Selective Non-Operative Management of Abdominal Gunshot Wounds at Groote Schuur Hospital: A Cohort Study on Clinical Outcomes and Financial Costs

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DECLARATION

I, Rebecca Kim (KMXREB001), 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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Abstract

Background: Selective non-operative management (SNOM) of abdominal gunshot wounds is a practice that is becoming more common in major urban trauma centres. With increasing levels of violence, SNOM offers a useful method for managing injured patients. Historically, operative management of blunt and penetrating wounds to the abdomen has been the standard of care. This has changed over the past several decades with the advancement of imaging techniques and the realization that many penetrating wounds do not require surgical intervention. However, reticence towards SNOM for the management of abdominal gunshot wounds has remained because of the high probability of visceral organ damage. This study contributes to the growing field of violence prevention and trauma systems management by examining the use of SNOM for abdominal gunshot wounds. We examined the hypothesis that SNOM does not increase morbidity or mortality in patients and decreases total hospital costs.

Methods: A retrospective cohort study of 257 consecutive patients admitted to a level I trauma centre in South Africa for the management of abdominal gunshot wounds over a one year period from 1 April 2004 to 31 March 2005 was performed.

Results: Ninety-three of 257 (36%) of abdominal gunshot wound victims were non-operatively managed. Of these 93 patients, 5 (5%) later required surgery and were converted to a delayed laparotomy. Of the 164 patients who were treated with immediate laparotomy, 10 (6%) underwent non-therapeutic laparotomies. There were no deaths within the cohort of patients that were managed non-operatively during the hospital stay compared to 9 deaths in the group of surgically managed patients (p=0.03). On multivariate analysis, there was no statistically significant difference in overall complication rate during the hospital stay between patients who were treated non-operatively compared to those who were treated operatively after adjusting for injury severity (HR 1.25, 95% CI 0.61-2.55). There was also no statistically significant difference in total hospital cost between the two groups (HR 0.40, 95% CI 0.15-1.08).

Conclusion: This study has policy implications for violence prevention and health systems management. It suggests that SNOM can be successfully used in less severely injured abdominal gunshot wounds. The use of SNOM does not increase morbidity or mortality rates during the hospital stay. Thus, it can also be used effectively as a part of cost-containment policies geared towards the redistribution of human and financial resources in the trauma centre.

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ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
DALY	Disability-adjusted life year
DBP	Diastolic blood pressure
GCS	Glasgow coma scale
HGB	Haemoglobin
HR	Hazard ratio
IQR	Interquartile range
ISS	Injury severity score
OR	Odds Ratio
PAWC	Provincial Administration of the Western Cape
RR	Respiratory rate
RTS	Revised trauma score
SBP	Systolic blood pressure
SNOM	Selective non-operative management
WHO	World Health Organization
95% CI	95% confidence Interval

Chapter 1: Introduction

"The question is no longer between violence and non-violence; it is between non-violence and non-existence." – Martin Luther King, Jr.

1.1 Background on Violence and Public Health

The issue of violence has oft been relegated to the desks of sociologists and criminologists as an inevitable part of the human condition. Seldom viewed as a disease to be studied or prevented, violence has traditionally forced health care providers into a reactionary role as the managers of traumas in the emergency room setting. Only recently has violence prevention entered into the minds of public health officials. Successes in chronic disease management such as diet modification and blood pressure control for cardiovascular disease, smoking cessation for lung cancer, and safe-sex education for HIV and AIDS have paved the way for injury and violence prevention.

The Global Burden of Disease Study of 1990 was one of the first worldwide studies to highlight intentional and unintentional injury as a major contributor to morbidity and mortality (Murray and Lopez, 1997). In this epidemiologic study, the authors found that injuries caused 10% of mortality worldwide and accounted for 15% of disability-adjusted life years (DALYs). Road-traffic accidents, falls, war injuries, self-inflicted injuries, violence, drowning, and burns were seven of the top 30 leading causes of DALYs worldwide. Following the publication of this study and the increased awareness of the harmful health effects of violence and injury, the 49th Assembly of the World Health Organization (WHO) declared violence as a leading worldwide public health problem (Krug, et al., 2002).

1.2 Burden of Violence: Mortality, Morbidity, and Cost

In their first *World Report on Violence*, the WHO estimated that 1.6 million people worldwide died as a result of violence in 2000 (Krug, et al., 2002). Put into context, this number represents approximately half of the number of deaths due to HIV/AIDS, equals the number of deaths due to tuberculosis, and is greater than the number of deaths due to malaria (Bartolomeos, et al., 2007). While communicable diseases remain an important cause of mortality in the world, the impact of violence is undeniable and numbers continue to grow. A subsequent Global Burden of Disease study conducted in 2001 illustrated the transition away from infectious diseases towards chronic diseases and injury. Excluding HIV/AIDS, deaths due to communicable diseases dropped from one-third of total deaths in 1990 to one-fifth in 2001. Meanwhile, traumatic injuries continued to be a disproportionately important cause of death in adults aged 15-59, accounting for one-quarter of total deaths among this age group in 2001 (Lopez, et al., 2006). Similarly, WHO global data showed violence to be the leading cause of death for people aged 15-44 years (Krug, et al., 2002). The situation is far more severe in developing countries. Rates of violent death in low- to middle- income countries are more than twice as high as those in high-income countries, 32.1 per 100,000 versus 14.4 per 100,000 (Krug, et al., 2002).

In addition to increased mortality, violence exerts a high toll on society through injury and increased healthcare costs. For every young person killed by violence, an estimated 20 to 40 others require hospital treatment (Krug, et al., 2002). The long term physical and psychological consequences of trauma have been poorly studied to date. However, several studies have shown that victims of sexual assault have more health problems with significantly higher health care costs and more frequent emergency room visits. They are prone to depression, alcohol abuse, anxiety, and suicidal behaviour (Bartolomeos, et al., 2007). Wintemute and Wright (1992) found that 30 of 250 (12%) patients admitted to a level I trauma centre for firearm injuries were rehospitalized. Half of the readmissions occurred during the first year following the injury.

The consequences of these numbers are grave for developing countries that depend on the youth as the backbone for economic growth. Moreover, the healthcare system of many of these countries are straining under the dual load of infectious diseases and violence. The majority of studies examining economic cost of violence have come out of the United States. In one study conducted at a level I trauma centre in the United States, a retrospective chart review of hospital records of 131 patients admitted for firearm injuries found average hospital costs (excluding professional fees) to be USD 6,915 per patient (Martin, et al., 1988). In 1990, firearm injury was estimated to cost USD 20.4 billion. Direct health care costs amounted to USD 1.4 billion. The remaining USD 19 billion resulted from lost productivity from injury and premature death (Max and Price, 1993). Vassar and Kizet (1996) estimated median hospital charges at USD 8,535 per patient in their one year retrospective population-based study of 9,562 patients discharged from the hospital for firearm-related injuries. Another study found the average cost for acute-care treatment following firearm injury to be

USD 14,757 in Maryland and USD 14,497 in New York. For nonfatal gunshot injury, the majority of medical treatment costs come after the patient has been discharged from the hospital (Cook, et al., 1999).

Overall, these studies indicate that violence has a great impact on the morbidity and mortality of potentially the most productive members of society. In addition, the total direct and indirect cost to society is exceedingly high. As healthcare costs continue to increase globally, many countries will be forced to address the issue of violence not only as a major public health concern but also as a health systems management issue. Within this context, the identification of effective strategies to prevent and treat violence-related injury, particularly in the developing country settings, is an important area for research aimed to promote the public's health.

1.3 Violence in South Africa

South Africa is a middle-income country with one of the highest rates of violence in the world. Unfortunately, exact mortality rate figures are difficult to come by as South Africa is a country where not all deaths are registered and misclassification of deaths often occurs. However, reports from national studies suggest that violence has a large impact on South African society. According to the South African Victims of Crimes Household Survey, 3.9 million of 26.7 million individuals (14.6%) reported experiencing a violent crime in 1997. For this survey, a violent crime included assault, corruption, fraud, robbery, sexual offences, or theft of property. Moreover, 4.0 million of 9.1 million households (44.0%) experienced a violent crime during the five year period between 1993 and 1997 (RSA, 1998). These data suggest that violence affects a large portion of South African individuals and household.

