wide, but there was much overlap between the studies. Disciplines included in the panels were various types of health care providers that have direct contact with trauma patients, pathologists, epidemiologists, and researchers. These multidisciplinary panels enhance the reliability of the panel judgments by providing more comprehensive clinical expertise.

Number of preventability categories

Ten of the 12 studies used a three-point classification system for assigning preventability status as recommended by MacKenzie et al. (1992).[4,7,14,15,16,17,18,19,20,21,22] Although Sugrue et al. (2008) reported their results using a two-point classification technique (NP and P), their panel members were asked to classify each death into one of four groups:

non-preventable, potentially preventable, probably preventable, and definitely preventable.[23] The reasoning for this distinction and the definitions of the terms are not explained, and there is no breakdown provided of the final assignments. The three latter categories have been grouped into one "preventable" category. The reliability with the reported two point classification was probably not severely jeopardized, but the similarity of the three latter terms may have been confusing to panel members and may have decreased the reliability amongst those categories.

Zafarghandi et al. (2003) also did not use a three-point classification system.[13] The panel members were asked to judge a case as P or NP, and then based on the number of preventable votes each case received, the final decision was stratified in a three-point system. A two-point system for the panel members' independent decisions reduces reliability even if the final results are reported using a three point system.

Information Available

Eight of the 12 studies included pre-hospital reports, in-hospital notes, and autopsy data as recommended by MacKenzie et al. (1992).[4,7,13,14,15,17,19,20,21] Two hospitals did not include autopsy data[18,23] and two hospitals did not specify what information was available.[16,22] Those studies without autopsy reports have less reliable results due to the lack of important contributing information for the panel's decision.

The completeness of the information provided is extremely important for a panel to make an informed decision. Zafarghandi et al. (2003) specifically states that cases were only included if both prehospital and autopsy reports were complete,[13] and Stewart et al. (2003) reports that 91% of cases had autopsies completed.[21] Otherwise, the rest of the studies did not mention the completeness of the reports the panel members reviewed. The completeness of the reports in the aforementioned studies makes their results more reliable, but it is difficult to draw any conclusions about the other studies and the impact that available information had on reliability.

External versus Internal panels

Five of the studies explicitly mentioned that their reviewers were external reviewers,[13,14,16,17,19] and one study noted that their reviewers were not involved in the study cases' care, but did not specify if they were external to the institution.[15] Three studies had internal reviewers that were not blinded to the cases[4,20,21] and three studies did not specify whether their reviewers were internal or external.[18,22,23]

The advantage of external versus internal reviewers is not clear. External reviewers should be less likely to hold a bias, but their decisions are also dependent on only the information documented in the patient's chart. The decision for creating an external panel should rely on the institution's data completeness. If the documented data are incomplete, then an internal panel with the possibility of bias is necessary. The direction of the bias of an internal panel can be difficult to predict. Healthcare providers may be defensive and

want to protect themselves and their institution by judging more mortalities NP. But some may be overly critical of themselves finding more cases P. A multidisciplinary panel may aid in decreasing this bias.

Inter-rater reliability

Five studies assessed inter-rater reliability. The methods of assessment were varied. Three studies used a second panel to either evaluate all or a random portion of cases and then used kappa statistics to calculate inter-rater reliability.[15,17,19] In Saltzherr et al. (2010), all cases were discussed first at an internal M&M conference and were then reviewed by an external panel.[14] The internal and external panels were compared using kappa statistics. Sanddal et al. (2010) interspersed 12 test cases previously judged by another panel and the test cases were used to assess inter-rater reliability.[16] Only the percent agreement was reported.

The four studies that used kappa statistics to assess reliability reported a varying degree of results. The kappa statistics for Saltzherr et al. (2010) and Esposito et al. (1995) were 0.51, demonstrating moderate agreement,[14] and 0.4, demonstrating fair agreement[17] respectively. Maio et al. (1996) and Chiara et al. (2002) both had kappa statistics greater than 0.86 illustrating very good agreement,[15,19] and Sanddal et al. (2010) reported 67% agreement between the test case panel and study panel judgments.[16]

It is difficult to draw conclusions explaining the range of kappa statistics reported in the four studies. The studies were conducted relatively similarly. They all followed

MacKenzie et al.'s (1992) recommendations[7] for increasing reliability and they all used external reviewers, except for Chiara et al. (2002) which did report that their reviewers were not involved in any of the patients' care.[15] Saltzherr et al. (2010) was unique in that their reliability was measured between an internal M&M conference and an external panel which may explain the low kappa value.[14] Sanddal et al.'s (2010) report of agreement between the test case panel and study panel did not add much value to their study.[16] The study assessed over 400 deaths, but only 12 test cases. A higher number of test cases and reporting the kappa value would have been beneficial.

TRISS

There were six studies that calculated the TRISS, and they reported their results in varying ways.[15,17,18,20,21,22] Ideally, the trauma population in which mortalities were observed would be compared to baseline data from the Major Trauma Outcome Study (MTOS).[24] A z score can be calculated quantifying the difference between observed deaths and expected deaths. Then an M score can be calculated estimating the injury severity match between the study group and the MTOS baseline group.[11] Finally, the Ps derived from the TRISS score is compared to the panel study assignments using kappa statistics. Fallon et al. (1997) is the only study that completely reported the TRISS results in this manner.[20] They reported a z score of -0.6779 indicating there were fewer observed deaths than predicted, and an M score of 0.96 establishing their study group was very similar to the baseline group in injury severity. The kappa statistics for their NP, PP, and P groups were 0.213, -0.197, and 0.074 respectively. These kappa statistics signify that

the conclusions from the panel and the Ps from the TRISS method had very poor agreement.

Shanti et al. (2003) calculated a z score of 0.79 demonstrating more deaths were observed than predicted, an M score of 0.89 meaning the groups were matched in injury severity, but no kappa statistics were calculated.[22] It was noted that there were 10 more deaths than predicted, but the panel found 45 deaths to be preventable.

Chiara et al. (2002) only mentioned that the value of the Ps was significantly lower for the non-preventable group than the two preventable groups.[15] Ali Jat et al. (2004) showed that 13 of the 17 deaths had a Ps of greater than 0.5 and that 13 of the 17 deaths were voted preventable. There was no indication of the overlap between those groups.[18] Stewart et al. (2003) and Esposito et al. (1995) did not report their Ps values or conclusions drawn from the TRISS calculations.[17,21]

Fallon et al.'s (1997) data from the TRISS method were useful in identifying that the panel's preventability assignments did not agree with the TRISS method's Ps.[20] Chiara et al.'s (2002) conclusion seemed to indicate that there was some agreement between the panel decisions and the TRISS method,[15] but the other studies lent no valuable conclusions.

The TRISS method has the potential for a significant contribution to panel studies because it adds objective information to an otherwise subjective study. However, the

TRISS method also has limitations, mainly being the availability of sufficient data to calculate the Ps and the fact that the MTOS data are criticized for being outdated and the derived norms are based on trauma populations from centres that voluntarily participated in the study.[6,8,20,22] Most importantly, if the Ps is calculated, it must be interpreted compared to the panel decisions for any conclusion to be made.

Preventable death rate

In the ten studies that reported a PDR, it ranged from 2.5% to 76%. The average PDR for those ten studies is 26%. Interestingly, the five studies with the highest rates were all done outside of the United States (US), and the five studies with the lowest rates were all completed within the US. Whether this is due to a highly effective trauma system in the US or due to methodological differences is difficult to discern. Only two studies were completed in developing countries where one would expect the PDR to be higher due to a lack of a structured trauma system. The PDR in those studies was 76% and 30%.[13,18]

It is difficult to draw broad conclusions from the range of PDRs reported in these studies, but the variation is likely due to the vastly different study settings and methodological techniques which led to varying degrees of reliability as discussed above.

CONCLUSION

The most notable trait of this literature review is the variability in all aspects of the studies. The varied approaches to the decision rule, the disciplines included in the panel review, and the assessment of reliability and validity using inter-rater reliability or the TRISS method, caused markedly different studies and an inability to draw strong

conclusions from the overall review. Additionally, the subjective nature of panel studies provides only Class III evidence.[8] This does not necessarily mean that these studies do not provide important information.

The key to a strong panel study is to adhere as faithfully as possible to the guidelines set forth by MacKenzie et al. (1992)[7] and to be explicit in the reasons that certain methods are chosen. There are environments where it is not feasible to follow the recommendations perfectly, but a thorough explanation of the limitations and attempts to overcome those limitations make it possible for others to replicate the study in the future. By following MacKenzie et al's reliability guidelines,[7] a more standardized type of panel study with more comparable results can be created.

There is great potential for panel studies to evaluate the effectiveness of an entire trauma system. Thus far, most published literature has been confined to using hospital survival and mortality as the only measure of trauma system effectiveness.[8] Including pre-hospital deaths and deaths after discharge for a certain period of time would add valuable information regarding the true effectiveness of the system. Evaluating the preventability of morbidities secondary to trauma such as physical and mental disabilities in addition to mortality would provide a more comprehensive understanding of a trauma system's shortcomings.[8]

Panel studies are an effective tool for outlining deficiencies that must be addressed and can be used to educate providers, assess the implementation of protocols designed to

enhance quality, and compare similar trauma systems. More importantly, the fact that individuals within a trauma system are purposely evaluating the quality of care provided at their institution means they are applying a compelling approach to system evaluation and quality improvement.

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ARTICLE

Preventable Deaths Presenting to a Level 1 Trauma Centre in South Africa: A Panel Study

Short Title: Preventable Trauma Deaths in South Africa

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Subject: **SUBMISSION OF A MANUSCRIPT FOR EVALUATION TO THE *JOURNAL OF TRAUMA***

Dear Editor

I am enclosing herewith a manuscript entitled "Preventable Deaths Presenting to a Level 1 Trauma Centre in South Africa" for publication in the "Journal of Trauma" for possible evaluation.

With this submission, I would like to undertake that the above mentioned manuscript has not been published elsewhere, accepted for publication elsewhere or under editorial review for publication elsewhere; and that the University of Cape Town representative is fully aware of this submission.

The submitted manuscript is a clinical article.

For the Editors, I would like to disclose the following information about the project:

The research project was conducted under the supervision of:
Associate Professor Landon Myer, BA, MA MBChB, MPhil, PhD, School of Public Health & Family Medicine, UCT

The research project was for my Master's of Public Health mini-dissertation.
This research project was conducted from June 1, 2010, to December 31, 2010.

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Sincerely,

Megan Frost, MD

ABSTRACT

Background: The burden of injury in South Africa is extremely high with the highest injury mortality in Cape Town. The objective of this study undertaken at Groote Schuur Hospital Trauma Centre (GSHTC) in Cape Town was to use a panel to analyze traumatic mortalities with respect to preventability and any factors contributing to poor outcome.