In many cases, these violent crimes lead to death and injury. Meel (2004) conducted a retrospective review of medicolegal autopsies performed in the Transkei region of South Africa and found that violent and traumatic deaths accounted for an average annual rate of 162 deaths per 100,000 population. Nearly 50% of deaths occurred in the 21- to 40- year old age group. Additionally, the previously mentioned Victims of Crime Household Survey found that 221,107 of 9.1 million households (2.4%) had experienced a deliberate killing or murder from 1993 to 1997 (RSA, 1998). According to the South African National Injury Mortality Surveillance System (NIMSS) 47% of 22,248 injury deaths reported by mortuaries in 2003 were attributable to violence (Matzapoulos, 2004). This number is consistent with a prior study of medicolegal laboratory, forensic, and police data showing that among 4,000 non-natural deaths in Cape Town in 1994, homicides accounted for 46% of these deaths (Lerer, et al., 1997). These numbers indicate that violence and homicide are major contributors to mortality in South Africa.

To better understand the gravity of the situation, it is useful to see the above numbers in comparison with other countries. On an international level these numbers represent the highest estimated all-cause homicide rate among a United Nations (UN) survey of 48 member states in 1997. In this survey, South Africa reported 64.6 deaths per 100,000 people. Second place Brazil had half the mortality rate with 29.2 deaths per 100,000 (UN, 1997). These numbers also represent the second leading cause of premature mortality in South Africa, second only to HIV/AIDS. According to the South African National Burden of Disease Study 2000 which used multiple demographic and epidemiological models to estimate age-standardized mortality rates, homicide and violence accounted for 6.8% of all years of life lost (YLL). Tuberculosis and diarrhoeal diseases accounted for 4.7% and 4.2%, respectively (Bradshaw, et al., 2006). All together, these data suggest that homicide and violence place a significant burden on the population in terms of both morbidity and mortality.

Much of the violence in South Africa has been attributed to firearm use. South Africa currently has one of the more low-to-moderate rates of gun ownership among UN member countries with 84 firearms per 1,000 population. In contrast, many of the Scandinavian countries such as Finland have rates almost five-fold higher at 411 firearms per 1,000 population (UN, 1997). Unfortunately, the number of firearms in South Africa is likely underestimated due to widespread illegal firearms trafficking. Following the political changing of the guard in 1994, there was a push to gain control over this illegal market. Unfortunately, illegal possession of firearms continues to steadily increase based on police statistics. From 1994 to 1997 the number of reported lost or stolen firearms rose from 7,285 to 16,963 (Hennop, 1999). While a concerted effort has been made by the South African Police Service (SAPS) to reduce the number of illegal firearms, rates of illegal possession of firearms have remained around 35 per 100,000 population from 1999 to 2004 (Selehi, 2005). To date, total unconfirmed estimates of firearms in South Africa range from as low as 9 million to as high as13 million (Meel, 2007). Approximately, 4 million firearms are held legally by registered owners and 5 million are held by South African National Defence Forces and Police Services.

Given this environment of violence and easy access to firearms, it should not be surprising that over 50% of violent deaths are due to firearms (Matzapoulos, 2004). According to the UN survey on civilian firearms, South Africa reported the highest firearm-related homicide rate with 26.6 deaths per 100,000 population, representing 41% of all homicides. Second-place Brazil experienced 25.8 firearm-related homicide deaths per 100,000 population (UN, 1997). These data are comparable to other studies from the subpopulations of South Africa. Wigton (1999) performed a retrospective study of hospital, medico-legal, laboratory, and police data and found that 1,736 children and adolescents under the age of 19 years were the victims of firearm-related incidents during the five-year period between 1992 and 1996. There was an average 19% mortality rate with 10.3 deaths per 100,000 by 1996. Moreover, the study also found that the incidence of firearm injuries almost tripled from 20.2 per 100,000 in 1992 to 58.1 per 100,000 in 1996. This study also highlights the aforementioned morbidity of gun violence. For every one person killed by gun violence in this study, another 6 were injured.

In terms of the cost impact of violence, there has only been one published study to date in South Africa that examined the cost burden of gun violence. Allard and Burch (2005) calculated the individual costs of hospital stay based on five variables: operating theatre time, hospital stay, pharmaceuticals and blood products, diagnostic imaging, and laboratory services. Based on the treatment of 21 abdominal gunshot victims over a period of 6 months, the authors found that the median cost of treatment was ZAR 10,270. Extrapolating the data, they estimated that the annual national cost of firearm-related injuries was ZAR 200 million, representing 4% of the total national government expenditure on health per year.

Put together, these studies illustrate the tremendous burden created by violence in South Africa. Gun violence is exacting a high toll on the healthcare system in terms of morbidity, mortality, and cost. There is an urgent need to investigate violence prevention strategies and health systems management in order to provide adequate treatment to victims of violence.

1.4 Approaching Gun Violence in South Africa from a Public Health Perspective

Like violence, the study of trauma systems and trauma management were infrequently considered topics in mainstream public health circles until recently. With the growing field of health systems management, the intersection between trauma surgery and public health is widening. As victims of violence flood healthcare facilities, using up larger and larger portions of public resources and medical attention, there has been a push towards primary, secondary, and tertiary prevention. Primary prevention activities focus on preventing the development of the disease. In regards to violence, primary prevention activities include the establishment of community areas such as centres, parks, and recreation areas to encourage social gatherings and creation of community networks and solidarity. Secondary prevention activities are aimed at detecting early disease to allow for the prevention of progression. In many cases of violence, increased police surveillance of high crime areas or in-school detection of juvenile conduct disorder have been effective as secondary prevention methods. More recent literature has suggested the use of home visits as a means of secondary prevention of violence. Tertiary prevention of violence involves the immediate treatment of an already established disease to restore function and reduce disease-related complications. It is within tertiary prevention that public health and trauma surgery overlap.

Moreover, health systems management is becoming an integral component to many public health issues given the economic realities in the world of medicine. Evidence-based medicine and cost-containment practices are being pushed forward in an attempt to provide equitable and effective healthcare. Given that the costs associated with firearms injuries are high, it is imperative to find effective methods of violence prevention. This study seeks to examine effective tertiary prevention activities.

1.5 Study Objectives

This study contributes to the growing field of public health and trauma management by examining the clinical outcomes and financial implications of selective non-operative management (SNOM) of abdominal gunshot wounds at Groote Schuur Hospital. We examined the hypothesis that SNOM does not increase morbidity or mortality in patients and decreases total hospital costs.

The objectives are as follows:

1. Perform a systematic review of the literature on the clinical efficacy of selective non-operative management of abdominal gunshot wounds.
2. Compare the clinical outcomes in patients with abdominal gunshot wounds who undergo SNOM versus surgical management at the Groote Schuur Hospital (GSH) Trauma Centre. Outcomes of interest include mortality rate, incidence of infection and other complications, and length of hospital stay.
3. Estimate the approximate total hospital costs based on the cost for hospital stay, theatre time, blood products and pharmaceutical products, laboratory studies and diagnostic imaging studies per individual.
4. Examine the rates of SNOM delayed laparotomy and rates of negative laparotomy.
5. Examine the relationship between outcomes and management protocol after adjusting for trauma severity and other demographic and clinical factors.

1.6 Preview of Future Chapters

Chapter 2 explores the current understanding of the management of abdominal gunshot wound through a systematic literature review. Chapter 3 describes the methods used in this current cohort study, including population selection, data collection and analysis, and ethical considerations of the study. Chapter 4 presents the results of the study. Chapter 5 provides a discussion of the results in the context of current understanding of field with suggestions for policy application and direction of future research.

Chapter 2: Literature Review

2.1 Overview of Management of Abdominal Gunshot Wounds

From the start of the modern surgical era in 1846, mandatory surgical exploration for general penetrating abdominal wounds had been the standard of care (Pryor, et al., 2004; Demetriades, et al., 2003). However, in the United States the rapid increase in trauma during the post-World War I era forced many surgeons to develop methods of triaging patients. Studies soon appeared that suggested that mandatory exploratory laparotomies were unnecessary in treating penetrating wounds to the abdomen (Shaftan, 1960). In one cohort study of 432 penetrating stab and gunshot abdominal wounds treated with mandatory laparotomies, 53% were found to have absolutely no injuries and 10% were found to have minor injuries that did not require surgical intervention. Moreover, only 4% of patients who were initially managed non-operatively eventually converted and received a delayed laparotomy. None experienced an increase in mortality or morbidity. Rather, complication rates were found to be higher in the mandatory laparotomy group (Nance, et al., 1974). These results were further corroborated studies looking specifically at abdominal stab wounds. These results prompted a new policy of expectant management for stab wounds (Demetriades and Rabinowitz, 1987; Robin, et al., 1989; Leppaniemi and Haapiainen, 1996).