Methods: A prospective audit was performed of all trauma patients admitted to GSH's trauma system which subsequently died. Each case was reviewed by a panel which assigned a preventability status, and a probability of survival (Ps) score was calculated using the TRauma Score-Injury Severity Score (TRISS) method. The agreement between the panel method and TRISS method was assessed using kappa statistics.

Results: The panel method found 84 (76%) cases to be non-preventable, 19 (17%) potentially preventable, and 8 (7%) preventable. The preventable death rate (PDR) was 24%. The TRISS method found 17 (17%) cases to be non-preventable, 10 (10%) potentially preventable, and 72 (73%) preventable. The PDR using the TRISS method was 83%. Kappa statistics showed very poor agreement between the panel and TRISS method.

Conclusion: These data show a major discrepancy between PDRs based on panel versus TRISS methods. The difference may be explained by methodological issues and the unique characteristics of the trauma population and GSHTC. More importantly, GSHTC identified areas for quality improvement to decrease the true PDR within their system.

Key Words: preventable mortality, panel review, TRISS,

INTRODUCTION

The inherent nature of trauma makes it susceptible to error. Decisions must be made quickly for patients that are frequently unstable and whose medical histories are usually unknown. Multiple disciplines are involved and junior personnel have often been working long hours.[1] These factors combined with a heavy burden of traumatic injuries make the probability of errors or delays in care extremely high. This creates an increased need for quality monitoring within trauma systems.

Trauma surgeons were pioneers in quality improvement.[1,2,3] The idea of "preventable" trauma deaths was first introduced by Robert Zollinger in 1955, and since that time trauma centres around the world have used preventable mortalities as a proxy for assessing the quality of care.[2,4] Worldwide, research evaluating preventable deaths has resulted in the creation of regionalized trauma systems and the implementation of protocols that make trauma systems more efficient and less prone to error.[1,2]

Two approaches that are often used to evaluate preventable deaths are panel studies and the TRauma Score-Injury Severity Score (TRISS) method. Panel studies consist of a group of professionals that review trauma mortalities and decide whether a death is preventable using the following three criteria set forth by MacKenzie et al. (1999): "the injury or sequelae of the injury must be survivable; the care delivered must be judged suboptimal; and identified errors in the delivery of care must be directly or indirectly implicated in the demise of the patient."[5] A preventable death rate (PDR), which is the

proportion of deaths that are considered preventable or potentially preventable divided by the total number of deaths, can then be calculated,[5] and an analysis of the error or delay that contributed is undertaken.

The TRISS method employs more objective measures using a patient's vital signs and injury severity to calculate a probability of survival (Ps) score for each case.[6] The Ps is then stratified into preventable (P), potentially preventable (PP), and non-preventable (NP) deaths,[3] and a PDR can be calculated.

Although there have been many preventable death studies utilizing panels and the TRISS method done throughout the world, few have been completed in low and middle income countries such as South Africa. Yet traumatic injuries have become one of the leading health threats to South Africans. In the country, 3.5 million people require care at a hospital for non-fatal injuries every year.[7] Additionally, in 2000 the death rate due to injury was 157.8 per 100,000 which is nearly twice the global average of 86.9 per 100,000.[8,9] Injury mortality represents 11.5 to 13.4% of South African deaths every year with violence accounting for 36% of these deaths and motor vehicle crashes (MVC) for 32%.[10] Such high rates of injuries are a tremendous burden on a trauma system, and efficiency and quality within the system are of the utmost importance to aid in decreasing the rate of mortality secondary to trauma.

Groote Schuur Hospital Trauma Centre (GSHTC) in Cape Town currently admits approximately 1000 trauma patients per month, of which approximately 15 to 25 expire.

The objective of this study undertaken at GSHTC was to use a panel review to analyze traumatic mortalities with respect to preventability and any factors contributing to poor outcome within the GSHTC. The TRISS method was used to assess the reliability of the panel's decisions.

MATERIALS AND METHODS

Patients

An audit was performed of all deaths from blunt and penetrating trauma that were admitted to GSH trauma centre from June 1, 2010 to December 31, 2010. GSHTC deals with patients that are 12 years or older. Younger patients are sent to a Pediatric Trauma Centre. Major burns are sent to a dedicated Burns Centre and near-drownings are managed in a separate Emergency Department. Patients were excluded if care was completely transferred to another independent team after arrival. Lastly, if a patient arrived with no vital signs and resuscitation or treatment was commenced, they were included in the study, but otherwise patients arriving without vital signs were excluded.

Panel Review

The selected cases were reviewed by a panel made up of five members. Four members were trauma surgeons at GSHTC and the fifth was a researcher with experience in trauma care. Pathologists were present at every meeting to report autopsy findings and cause of death, but did not vote in the final panel decision. Additionally, registrars that assisted in patient care attended the meetings to provide missing information and participate in the

discussion, but also did not vote in the final panel decision. For the review, all patient data were summarized for the reviewers and distributed prior to each panel meeting. This included pre-hospital reports, in-hospital notes, and autopsy findings. In cases when documentation was incomplete, when possible, those taking care of the patients were available to contribute any missing information. In addition, copies of the patient folders were available during the panel meetings if needed for clarification purposes.

The panel met monthly to review cases and every case was discussed. The vote was not anonymous. Each reviewer's independent vote was recorded, and the consensus decision was made based on the majority of the votes after discussion. Before the study commenced, a practice session including seven real cases was reviewed by the panel. This was an orientation and training session where the definitions of all terms to be used in the panel judgments were introduced. The session also gave panel members a chance to ask questions and clarify definitions.