Similar policies of SNOM have been slow to come for abdominal gunshot wound. Gunshot wounds provide unique degree of complexity stemming from refractory trajectories as the bullet passes through different tissue densities. Additionally, the high energy associated with the bullet causes fragmentation and cavitation of hard and soft tissues ultimately leading to greater overall trauma compared to stab wounds. This greater morbidity has justified a lower threshold for surgical intervention in the management of abdominal gunshot wounds. Mandatory exploration of all abdominal gunshot wounds has remained the standard of care until the 1990s. During this time attention shifted to the use of SNOM for gunshot wounds to the abdomen based on studies from the United States and South Africa (Muckart, et al., 1990; Demetriades, et al., 1991; Renz and Feliciano, 1994; Chmielewski, et al., 1995; Demetriades, et al., 1997; Velmahos, et al., 2001). In many of these studies the use of SNOM has been justified in order to reduce the morbidity associated with unnecessary laparotomy. When complications such as atelectasis, prolonged ileus, and urinary tract infections are included, morbidity associated with negative laparotomies can be as high as 41% (Renz and Feliciano, 1994). Moreover, with the development of imaging technology, it is becoming easier to detect peritoneal injury prior to surgery. Originally criticized for its limited ability to diagnose mesenteric, hollow visceral, and diaphragmatic injuries, single- and triple-contrast CT scans have been proven to be 90-95% sensitive and 96% specific in correctly predicting need for laparotomy (Chui, et al., 2001; Munera, et al., 2004; Velmahos, et al., 2005; Salim, et al., 2006). Thus, a slowly growing body of empirical evidence suggests mandatory laparotomy is clinically unnecessary for the management of abdominal gunshot wounds. This systematic review was conducted in order to describe the current literature on SNOM for abdominal gunshot wounds.

2.2 Methods

2.2.1 Search Strategy

A search of the electronic database Medline using the PubMed interface (National Library of Medicine, Bethesda, MD) was conducted using the search strategy illustrated in Table 2.1. Briefly, SEARCH 1 targeted studies related to "abdominal injuries". SEARCH 2 targeted studies regarding "gunshot wounds". SEARCH 3 targeted "management". SEARCH 4 targeted "trauma". SEARCHES 1, 2, 3, and 4 were combined to retrieve all articles published through 8 April 2007 regarding the management of traumatic abdominal gunshot wounds. The final search limited studies to English text with human subjects, excluding editorials and letters. Titles and abstracts were retrieved and imported into Sente 4.2.2 (Third Street Software, Inc.) bibliography software.

Titles and abstracts were reviewed using pre-established inclusion and exclusion criteria described below. Full-text articles were then retrieved from the library whenever possible. Additional articles were added to the review by cross-referencing included studies.

Table 2.1 Systematic Review Search Strategy

	Target	Search text	Citations
1	Abdomen	"Abdomen" [MeSH] or abdom* [tw]	230920
2	Gunshot Wound	"Wounds, Gunshot"[MeSH] or gun* [tw] or firearm* [tw]	20260
3	Management	Manage* [tw] or treat* [tw]	2898554
4	Trauma	Trauma*	188517
5	Combination	#1 AND #2 AND #3 AND #4	493

2.2.2 Selection Criteria

Qualitative and quantitative studies pertaining to management of abdominal gunshot wounds in adult patient populations were selected regardless of country of origin, hospital setting, or study design. In this review, the boundaries of the abdomen were specified as extending from the nipple line to the pubic symphysis anteriorly or from the lower border of the scapula to the buttock crease posteriorly (See Figure 3.1). In addition, articles were included provided that they addressed the issue of non-operative management versus mandatory laparotomy. Studies were excluded if they pertained specifically to paediatric trauma or blunt injury. Studies investigating various diagnostic modalities used in non-operative management were also rejected in order to allow for a more concise review. In addition, because injuries from shotgun wounds tend to be vastly different from gunshot wounds, studies specifically examining shotgun wounds were excluded. Lastly, studies that examined specific organ damage or compared various surgical interventions alone were excluded. A summary of inclusion and exclusion criteria can be found in Table 2.2. Studies that examined the more general category of penetrating abdominal injuries were included if results specifically highlighted gunshot wounds as an individual category.

Table 2.2 Systematic Review Inclusion and Exclusion Criteria

Inclusion	Exclusion
• Adult patient population • Management of gunshot wounds to the abdomen, where abdomen extends from nipple line to pubic symphysis including the buttock, without preference for specific organ damage • Comparison of non-operative management versus mandatory laparotomy • General penetrating abdominal injuries included, provided that gunshot wounds were discussed individually.	• Paediatric patient population • Blunt injury • Research specific for organ trauma (spleen, liver, colon, vascular, etc.) • Comparisons of different surgical methods (i.e., non-operative approaches not evaluated) • Assessment of diagnostic modalities used in non-operative management • Examination of shotgun injuries

2.2.3 Data Collection & Extraction

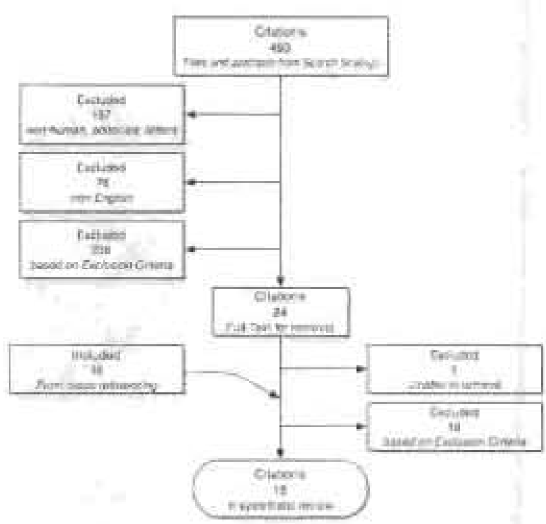
Data were collected using the abstraction form found in Appendix 1. Extracted data included authors, year of publication, study design, country of study, hospital setting, number of subjects, and outcome.

2.3 Results

2.3.1 Articles for Inclusion

Figure 2.1 illustrates the results of the systematic review. Using the search strategy, 493 titles and abstracts were found related to the management of traumatic abdominal gunshot wounds. Two hundred and thirty-three titles were rejected because they were non-human, non-English, editorials, or letters. The remaining 260 titles and abstracts were retrieved for review using the inclusion/exclusion criteria described above. Two hundred and thirty-six titles and abstracts were rejected based on the selection criteria, leaving 24 citations for full-text retrieval. At the full-text stage, articles were cross-referenced in order to ensure the most thorough review. Fourteen full-text articles were retrieved based on the cross-referencing. From the 38 articles in total, 5 were excluded because they were not accessible and 18 were excluded based on the

Figure 2.1 Summary of Systematic Review



inclusion/exclusion criteria. In total, 15 full-text articles were extracted for the systematic review.

2.3.2 *Qualitative Overview of Articles in Systematic Review*

Table 2.3 summarizes articles from the systematic review. In brief, 15 articles were included in the systematic review. These studies examined the role of SNOM of abdominal gunshot wounds. All studies were conducted at a level I trauma centre in major USA or South African cities. The vast majority were designed as cohort studies. There was one case-series study. No randomized-controlled trials were found. Data analysis varied between studies, but primarily focused on incidence rates, specifically examining the proportion of patients managed non-surgically. Of the non-surgically managed patient, studies calculated the proportions that converted to surgery (received a delayed laparotomy), occasionally mentioning complications from the delay. For patients undergoing surgical treatment, outcomes of interest included the number of non-therapeutic or negative laparotomies, mortality rate, and complication rate.

In general, rates of non-operative management ranged from 5% to 73.3% with lower proportions of non-operative management associated with earlier dated studies. This was mostly due to the fact that the majority of hospitals did not pursue a protocol of non-operative management until recently.

For patients who were treated surgically, the rates of negative or non-therapeutic laparotomy varied from 0-19%. Velmahos, et al., (1997a) reported on a prospective cohort study of 59 patients admitted for gunshot wounds to the buttock. Seventeen (29%) of these patients were treated surgically and all were found to have injuries requiring surgical repair. Another cohort study conducted found 185 of 309 (59.9%) patients with anterior abdominal gunshot wounds were treated surgically with only 4 of 185 (2.2%) of these being non-therapeutic (Demetriades, et al., 1997). In contrast, an earlier study examining a similar patient population found that 5 of 27 (19%) surgeries were non-therapeutic (DiGiacomo, et al., 1994). This difference in rates of negative laparotomy could potentially be explained by a lower threshold for surgical management leading to greater number of unnecessary operations.

For patients initially treated non-operatively, the rates of conversion or delayed laparotomy, ranged from 0-17%. There was no apparent association between the rates of non-operative management and rates of delayed laparotomy. Demetriades, et al., (1991) conducted a prospective cohort study on 146 patients admitted for abdominal gunshot wounds. Forty-one of 146 (28%) of these patients were managed non-operatively and 7 of 41 (17%) required a delayed operation. In contrast, Velmahos, et al., (2001), found only 80 of 792 (10%) underwent delayed laparotomy despite having a higher rate of non-operative management. Interestingly, the delayed laparotomy was non-therapeutic in many instances (Velmahos, et al., 1997a; Velmahos, et al., 1997b, Velmahos, et al., 1998).

According to these studies, there does not appear to be a relationship between the rates of non-operative management and rates of delayed laparotomy, nor between the rates of operative management and rates of negative laparotomy. Rather, rates of delayed laparotomy and negative laparotomy are most likely dependent on the sensitivity and specificity of the clinical examination at the hospital. Studies from Velmahos suggest that the clinical examination is 100% sensitive (Velmahos, et al., 1997a; Velmahos, et al., 1997b; Velmahos, et al., 1998). However, results from Lowe, et al., (1977) suggest that rates could be much lower. In their cohort study of 362 patients admitted for abdominal gunshot wounds, 17 of 41 (41%) patients without any clinical symptoms underwent surgery and were found to have an injury requiring repair. Similarly, Moore, et al., (1980) showed in their cohort study of 245 patients that 26 of 153 (17%) patients with major intraperitoneal trauma had no physical signs of injury. This suggests that the clinical examination may have a high degree of inter-physician variability.

In terms of specificity of the clinical examination leading to negative laparotomies, clinical data suggest specificity ranges from 71.4% to 95.3% (Velmahos, et al., 1997a; Velmahos, et al., 1997b; Velmahos, et al., 1998). In addition, Lowe, et al., (1977) found that 30 of 227 (13%) of patients admitted for abdominal gunshot wounds presenting with peritoneal signs had no injury on surgical examination.

In all reported cases, there were no mortalities associated with a delayed laparotomy (Nance, et al., 1973; Lowe, et al., 1977; Velmahos, et al., 1997). In comparison, surgical groups had mortality rates up to 13.3% (Nance, et al., 1973). Velmahos, et al., (2001) reported a 9%

complication rate because of the delayed surgery. This contrasted with the complication rates for surgical management which varied up to 50%. (Burns, et al., 1994; Velmahos, et al., 1997b). Length of hospital stay was significantly shorter for non-operatively managed patients as well. Patients managed non-operatively stayed in the hospital from less than 48 hours to 2.2 days compared to surgically managed patients who stayed in the hospital for 1-2 weeks (Burns, et al., 1994; Velmahos, et al., 1998; Velmahos, et al., 1997a; Velmahos, et al., 1997b).

2.4 Summary of Findings

In summary, there are several studies in the literature on SNOM showing that rates of non-operative management vary between 5% and 73.3%. The majority of studies rely on the clinical examination in order to determine surgical intervention. Both sensitivity and specificity have been found to be adequately high to limit negative health consequences of delayed laparotomies and negative laparotomies. The evidence suggests that surgical management leads to increased length of hospital stay, higher rates of mortality, and higher rates of post-operative complications compared to non-operative management. Unfortunately, no studies to date have taken into consideration the severity of the injury in predicting mortality rates or complication rates between the two management groups. In addition, financial cost has not been used as an outcome of interest.

Authors	Year	Study Design	Study Population	Hospital	Period of study	N	Inclusion/Exclusion Criteria for SNOM	Management Analysis	Outcome analysis
Burns, et al.	1994	Retrospective cohort	Patients admitted for penetrating posterior abdominal wounds.	Episcopal Hospital, PA	Jan 1986-Dec 1990	29	I: penetrating wound to posterior abdomen and/or flank. E: hemodynamic instability, abnormal physical examination, or inability to perform serial physical examination necessitated immediate laparotomy.	8/12 (66%) AGSW patients managed non-operatively.	Hospital stay was less than 48 hours for 20 (83%) of non-operative patients compared to 7-9 days for non-complicated operative patients. 2/4 (50%) surgical patients with AGSW had postoperative complications requiring re-exploration.
Chmielewski, et al.	1995	Prospective cohort	Patients admitted for abdominal gunshot wounds.	Detroit Receiving Hospital, MI	May 1991-Jan 1994	184	I: single gunshot wound to right upper quadrant, stable blood pressure, reliable abdominal examination, minimal abdominal tenderness, and informed consent	18/184 (9.5%) managed non-operatively. 166 (81.5%) surgically managed.	0/18 (0%) complication rate for SNOM. 1/18 (5.6%) patient had a delayed non-therapeutic laparotomy.
Demetriades, et al.	1997	Prospective cohort	Patients admitted for anterior abdominal gunshot wound.	LA County & USC Trauma Center, CA	Mar 1999-Jun 1995	309	I: anterior abdominal gunshot wound. E: hemodynamic instability, peritonitis, associated spinal cord or head injury, anesthetic requirement for other injury	106/309 (34.3%) managed non-operatively. 185/309 (59.9%) surgically managed. 18/309 (5.8%) underwent ED-thoracotomy.	4/185 (2.2%) non-therapeutic laparotomy; 16/185 (8.6%) negative laparotomy; 14/106 (13.2%) had delayed laparotomy; 9/14 (64.0%)were non-therapeutic.
Demetriades, et al.	1991	Prospective cohort	Patients admitted for abdominal gunshot wounds.	Baragwanath Hospital, South Africa	Jul 1988-Feb 1990	146	I: abdominal gunshot wound. E: acute abdomen, rectal bleeding, blood in the nasogastric tube	41/146 (28%) managed non-operatively. 105/146 (72%) surgical management.	99/105 (94%) of surgeries were therapeutic. 7/41 (17%) of SNOM required delayed surgery. 7/7 (100%) of delayed surgeries were therapeutic.
DiGiacomo, et al.	1994	Retrospective cohort	Patients admitted for gunshot wounds to buttock.	University of PA Medical Center, PA	Jan 1990-Dec 1993	73	I: isolated entrance wound gluteal gunshot injury. E: additional gunshot wound to non gluteal region.	46/73 (63%) managed non-operatively. 27/73 (37%) surgical management.	5/27 (19%) of surgeries were non-therapeutic. 2/46 (4%) of SNOM required delayed surgery. 2/2 (100%) of delayed surgeries were therapeutic.
Ivatury, et al.	1982	Case series	Patients admitted penetrating gluteal injuries.	Lincoln Medical and Mental Health Center, NY	1977-1980	60	I: entrance wound in the gluteal region, negative investigative work-up including chest and abdominal x-ray, cystogram, peritoneal lavage. E: multiple abdominal injuries.	33/45 (73.3%) managed non operatively. 12/45 (26.7%) surgical management.	No mortality for either management of the AGSW.
Lowe, et al.	1977	Retrospective cohort	Patients admitted for abdominal gunshot wounds.	Cook County Hospital, IL	Jan 1972-Dec 1974	362	I: missile course that has obviously passed tangentially through the superficial tissues of the abdominal wall. E: gunshot wound that appears to have penetrated the abdominal cavity.	55/362 (15.2%) managed non-operatively. 307/362 (84.8%) surgical management.	54/307 (18%) of surgeries were non-therapeutic. 17/41 (41%) of patients without any clinical symptoms underwent surgery and were found to have an injury requiring repair. 30/227 (13%) of patients with peritoneal signs had no injury on surgical examination. No mortality in the group observed or with a negative surgery.
Moore, et al.	1980	Prospective cohort	Patients admitted for anterior abdominal gunshot wound.	Denver General Hospital, CO	1976-1979	245	I: missile course that has obviously passed tangentially through the superficial tissues of the abdominal wall. E: patient who died from injuries in the emergency department, hemodynamic instability fluid resuscitation	23/144 (16%) managed non-operatively. 121/144 (84%) surgical management.	6/121 surgeries (5%) were negative. Mortality of 7% for lap group. 26 (17%) of patients with major intraperitoneal trauma had no physical signs of injury.
Muckart, et al.	1990	Prospective cohort	Patients admitted for abdominal gunshot wounds.	King Edward VIII Hospital, South Africa	Jul 1988-Dec 1988	111	I: abdominal gunshot wound. E: shock, generalized peritonitis, leakage of intestinal content through the wound, hematemesis, proctorhagia, frank haematuria with infraumbilical entrance wound, free intraperitoneal gas with supradiaphragmatic entrance wound and radio-opaque missile within the peritoneal cavity.	22/111 (20%) managed non-operatively. 89/111 (80%) surgical management.	7/89 (8%) of surgeries were non-therapeutic. 0/22 of SNOM required delayed laparotomy.