The panel decided whether each death was P, PP, or NP using the criteria set forth by Shackford et al. (1987) (Table 1).[11] A PDR was then calculated for the cohort using the number of P and PP cases divided by the total number of deaths. For each case that the consensus agreed was P or PP, the panel decided what error or delay contributed to the death (Table 2), whether it occurred in the pre-hospital setting, the referring facility, or at GSHTC, and whether the error or delay was provider related or system related. For all deaths, the panel decided whether the care was acceptable, acceptable with reservations, or unacceptable.

Table 1. Guideline for Judgments Concerning Preventability[11]

Non-Preventable	1. Anatomic injury or combination of injuries considered to be nonsurvivable with optimum care 2. Physiologic state at time of arrival of first responder important but not critical to judgment of nonpreventability 3. Evaluation and management appropriate to ACLS* and ATLS** guidelines; if care is suspect it is handled as a morbidity and does not affect judgment regarding death 4. Ps < 0.25
Potentially Preventable	1. Anatomic injury or combination of injuries considered to be very severe but survivable under optimal conditions 2. Physiologic state at time of arrival of first responder critical to judgment of potential survivability; patient generally considered to be unstable; responds minimally to treatment 3. Evaluation and management generally appropriate to ACLS* and ATLS** guidelines; any suspect care directly or indirectly implicated in patient demise 4. 0.50 > Ps > 0.25
Preventable	1. Anatomic injury or combination of injuries considered survivable 2. Physiologic state at time of arrival of first responder critical to judgment of preventability; patient generally stable; if unstable, patient becomes stable with treatment 3. Evaluation and management suspect in any way 4. Ps > 0.50

*Advanced cardiac life support; **Advanced trauma life support

Probability of survival calculation

Data were collected to calculate the Injury Severity Score (ISS) and the Revised Trauma Score (RTS). Then using these scores, clinical notes, and imaging findings, the clinical probability of survival (CPs) was calculated for each patient using the MediBank trauma registry software (MediBank Version 5.2, Cleveland, GP, SA. Netcare Linksfield) which uses the method put forth by Boyd et al. (1987).[6] Autopsy findings were reviewed when available and a separate autopsy probability of survival score (APs) was also calculated for each case. Each probability of survival (Ps) calculation was stratified into P (Ps > 0.50), PP (Ps=0.25-0.50), and NP (Ps<0.25) as described by Shackford et al. (1986).[12] When data to calculate the RTS were missing, it was assumed to be within normal range for respiratory rate and blood pressure. The GCS was assumed to be 15, but if the patient

required intubation then the GCS was assumed to be eight. These assumptions were made in this manner to create the highest Ps for the patient, erring on the side of labeling more deaths P and PP.

Table 2. Definitions for delays and errors used in panel decisions

Delay in transfer: transfer of patient from one care centre to GSHTC takes longer than expected transfer times
Delay in doctor response: greater than 5 minutes from arrival of patient
Delay to ICU: the patient is not admitted to the ICU in a timely manner when they require ICU care
Delay to theatre: greater than two hours for life-threatening injury from time of patient arrival
Delay in obtaining consultation: consultant has not arrived at greater than 30 minutes from arrival of patient
Delay in diagnosis: diagnosis not made in timely fashion when considered in context of patients overall condition
Error in judgment: therapeutic or diagnostic decision made contrary to available data
Error in technique: technical error occurring during the performance of a diagnostic or therapeutic procedure
Error in diagnosis: injury missed because of misinterpretation or inadequacy of physical examination or diagnostic procedures
Error in communication: information was either incorrectly given or incorrectly received

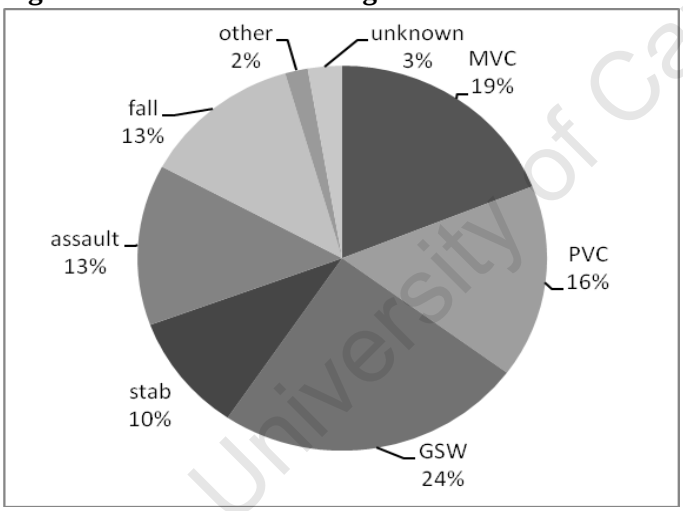
Statistical Analysis

Exploratory analyses were performed on all demographic data. Continuous variables were described using either the mean or median, and categorical variables with percentages. Kappa statistics were performed to compare each independent reviewer's decisions to the group consensus. Kappa statistics were also used to compare both the CPs and the APs to the consensus decision on preventability made by the panel. A separate kappa analysis was made for just the patients that had complete data regarding the RTS. Younger age, central nervous system (CNS) deaths, and earlier death have been reported to have an increased reliability in panel studies[13] and separate kappa analyses for these variables comparing the panel decisions and the TRISS were performed. Chi square analyses and the Fisher's exact test were used to test associations between the demographic data and the preventability decisions. Analyses were conducted on Stata 11 (College Station, TX, USA; StataCorp LP).