Authors	Year	Study Design	Study Population	Hospital	Period of study	N	Inclusion/exclusion Critera for SNOM	Management Analysis	Outcome analysis
Nance, et al.	1973	Case series	Patients admitted for penetrating abdominal injuries.	Louisiana State University Medical Center, LA	1964-1973	2212		52/1032 (5%) managed non operatively. 970/1032 (95%) surgical management.	130/970 (13.4%) surgical patients had negative laparotomy. 129/970 (13.3%) mortality in surgery group. No mortality among SNOM.
Renz and Feliciano.	1994	Prospective case series	Patients admitted for abdominal gunshot wounds to right thoracoabdomen.	Grady Memorial Hospital, GA	1990-1993	32	I: AGSW to right thoracoabdomen, absence of peritonitis, hemodynamic stability, no requirement for laparotomy. E: peritonitis, hemodynamic instability, or GI track injury suggested by CT scan.	13/32 (41%) managed non-operatively. 19/32 (59%) surgical management.	0/13 delayed surgery or mortality.
Velmahos, et al.	1998	Prospective cohort	Patient admitted for transpelvic gunshot wounds.	LA County & USC Trauma Center, CA	12 months	37	I: transpelvic gunshot wound based on bullet trajectory reconstruction. E: superficial trajectories, multiple truncal gunshot wounds, depressed level of consciousness.	18/37 (48.6%) managed non operatively. 19/37 (51.4%) surgical management.	16/19 (84%) surgeries were therapeutic. 3/18 (17%) of SNOM had delayed surgery. 0/3 delayed surgeries were therapeutic. No complications in SNOM. Mean length of hospital stay was 9.5 days for surgical patients and 2.0 days for SNOM.
Velmahos, et al.	1997a	Prospective cohort	Patients admitted for gunshot wounds to buttock.	LA County & USC Trauma Center, CA	12 months	59	I: gunshot wounds to buttock. E: superficial wounds, bullet trajectories away from peritoneal cavity, emergency room thoracotomy, hemodynamic instability, peritoneal signs.	42/59 (71.2%) managed non operatively. 17/59 (28.8%) surgical management.	17/17 (100%) surgeries were therapeutic. 2/42 (5%) had delayed surgery. 0/2 delayed surgeries were therapeutic. 2/42 (5%) were negative. There were no mortalities. Mean hospital stay was 7.2 for surgical group and 2.0 for non-surgical group.
Velmahos, et al.	1997b	Prospective cohort	Patients admitted for gunshot wounds to the back.	LA County & USC Trauma Center, CA	Sep 1994-Aug 1995	192	I: gunshot wounds to back. E: superficial wounds, bullet trajectories away from peritoneal cavity, emergency room thoracotomy, hemodynamic instability, peritoneal signs.	131/192 (68%) managed non-operatively. 61/203 (32%) surgical management.	3/61 (5%) of surgeries were negative. 4/131 (3%) of SNOM had delayed surgery. 4/4 (100%) delayed surgeries were non-therapeutic. Mean hospital stay was 18.4 days for surgerical patients versus 2.2 days for SNOM patients. Morbidity was 34% for surgery versus 2.5% for SNOM. No patients died in the SNOM group.
Velmahos, et al.	2001	Retrospective cohort	Patients admitted for abdominal gunshot wounds.	LA County & USC Trauma Center, CA	Jan 1993-Dec 2000	1856	I: abdominal gunshot wound. E: peritonitis, hematemesis, proctorrhagia, radiographically demonstrable free air, bowel evisceration, shock.	792/1856 (42%) managed non-operatively. 1064/1856 (58%) surgical management.	149/1064 (10%) of initial surgeries were negative or non-therapeutic. 80/792 (10%) of SNOM had delayed surgery. 57/80 (71%) of delayed surgery were therapeutic. 5/57 (9%) had complications because of the delayed surgery. Significantly shorter hospital stays and lower hospital charges based on hypothetical population.

Chapter 3: Methods

3.1 Study Design

This cohort study was conducted by retrospective chart review of a consecutive sample of all patients admitted to Groote Schuur Hospital (GSH) Trauma Centre, Cape Town, South Africa for the evaluation and management of abdominal gunshot wounds during the one-year period from 1 April 2004 to 31 March 2005. Patient names and hospital numbers were collected prospectively by GSH Trauma senior consultants as part of a larger on-going study analyzing outcomes of SNOM for abdominal gunshot wounds. The exposure of interest in the current study was SNOM versus laparotomy. Outcomes of interest included mortality within the first 24 hours of admission, mortality within the first week of admission, overall mortality during hospital admission, rates of infection, rates of non-infectious complications, rates of overall complications, and financial costs.

3.2 Population and Sampling Strategy

GSH is a level I urban trauma centre serving a metropolitan population of two million in the Western Cape Province of South Africa. Affiliated with the University of Cape Town School of Medicine, it is a major teaching hospital for the country. As the majority of gunshot wounds from the surrounding metropolitan area are transferred to GSH, it provides a representative sample of urban gunshot violence in South Africa.

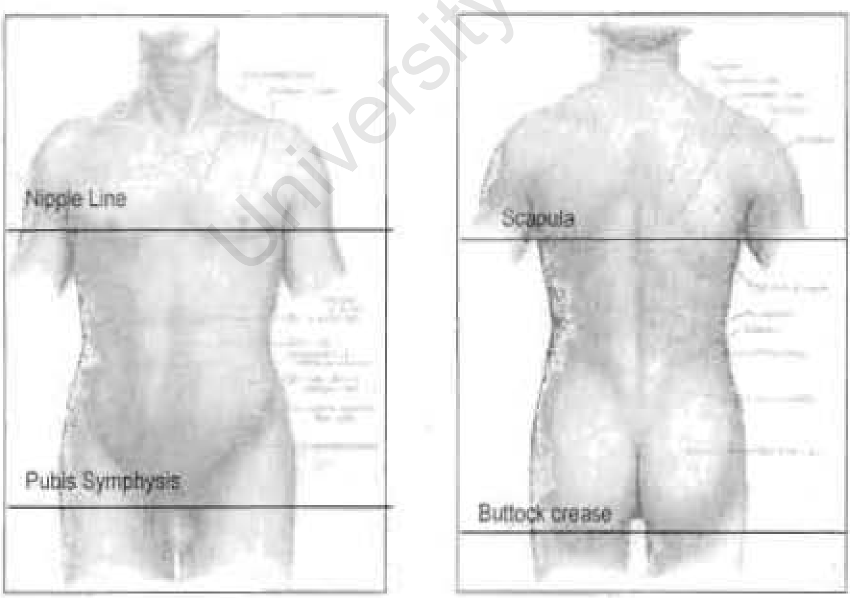
In order to achieve an accurate representation of the population of patients admitted to GSH for gunshot wounds, a consecutive sample of patients admitted during a one-year period was used in order to take into account variations in levels of violence that occur on a daily, weekly, and monthly basis. For example, levels of gun violence increase on the weekends compared to weekdays and towards the end of the month compared to the middle of the month. In addition, the academic year begins with each calendar year resulting in increasing levels of physician experience or conversely possible burn-out as the year progresses. A multi-year study was not logistically possible for this particular study.

Table 3.1 Cohort Study Inclusion and Exclusions Criteria

Inclusion Criteria	Exclusion Criteria
• Evaluated at GSH Trauma Centre between 1 April 2004 and 31 March 2005 • Admitted to GSH for 24-hour minimum stay • Presence of abdominal gunshot wound defined by radio-opaque projectile, projectile track, or wound within the boundaries of the abdomen.	• Isolated injury to male genital region • Isolated injury to superior chest and neck region • Death in resuscitation prior to surgical evaluation • Death in resuscitation after surgical evaluation deemed further treatment to be futile

Table 3.1 summarizes inclusion and exterior criteria for the cohort study. The anterior abdomen was defined as the region bound by the horizontal lines at the level of the nipple and the pubic symphysis; the posterior abdomen was bound by the horizontal lines at the inferior aspect of the scapula and the buttock crease (see Figure 3.1). Patients with isolated wounds to the male genital region or superior chest and neck region were excluded. All patients must have been admitted to GSH between the 1 April 2004 and 31 March 2005 for a minimum stay of 24 hours. Patients who were brought to the trauma unit but failed resuscitation were excluded from the study since they were not admitted to the hospital; however, patients who were stabilized, sent to theatre, and failed surgical treatment were included in the study.

Figure 3.1 Boundaries of the Abdomen



Adapted from Gray, 2000

3.3 Data Collection

Key sources of information for this chart review came from heterogeneous paper or microfilm medical records that consisted of a patient demographic information sheet, trauma admission form, nursing admission form, physicians' and nurses' notes during the hospital stay, physicians' orders/medication list, operating note, Provincial Administration Western Cape (PAWC) Operating Theatre Usage Sheet, discharge summary, radiology provisional report or final report, and x-ray folder. In addition, the computerized data system contained the dates for inpatient hospital stay and outpatient clinic visits.

A data collection form was created and piloted on an initial sample of 20 records to ensure uniform data collection. After minor modifications, the final form was used for the entire study sample. This form can be found in Appendix 2.

3.4 Variables

Table 3.2 lists the key variables of interest that were collected by chart review. Briefly, demographic information included patient age, gender, primary language, marital status, and employment status. In order to control for potential confounders of injury severity, clinical data from the initial trauma admission note was captured on the data collection form. These data included heart rate, blood pressure, respiratory rate, haemoglobin level, Glasgow Coma Scale (GCS), and macroscopic presence of blood in the urine. Based on this information, a weighted, non-triage Revised Trauma Score (RTS) was calculated retrospectively. In addition, a retrospective Injury Severity Score (ISS) was calculated based on diagnostic imaging studies and/or surgery operation notes. Both scores have been described elsewhere for use in retrospective studies to control for severity (see below). Subjective clinical observations taken during the initial assessment at GSH were also captured on the data collection form, including the presence of an acute abdomen versus focal tenderness, haemodynamic instability, and free air under the diaphragm. Evaluations made by referring hospitals were not taken into account for the purposes of this study.

Surgical details including duration, surgical findings, and procedures, were collected from individual operation notes, anaesthesia charts, and PAWC Operating Theatre usage sheets.

Lapsed time to theatre was calculated based on the time of evaluation in the trauma unit to the time of the start of the operation or time of discharge in cases where an operation was not performed.

Outcomes of interest included abdominal organs injured, mortality within 24 hours of admission, mortality within 1 week of admission, and overall mortality during hospital admission. In addition, infections were noted; these were generally in the form of localized wound, respiratory, or urinary tract infection as documented by fluctuating temperatures with prolonged use of antibiotic and/or a physician's diagnosis in the patient chart. Other complications during hospital admission were noted such as bowel obstruction, iatrogenic injuries, respiratory distress, or cardiovascular complications. Readmissions related to the treatment of the abdominal gunshot wound were also documented. In cases where the readmission was less than 7 days past the initial discharge, the patient was assumed to have had only one admission with the total length of the hospital stay based on the number of days in the hospital. Lastly, costs were calculated for the hospital stay.

Table 3.2 Description of Variables

	Variable	Description	Type of Variable	Units
Exposure	MGMT	Management	Binary	SNOM, LAP
Potential Confounders/ Effect Modifiers	AGE	Age	Continuous	Years
	GEND	Gender	Binary	Male, Female
	LANG	Primary language	Binary	Xhosa, Other
	MAR	Marital status	Binary	Single, Not Single
	EMPL	Employment status	Binary	Yes, No
	HR	Admission heart rate	Discrete	Beats/minute
	SBP	Admission systolic blood pressure	Discrete	mmHG
	RR	Admission respiratory rate	Discrete	Breaths/minute
	HGB	Admission haemoglobin	Continuous	g/dl
	GCS	Admission Glasgow Coma Scale	Binary	>13, <13
	URINE	Admission urine blood	Nominal	Absent, Trace, Present
	RTS	Revised Trauma Score	Continuous	
	ISS	Injury Severity Score	Discrete	
	DELAY	Lapsed time to operating theatre from time of admission	Discrete	Minutes
	OR_TIME	Time in operating theatre	Discrete	Minutes
Outcomes	MORT1	Mortality within 24hr	Binary	Yes, No
	MORT2	Mortality within 1 wk	Binary	Yes, No
	MORT3	Overall mortality during hospital stay	Binary	Yes, No
	INFXN	Infection during hospital stay requiring antibiotics	Binary	Yes, No
	COMP	Other complication during admission	Binary	Yes, No
	READMIT	Readmission related to AGSW	Binary	Yes, No
	REAL_HOSP	Total number of real days hospitalized	Discrete	
	BILL_HOSP	Total number of billed days based on a noon start time	Discrete	
	OP	Total number of operations during stay	Discrete	
	COST	Cost of hospital stay	Continuous	ZAR
	COST2	Cost of hospital stay	Binary	High, Low

3.5 Measurements

3.5.1 RTS

The Revised Trauma Score (RTS) is the most widely used physiological scoring system in the trauma literature (Boffard, 2003) and has been used for retrospective outcome analysis using weighted coefficients for scores assessing respiratory, cardiac, and neurological function (Champion, 1989). Calculation of RTS is illustrated in Table 3.3.

Table 3.3 Calculation of RTS (from Boffard, 2003)

Clinical Parameter	Category	Score	Weight
Respiratory Rate	10-29	4	0.2908
	>29	3	
	6-9	2	
	1-5	1	
	0	0	
SBP	>89	4	0.7326
	76-89	3	
	50-75	2	
	1-49	1	
	0	0	
GCS	13-15	4	0.9368
	9-12	3	
	6-8	2	
	4-5	1	
	3	0	

3.5.2 ISS

The Injury Severity Score (ISS) is a retrospective tool that has been shown to be a valid predictor of mortality, length of hospital stay, and cost. The three most severely injured anatomical regions (Head and Neck, Face, Thorax, Abdomen, Extremities, and External) are graded on a scale of 1-5 with 5 being injury resulting in uncertain survival. The ISS is calculated by summing the square the three most severely injured regions of the body, taking into consideration only the most severe injury for each anatomical location (Baker, et al., 1974).

The various severity scores used in this study have been validated elsewhere and have been used for trauma research in South Africa (Roux and Fischer, 1992; Brooks, 1999; Navsaria, et al., 2005).

3.5.3 Cost

The calculation of hospital costs is illustrated in Appendix 3. In brief, cost was calculated based on quantities of 1) hospital stay divided by ward, high-care, and ICU, 2) procedures received, 3) imaging procedures conducted, and 4) blood products consumed. These costs were based on the Uniform Patient Fee Schedule For Paying Patients Attending Public Hospitals (NDOH, 2004; NDOH, 2006) assuming private patient costs. The Uniform Patient Fee Schedule was developed by the Department of Health to provide a simpler charging mechanism for public sector hospitals, replacing an itemized billing approach with a grouped fee approach. Each patient at GSH is billed for accommodations, procedures, and imaging studies. In general, accommodation, procedures, and imaging studies are broken down into two components: the facility fee and the professional fee. The facility fee reflects the overhead costs of providing the environment in which the healthcare services are delivered; the professional fee reflects the costs of healthcare professionals rendering services to the patient. Both components are scaled based on the level of the facility and complexity of the procedure or study. Thus, services rendered at tertiary facilities by health specialists are substantially more costly than those rendered at a primary care setting by a generalist. In addition, simple chest x-rays are significantly cheaper than computed-tomography (CT) scans. In the costing of patient's hospital stay, it was assumed that the billing cost of a private patient accurately reflects the cost to the hospital.

Blood products were costed according to Western Province Blood Transfusion Service 2005 Private Patient Hospital Price List. These prices did not take into account the non-business hour surcharge of ZAR 175 levied on weekends, public holidays, and after 6pm during weekdays for the delivery of blood products. Crossmatch services were not included either.

A second binary cost variable was generated using the median cost value from the sample as a cut-off point. Those hospital costs that were lower than the median value were deemed to be "low" while those above the median value were labelled "high."

3.6 Bias Reduction

Data collection, data entry, and analysis was conducted by one person (RYK) to ensure consistency of reporting. ISS was calculated by one person (RYK) based on operation notes and diagnostic reports which were photocopied.

While the initial designation of SNOM was given by the senior consultant as part of the larger prospective study, it was necessary to take into consideration unintentional delays to the operating theatre that essentially changed the categorization of "laparotomy" to a "SNOM". These delays were often due to the unavailability of surgeons, anaesthetists, or operating theatres, or delays in clinical decision making. Such delays are unavoidable and expected in trauma settings. Thus, in order to provide an objective classification of management, the lapsed time to the operating theatre was used to generate a binary variable. In order to determine a cut-off point for classification of management by lapsed time, a logistic regression for classification was used where the senior consultant's classification was designated as the dependent variable and the lapsed time was designated as the independent variable. A threshold level of probability, π_0, was determined that maximized the proportion of correctly classified patients. The cut-off value for the lapse to operating theatre was calculated using this value of π_0.