RESULTS

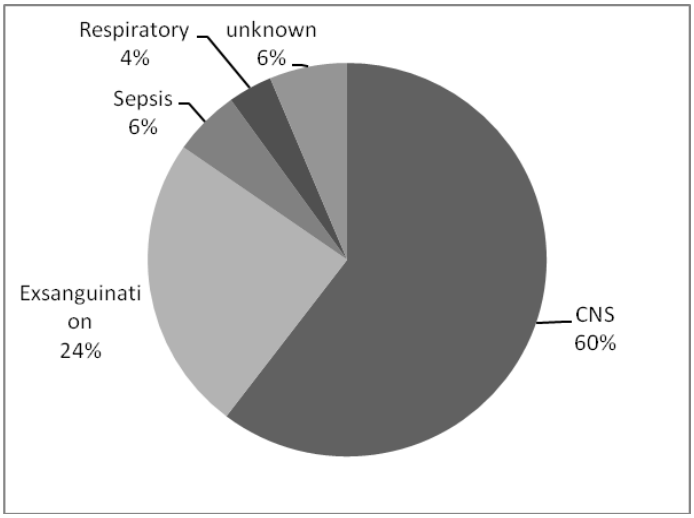
During the seven month study period, 126 trauma deaths occurred at GSHTC. Fifteen (12%) patients were excluded. Eleven patients (9%) did not have enough information for the panel to make a decision, and on autopsy four (3%) patients were found to have died from natural causes. Ninety-six (86%) of the patients were male with a median age of 27.5 (Inter-quartile range (IQR) = 23 to 35.5) years old, and 15 (14%) were female with a median age of 51 (IQR = 27 to 72). Twenty-three (20%) patients were younger than 25 years old, 75 (68%) were age 25 to 55, and 13 (12%) were older than 55.

Figure 1. Mechanism Leading to Death



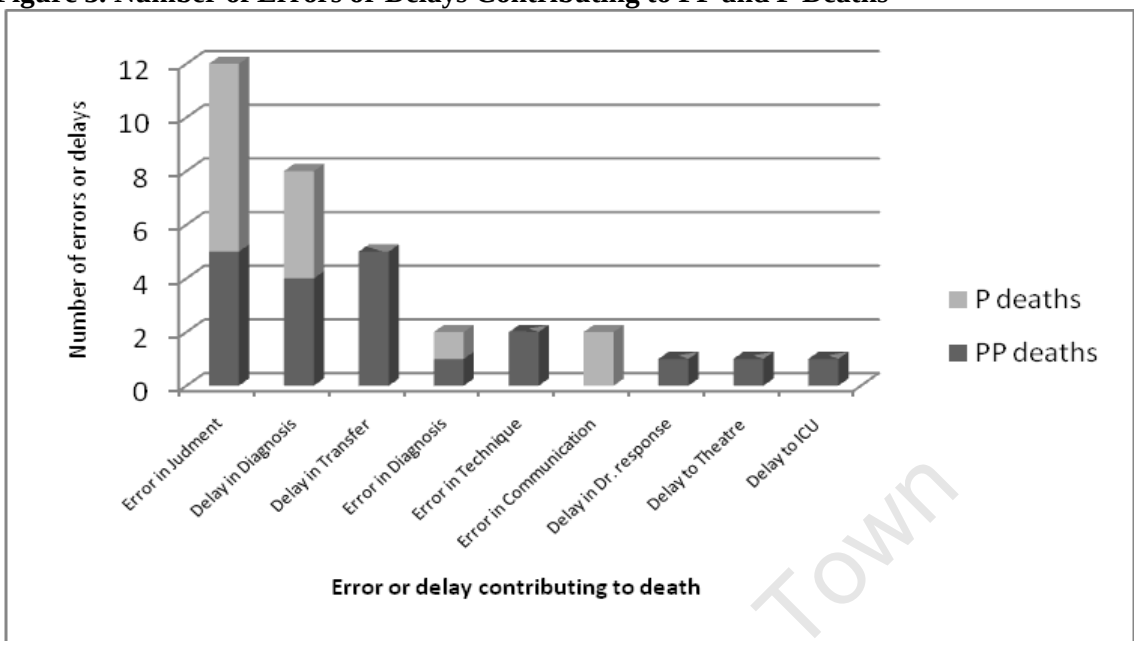
Seventy-three (66%) of the mortalities were due to blunt trauma, while the other 38 (34%) were due to penetrating trauma. Fifty-seven (51%) were unintentional injuries with the most common mechanism of death being due to an MVC (68%) (Figure 1). Almost half (46%) of the MVCs were pedestrians that were hit by motor vehicles (PVC). Fifty-one (49%) of the overall mortalities were intentional injuries comprised of gun shot wounds (GSW) (45%), assaults (18%) and stabbings (10%). The cause of death was taken from the pathologist's final report and the most common cause was from CNS trauma (60%) followed by exsanguination (24%) (Figure 2).