Table 3.4 Determining Cut-off Value for Lapsed-Time to OR

1. Equation for Logistical Regression

$$\log it(p) = \log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 x_1 + \ldots + \beta_p x_p$$

2. Use logistical regression using senior consultant's classification as the dependent variable and lapsed time as the independent variable to determined beta coefficients of regression equation.

$$\log it(MGMT) = \log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1(LAPSE)$$

3. Using STATA, determine threshold value π_0 to optimize proportion of correct classification.

4. Solve for value of *LAPSE*

$$\pi_0 = \frac{e^{\beta_0 + \beta_1(LAPSE)}}{1 + e^{\beta_0 + \beta_1(LAPSE)}}$$

$$LAPSE = \frac{\log(\frac{\pi_0}{1-\pi_0}) - \beta_0}{\beta_1}$$

3.7 Data Entry and Cleaning

Once the majority of data had been collected, data were entered into Microsoft Excel X (Microsoft Corporation, Redmond, WA, 2001). Cost calculations were performed using Excel. Once the entire dataset had been entered, data were cleaned and coded before being transferred for data analysis. Exploratory data analysis was used to identify any irregularities in data entry. When found, the original data collection sheet was used to verify the correct entry of data into the database.

3.8 Statistical Analysis

Final data analysis was performed in STATA 9.0 (STATA Corporation, College Station, TX, 2006). Exploratory analyses of continuous data included histograms, means, and standard deviations for normally distributed data and medians and interquartile ranges for non-normal data. Normality of the continuous variables was gauged by using histograms and confirmed with the Shapiro-Wilks test using a critical p-value of 0.05. For categorical data, tables were generated showing frequencies and percentages.

Bivariate analyses were conducted to assess the association between two variables. For the comparison of categorical versus continuous variables, Wilcoxon Rank-Sum test measured for differences in medians. Two-by-two tables were generated to test for associations between two categorical variables with the chi-squared test or Fisher's exact test. In addition, the measure of association in the form of the odds ratio was calculated. Although the risk ratio is a more accurate measure of association for a cohort study, the odds ratio was reported for the bivariate analysis in order to maintain consistency with the reporting of the multivariate analysis.

Multivariate analyses were conducted to describe the association between exposures and outcomes after adjusting for potential confounders. Given the incomplete nature of the data set, further data cleaning was required prior to multivariate analysis. Observations were dropped from the analysis if one or more variables were found to be missing. This yielded a complete set of 152 individual observations. Once a best-fit model was selected using the data set of 152 individuals, the model was refit with to the dataset of 257 individuals.

Logistic regression analysis was used to predict the use of SNOM based on demographic and clinical indicators. Variables were included in the analysis if they showed significant levels of difference during bivariate analysis or if they were of particular interest. A single-variable model was selected based on maximization of the likelihood ratio χ^2 goodness-of-fit statistic. Additional predictors were added to the model in a step-wise progression. Higher-order models (increased number of variables) were compared with previous versions using the likelihood-ratio test. The best-fit higher-order models were selected such that Aikaiki's Information Criterion (AIC) was minimized. The process was continued until all significant variables had been added.

Once the best-fit model had been determined, possible common confounders and effect modifiers were added and tested. Confounding between variables was examined by comparing β-coefficients. Changes of greater than 10% were considered to indicate likely confounding terms. To test for effect modification, interaction terms were added to the model and evaluated for statistical significance.

Regression diagnostics were used to check the accuracy of the model. Standardized Pearson residuals and deviance residuals were plotted against the linear predictor. The plots were examined for systematic patterns which would indicate incorrect models. In addition, outliers were identified, after which the models were rerun with the outliers excluded.

Because of the variability in the length of hospital, the Kaplan-Meier method was used to analyze the time-to-event functions for mortality and overall complications during hospital stay. Overall time-to-event was measured from the date of admission until discharge or death. Data on survivors were censored at the time of discharge. Differences between Kaplan-Meier curves were detected using the log-rank χ^2-test. Cox proportional hazard model was used to examine the relationship between time-to-event and prognostic variables. A best-fit multivariable model was created using a logical forward selection of all available prognostic indicators similar to the method for the logistic regression model selection and checking described above.

All statistical tests were 2-sided at $\alpha=0.05$, and 95% confidence intervals (CI) are used throughout.

3.9 Ethics

The key ethical issues that arose from this retrospective chart review involved aspects of autonomy, beneficence, and non-maleficence. In general, this study posed minimal potential risks to the patients since human subjects were not actually involved. In regard to autonomy, participants were not recruited or reimbursement and informed consent was not sought since patients had been previously discharged. However, consent to view patient records was necessary and was granted by the Department of Surgery Research Committee.

In regard to beneficence, this study, while having no direct benefit to participants, has the potential for indirect benefits by addressing resources allocation and quality of service. Issues of resource allocation are particularly important in public sector settings that are financially strapped. With the alarming rates of gun violence in South Africa, cost-effective management of trauma services are needed that do not compromise quality of care. This research provides direct benefit to the Department of Surgery and the Groote Schuur Hospital by providing information on patient management protocols.

In regard to non-maleficence, major patient risks of this retrospective chart review centred on confidentiality and disclosure of sensitive medical information. As such, safety measures were put in place to ensure anonymity of patients during the review, collection, and analysis of data. First, only absolutely necessary demographic information was collected on each patient. Second, each patient received a study-issued, automatically generated number that was wholly independent of other personal identification markers. This number was used to distinguish study participants. Only one master list contained information directly linking study-issued numbers to patient folder numbers. This list was kept as an encrypted and password protected document on one computer. In addition, all databases in Excel and STATA used the study-issued number as the patient identifier without links to any personal identifiers such as surnames or hospital identification numbers. As a result, no participant identifiers have been included in the presentation of results. Third, after publication of the study results, all electronic files with personal identification information will be deleted and all data collection forms will be destroyed. Every possible step has been taken to minimize the risk of unintentional disclosure of private information during the course of the study.

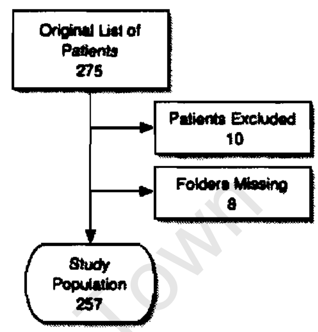
The study adheres to the Declaration of Helsinki 2000 (WMA, 2000) and was conducted upon approval from the University of Cape Town Faculty of Health Sciences Research Ethics Committee and the Department of Surgery Research Committee.

Chapter 4: Results

4.1 Study Population

From the original 275 patients admitted to GSH for the treatment of abdominal gunshot wounds between 1 April 2004 and 31 March 2005, 10 patients were excluded based on the exclusion criteria described above. Two patients died in the trauma resuscitation bay immediately upon arrival to the hospital. One patient had been misidentified as a gunshot wound; upon review of the trauma report, he was found to have sustained a stab wound and was therefore excluded. Seven patients sustained injuries outside of the boundaries of the abdomen. In addition, 8 patients' records were missing. In the end, 257 patients were included in the study population (see Figure 4.1).

Figure 4.1 Diagram of Study Population



4.2 Completeness of Data

Appendix 4 illustrates the completeness of the data collection process. Given the heterogeneity of the paper/microfilm patient records, there was initial concern regarding the ability to analyze the data set if many values were missing. Fortunately, complete demographic data were found for greater than 80% of patients' charts.

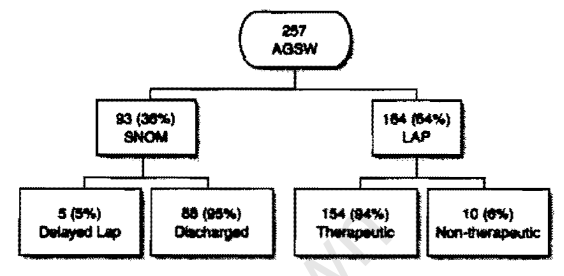
Clinical variables were also available for the majority of patients using the initial Trauma Unit Record. However, the respiratory rate (RR) was consistently unrecorded in over 70% of the patients. Because of the missing respiratory rate, the revised trauma score (RTS) was not computable for these patients. In addition, the presence of free air under the diaphragm (FREE) was often missing from the Trauma Unit Record.