Figure 2. Cause of Death



The panel judged 84 (76%) cases to be NP, 19 (17%) PP, and 8 (7%) P. A PDR of 24% was calculated for the group. Of the PP deaths, the panel found 12 (63%) to be provider related and 7 (27%) system related. Of the P deaths, all 8 were provider related. Additionally, the panel found 34 errors or delays contributing to PP or P deaths. The most common being an error in judgment (35%), delay in diagnosis (24%), and delay in transfer (15%) (Figure 3). Of the deaths judged P or PP, 17 (63%) of the errors occurred at GSHTC and 10 (37%) at the referring facility. Lastly, the panel found that in 17 (15%) cases, the care was acceptable with reservations and in 14 (13%) cases the care was unacceptable. Kappa statistics showed there was very good agreement between each panel member and the consensus decision on preventability assignment (kappa = 0.82 to 1.0), on the error or delay that occurred (kappa = 0.91 to 1.0), and on the acceptability of care (kappa = 0.84 to 1.0). When the preventability categories were stratified into NP, PP, and P, and then analyzed using kappa statistics, there was always good or very good agreement between the individual panel members and the consensus decision (NP kappa = 0.83 to 1.0, PP kappa = 0.76 to 1.0, P kappa = 0.93 to 1.0).

Figure 3. Number of Errors or Delays Contributing to PP and P Deaths



Ninety-nine (89%) of the cases had autopsy information available for review. The median values for the clinical ISS and autopsy ISS were 25 (IQR = 16 to 26) and 26 (25 to 33) respectively. The median CPs and APs were 89% (IQR = 62 to 97) and 76% (42 to 95) respectively. Based on autopsy data which was more complete, the TRISS method classified 17 deaths as NP, 10 deaths as PP, and 72 deaths as P (Figure 4). A PDR of 83% was calculated for the group using the TRISS method. Kappa statistics showed very poor agreement between the CPs and APs and the panel's preventability assignments even when calculated just for patients with complete RTS data (Table 3). There was complete data on 41 (37%) cases. Kappa statistics were also calculated for the individual categories of NP, PP, and P compared to the CPs and APs, and consistently showed very poor agreement (kappa = -0.05 to 0.08).

Figure 4. Preventability Judgment by Panel and TRISS Method

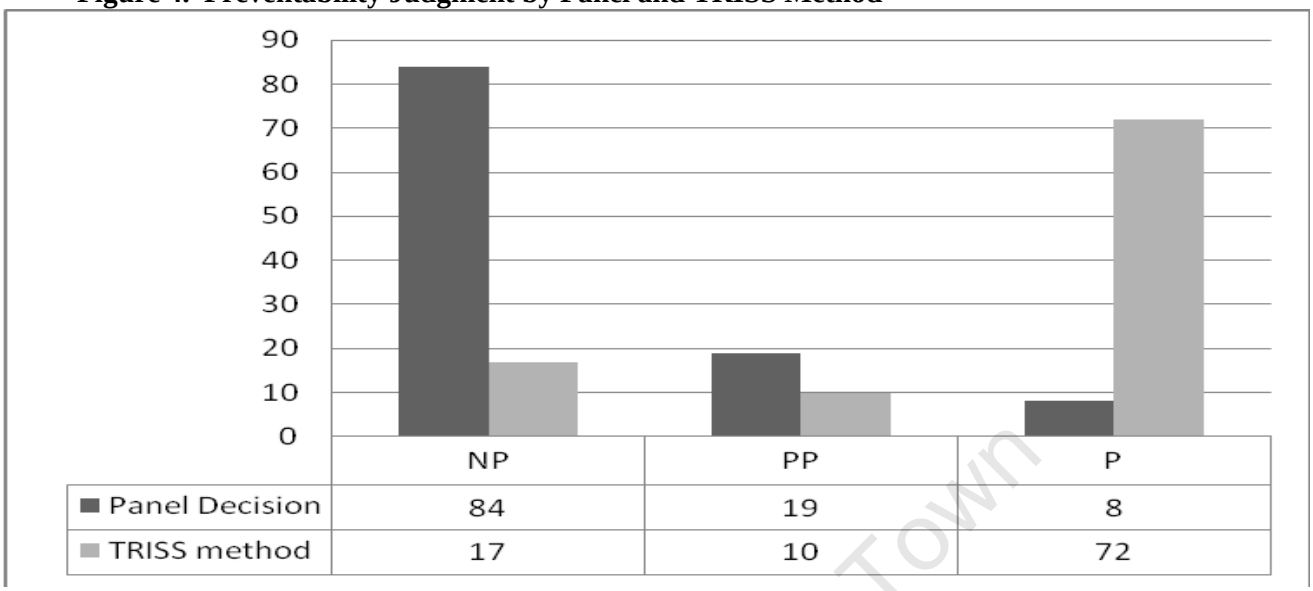


Table 3. Kappa Scores Comparing CPs and APs with Preventability Assignment

	Kappa
CPs for full cohort	-0.0215
CPs for partial cohort, complete data	-0.0263
APs for full cohort	-0.0268
APs for partial cohort, complete table	-0.0934

MacKenzie et al. (1992) reports that there is greater reliability in patients whose length of stay is less than 24 hours, in those with a CNS cause of death, and in patients younger than 55 (Table 4).[13] Eighty-three (75%) of the patients were in the hospital less than 24 hours. The rest of the patients' hospital stays ranged from two to 34 days. The cases whose hospital stays were less than 24 hours were 1.3 times more likely to be judged as NP ($p = 0.03$). Additionally, deaths caused by a CNS injury were 1.3 times more likely to be judged as NP ($p = 0.02$). There was no association between preventability assignments and age, gender, or whether the injury was blunt or penetrating ($p = 0.51, 0.68, 0.41$ respectively). Kappa statistics comparing the CPs and APs to the panel's decision in these stratified groups also showed very poor agreement (CPs kappa = -0.0175 to -0.0213; APs kappa = -0.0216 to -0.0295)

Table 4. Factors Potentially Affecting Reliability of Preventable Death Judgment

	Age				Length of Stay				Cause of Death			
	<=55yr		>55yr		<24hr		>=24hr		CNS		Other	
Study n	n.	%	n	%	n	%	n	%	n	%	n	%
111	98	88	13	12	83	75	28	25	67	60	44	40

DISCUSSION

South Africa has one of the highest rates of traumatic injuries in the world, which puts a great burden on the trauma system at GSHTC.[8] Based on this panel study, a PDR of 24% was calculated. This is consistent with the worldwide average of 26% based on the published literature of similar studies since 1995.[14-20] However, these types of studies are difficult to compare to one another unless methodologically similar, and the trauma population and available resources in South Africa make GSHTC a unique environment compared to the locations where many of these studies were completed. The methodology for this study was purposely chosen to accommodate the distinctive characteristics of GSHTC, and an interpretation of the results must do the same.

This study used a modified panel consensus technique discussing all cases which is a similar technique used throughout the literature.[15,16,17,19] Instead of using an external panel for review which is associated with a decrease in bias, an internal panel was necessary due to the fact that documentation is often incomplete. The panel decision was made based on pre-hospital, in-hospital, and autopsy reports. With the exception of autopsies, detailed information was often lacking. It was unrealistic to send deficient information to external reviewers and expect an informed decision. Therefore, a potential

bias had to be accepted. Additionally, for the same reasons a second panel of reviewers to assess inter-rater reliability between panels was also not feasible.

The panel was made up of only trauma surgeons and a researcher with experience in trauma care. This is in opposition to the recommendations made by MacKenzie et al. (1992) to create a multidisciplinary team.[13] However, GSHTC is dissimilar to many trauma centres in that emergency room physicians and anesthesiologists are not routinely a part of the patients' care. In addition, other surgical subspecialties are not involved until resuscitation has fully commenced and imaging has been completed. Due to staffing shortages, the nursing staff takes a less active role in the care of patients with registrars completing many duties that nurses would perform in other trauma centres. Pathologists were included in the panel discussions to provide information gained from the autopsy report, but were not included in the final decision because of a lack of clinical trauma experience.

A great strength of this study is that 89% of patients had autopsy information available for the discussion. This allows for a more informed decision for the panelists and for a more valid calculation of the ISS. Therefore, the Ps could be calculated and compared to the panel's decisions. The results of the kappa analysis showed very poor agreement between the panel and Ps. This is similar to Fallon et al.'s (1997) results and may be explained by the vastly different trauma population in Cape Town compared to the Major Trauma Outcome Study (MTOS) that the Ps calculation is based on.[6,18,21] Unfortunately, the trauma burden at GSHTC is so great that it was impossible to record the admission

and calculate the ISS for every trauma that presented during the study period. Consequently, z scores and M scores could not be calculated to compare the observed deaths with expected deaths or to measure the similarities of the study population with the MTOS baseline. But one can surmise that the populations are very different. The MTOS population was taken from voluntarily participating trauma centres in the United States over 20 years ago, not on international norms.[3] It contained 79% blunt and 21% penetrating injuries[22] contrasted to our study population with 66% blunt and 34% penetrating injuries. A large amount of the blunt injuries in our study were due to assault (13%), and the excessive amount of violence in South Africa provides a much different injury profile when compared to the MTOS population from the United States. Although a better correlation between the Ps and the panel's decision is ideal, the decrease in the reliability and validity of the TRISS measurement in the South African population may account for the generous difference.

Another explanation for the panel and TRISS methods' divergent results is that panelists did not vote anonymously. This has been shown to increase the number of NP assignments made by the panel.[23] Anonymous voting decreases peer pressure and the tendency to vote with the perceived majority.[23] In this study, the TRISS method identified many more PP and P cases than the panel. Had the voting been done anonymously, this discrepancy may not have been as wide.

An additional limitation of this study was that there was insufficient information to calculate the Ps for 70 (63%) of the cases. The assumptions that were made regarding the

blood pressure, respiratory rate, and GCS most likely skewed the Ps values causing more cases to be labeled PP and P using the TRISS method. Because the goal of the study was to identify deaths that may have been prevented and the factors contributing to the deaths, we erred in this direction. The correlation between the panel decisions and the Ps values were analyzed both with and without the cases with insufficient data, and both analyses showed a poor agreement. We can hypothesize that had information been complete in all of the cases, the correlation results would still show poor agreement.

The true purpose of this study was to identify areas of improvement within the GSHTC trauma system. Although the panel's decisions did not align with the Ps scores, the recognition of a 24% PDR is the first step towards quality improvement at GSHTC. Of the 27 deaths considered PP or P, 20 (74%) were found to be provider related and only 7 (26%) were system related. Eight (24%) of the 34 errors were system related, and not surprisingly, the most common system related error was a delay in transfer from the referring facility (63%). This illuminates a weakness of this study and the potential for future research in South Africa. An often cited limitation of panel studies is their restriction to deaths that occur in the main facility studied.[5,24] To truly evaluate a complete trauma system, all deaths that occur within a certain area should be included. The pre-hospital mortalities and the mortalities at referring facilities should be assessed along with the tertiary institution to comprehend the quality of an entire system. In this study, based on the information provided by referring facilities, the panel was able to conclude that there was a delay in transfer in at least 5 cases. However, information regarding both pre-hospital times and times of transfers between facilities was often

scarce, and this judgment is probably an underestimation of the number of patients who may have benefited from quicker transport times.

Overall, during the study period in the GSHTC catchment area, there were 812 deaths due to trauma and only 126 (15.5%) of those made it to GSHTC. In South Africa, the average pre-hospital time is 120 minutes and much of this is due to the great distances within the country.[25] Within the city of Cape Town, it is not just distance that affects the pre-hospital time, but there is often inadequate access in informal urban settlements making it difficult to both locate and get to patients.[25] A study done from 1994 to 1998 in South Africa, showed that 75% of pre-hospital mortalities secondary to violence and 32% of MVC pre-hospital mortalities had an ISS of 30 or less.[25] This indicates that more rapid transport times may have made a difference in their survival. In further studies, it would be prudent to include both pre-hospital mortalities and mortalities at referring facilities to adequately assess the quality of the entire trauma system.

Of the 26 provider related errors (75%), 12 (46%) were found to be due to an error in judgment, and 6 (23%) were found to be due to a delay in diagnosis. This breakdown of provider related errors is not unexpected in a teaching institution where junior personnel are often the first caregivers available to make diagnoses and subsequent decisions. Compared to many institutions in the United States where rules mandate the presence of an attending physician at all major traumas and in the operating theatre, registrars in South Africa are often afforded more independence and may be the only immediately available physician after hours. Although this provides great learning opportunities for

younger physicians, those with less experience are naturally prone to making more errors. In this study, the registrars taking care of the patients were present at the panel discussions. Reviewing the preventable deaths and the contributing errors gave these registrars some insight and feedback about the care they provide for patients. Learning from one's errors is a part of a surgeon's training. The opportunity to discuss the implications of these errors in a safe environment that is focused on quality improvement allows self criticism, confession and forgiveness.[2] All of the cases in this study are subsequently presented at the departmental Morbidity and Mortality conference for review so all registrars have the chance to learn from the errors contributing to preventable deaths.

CONCLUSION

The unique characteristics of both the trauma population and GSHTC make it difficult to compare the results of this study to other published literature. For the same reasons, it is also complicated to draw significant conclusions from comparing the panel's decisions to the Ps scores. Most importantly, GSHTC identified that 24% of mortalities may be prevented if optimal care is delivered. Future research should focus on pre-hospital and referring hospitals' mortalities to evaluate areas of improvement in the entire system. Within GSHTC, supervision of registrars when possible may decrease errors in judgment and delays in diagnosis. Continuing the process of reviewing preventable deaths and their contributing errors provides a forum for learning from one's own and others' mistakes.

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APPENDIX

GROOTE SCHUUR HOSPITAL TRAUMA CENTRE
MORTALITY DATA

Surname:	**First Name**:	**Folder Number**:
Age:	**Sex**: ❒M ❒ F	**Home Suburb:**

Time and date of Death: **Time:** **Date:**

Mechanism of Trauma: ❒ Interpersonal violence ❒ Road traffic death ❒ Fall ❒ Other

Reviewed:	❒ Yes	❒ No	❒ Pending
Death:	❒ Non Preventable	❒ Potentially Preventable	❒ Preventable
Nature:	❒ Trauma Related	❒ Provider Related	❒ System Related
Phase of Care:	❒ Pre-Hospital	❒ First Facility	❒ GSH
Provider Related Detail:	❒ Delay in Transfer ❒ Delay in Doctor Response ❒ Error in Diagnosis	❒ Error in Technique ❒ Error in Judgment ❒ Delay in Diagnosis	❒ Delay to Theatre ❒ Delay to ICU ❒ Error in Communication ❒ Not applicable

Resource Limitation: ❒ Trauma centre full ❒ No ICU beds

❒ Theatres full ❒ Head injury policy ❒ Burns unit full

Care:	❒ Acceptable	❒ Acceptable with Reservations	❒ Unacceptable
Corrective Action :	❒ No Action	❒ Peer Review Presentation	❒ Guideline / Protocol development
	❒ Discussion at Surgical M&M	❒ GSH management review	

Forensic Pathology Review Notes:

Status: ❒ Closed ❒ Open

UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Human Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6626 • Facsimile [021] 406 6411
e-mail: shuretta.thomas@uct.ac.za

14 October 2010

HREC REF: 486/2010

A/Prof A Nicol
Surgery
Trauma Centre C14
NGSH

Dear A/Prof Nicol

PROJECT TITLE: PREVENTABLE DEATHS PRESENTING TO A LEVEL 1 TRAUMA CENTRE IN SOUTH AFRICA.

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

It is a pleasure to inform you that the Ethics Committee has **formally approved** the above-mentioned study.

Approval is granted for one year till the 15th October 2011.

Please submit an annual progress report if the research continues beyond the approval period. Please submit a brief summary of findings if you complete the study within the approval period so that we can close our file.

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

Please quote the REC. REF in all your correspondence.

Yours sincerely

pp

PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS
Federal Wide Assurance Number: FWA00001637.
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S Thomas

ABBREVIATIONS

APs	Autopsy probability of survival
CNS	Central nervous system
CPs	Clinical probability of survival
GCS	Glascow Coma Score
GSHTC	Groote Schuur Hospital Trauma Centre
GSW	Gun shot wound
ISS	Injury Severity Score
M&M	Morbidity and mortality
MTOS	Major Trauma Outcome Study
MVC	Motor vehicle crash
NP	Non-preventable
P	Preventable
PDR	Preventable death rate
PP	Potentially Preventable
Ps	Probability of survival
PVC	Pedestrian versus vehicle crash
RTS	Revised Trauma Score
TRISS	TRauma Score-Injury Severity Score

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