Outcome variables were consistently available for greater than 80% of the patients as well. Mortality after 1 week was the exception; however, this is understandable given that many patients were discharged from the hospital prior to 1 week lapse.

4.3 Rates of Delayed Surgery and Negative Laparotomy

Figure 4.2 illustrates the breakdown of abdominal gunshot wound into management categories from initial presentation at the trauma centre. Ninety-three of 257 (36%) patients were initially managed non-operatively. Of these 93 participants, 5 (5%) eventually failed non-operative management and went to the operating theatre for a delayed laparotomy. For this study, a delayed laparotomy specifically denotes a participant who was initially selected for SNOM but failed as indicated by the appearance of new abdominal tenderness, progression of abdominal pain to a more diffuse peritonitis, unexplained hypotension, or drop in haemoglobin over the course of the observation period. There were 164 of 257 (64%) participants who were managed surgically. Ten (6%) of these laparotomies were non-therapeutic. A non-therapeutic laparotomy occurred when no intraadominal injuries were found to require repair. Based on this sample, the clinical examination has a sensitivity and specificity of 97% and 90%, respectively.

Figure 4.2 Delayed Lap and Negative Lap Rates



Neither a delayed laparotomy or a negative laparotomy resulted in mortality during the hospital stay. For those who underwent delayed laparotomy, 2 of 5 (40%) had complications compared to 2 of 10 (20%) in the negative laparotomy group. However, these proportions are not statistically different given the small sample size (data not shown).

4.4 Frequency of Organ Injuries

Table 4.1 lists the frequency of organ injury by initial management group in this cohort study. As can be seen, injuries to hollow visceral organs, such as the stomach, small bowel, colon, and rectum, were most often taken for immediate laparotomy. However, a few patients were found to have questionable hollow visceral organ injuries. In one case, the patient presented with a stomach injury as reported on CT scan. The patient was clinically stable, managed non-operatively, and was discharged home. Another patient was found to have a superficial rectal injury seen by rigid sigmoidoscopy. The decision was made for non-operative management because of the superficial nature of the injury. This was also successfully managed non-operatively and the patient was discharged home. Although retrospective review of these two cases creates doubt as the whether these were actual hollow visceral organ injuries, for the purposes of this study, these patients were classified based on their initial imaging and endoscopy results.

In contrast to hollow organs, solid organ injuries were more frequently treated with SNOM. Approximately one-third of liver injuries were successfully treated non-operatively. Lung injuries were also commonly found in both surgically and non-surgically managed groups. It should be noted that the insertion of a chest tube is the standard of care for a pneumothorax or hemothorax and does not require the operating theatre.

Table 4.1 Frequencies of Organ Injuries

Initial Management	Lung	Diaphragm	Stomach	Small Bowel	Colon	Rectum	Liver	Spleen	Kidney	Bladder	Spine	Ortho	Vascular	Other
LAP (n=164)	31 50%	29 88%	35 96%	83 97%	52 99%	19 95%	45 70%	13 87%	32 82%	13 87%	9 75%	18 72%	19 95%	23 73%
SNOM * (n=93)	31(3) 50%	4 (2) 12%	1 (0) 4%	1 (1) 3%	2 (2) 1%	1 (0) 5%	19 (2) 30%	2 (1) 13%	7 (1) 18%	2 (1) 13%	3 (1) 25%	7 (0) 28%	1 (0) 5%	9 (1) 27%
Total (n=257)	62 24%	33 13%	36 14%	84 33%	54 21%	20 8%	64 25%	15 6%	39 15%	15 6%	12 5%	25 10%	20 8%	32 13%

* Number in parentheses denote the number of SNOM that eventually converted to a delayed laparotomy.

4.5 Demographic Description

4.5.1 Study Cohort

A total of 257 patients were included in the data analysis. All continuous variables were not normally distributed and are reported with median (IQR). In general, the study population consisted of young, male, unemployed, unmarried Xhosa-speakers. The median age of the study population was 25 years (IQR 21-33). Males accounted for the vast majority of participants (91%). Xhosa was the primary language for 171 (73%) participants. One-hundred-eighty-two (85%) were single and 159 (69%) were unemployed. Approximately one-third of all patients in the study population received SNOM. (See Table 4.2)

Table 4.2 Demographic Description of Study Population

Variable	Total	LAP n (%)	SNOM n (%)	OR (95% CI) *p-value*
Management		164 (64%)	93 (36%)	
Age (n=257)*	25 (21-33)	24 (21-32)	27 (20-34)	*0.57*
Gender (n=257)				
Male	234 (91%)	150 (91%)	84 (90%)	1.14 (0.48-2.76)
Female	23 (9%)	14 (9%)	9 (10%)	*0.76*
Language (n=235)				
Xhosa	171 (73%)	110 (75%)	61 (69%)	1.32 (0.73-2.37)
Other	64 (27%)	37 (25%)	27 (31%)	*0.36*
Marital Status (n=213)				
Single	182 (85%)	115 (86%)	67 (84%)	1.24 (0.57-2.69)
Other	31 (15%)	18 (14%)	13 (16%)	*0.59*
Employment (n=231)				
Unemployed	159 (69%)	109 (74%)	50 (60%)	1.95 (1.10-3.45)
Employed	72 (31%)	38 (26%)	34 (40%)	*0.02*

* Median (IQR) values indicated

4.5.2 Bivariate Analysis by Management Group

Division of the total cohort by management yielded subgroups that were similar in terms of demographic characteristics (see Table 4.2). Participants undergoing SNOM were generally similar to those undergoing surgical intervention for all variables examined. The mean age for the SNOM group was 27 years (IQR 20-34) compared to 24 years (IQR 21-32) for the surgical group. Eighty-four (90%) of SNOM patients were male compared to 150 (91%) of surgical patients. Xhosa was the primary language for 110 (75%) of surgically managed patients compared to 61 (69%) of SNOM patients. Interestingly, employment status was the only demographic character that was statistically different between the two treatment subgroups. Fifty (60%) of SNOM patients were unemployed compared to 109 (74%) of surgical patients. Being unemployed increased the odds of surgical management by 95% (OR 1.95; 95% CI 1.10-3.45).

4.6 Clinical Indicators

4.6.1 Study Cohort

Table 4.3 lists the clinical measurements that were available at presentation to the trauma centre. Approximately 80% of the participants were transferred to GSH from an outside hospital for treatment. The median heart rate was 92 beats per minute (IQR 81-105) with a median blood pressure was 135/74 mmHg (IQR 118-148/64-87). Median haemoglobin value was 12 g/dL(IQR 10-13.5) These values are generally consistent with normal vital signs. The median ISS was 10 (IQR 9-17). Clinical signs of an acute abdomen were noted in 136 (54%)

patients. Twenty-four (13%) had free air under the diaphragm by chest x-ray. Thirty-eight (15%) presented with haemodynamic instability.

4.6.2 Bivariate Analysis by Management Group

Despite having similar modes of arrival to the hospital, the two management groups differed in clinical measurements at initial presentation. Participants who underwent SNOM had a lower median heart rate (p=0.0001), higher median systolic blood pressures (p=0.02), and higher median haemoglobin levels (p=0.004) compared to participants in the surgical group. In addition, the median retrospective calculation of the ISS was also lower in the SNOM group versus the surgical group, 4 versus 10 (p=0.0001). Lastly, those participants presenting with an acute abdomen, free air under the diaphragm, or haemodynamic instability were more likely to undergo surgical intervention. Of note, the median delay to the operating room was 182.5 minutes (IQR, 122.5-314) for those undergoing surgical intervention. (see Table 4.3)

Table 4.3 Clinical Description of Study Population

Variable	Total	LAP n (%)	SNOM n (%)	OR (95% CI) *p-value*
Management		164 (64%)	93 (36%)	
Mode of Arrival (n=249)				
Direct	49 (20%)	32 (20%)	17 (19%)	1.11 (0.57-2.13)
Transfer	200 (80%)	126 (80%)	74 (81%)	*0.76*
HR in bpm (n=254)*	92 (81-105)	96 (85-109)	87 (76-98)	*0.0001*
SBP in mmHg (n=257)*	135 (118-148)	131 (115-147)	139 (126-151)	*0.02*
DBP in mmHg (n=257)*	74 (64-87)	73 (61-85)	76 (67-92)	*0.02*
RR in bpm (n=73)*	18 (15-20)	18 (15-20)	16 (14-20)	*0.70*
HGB in g/dL (n=248)*	12 (10-13.5)	11.5 (10-13)	12.5 (11-14)	*0.004*
GCS (n=252)*	15 (15-15)	15 (15-15)	15 (15-15)	*0.009*
ISS (n=257)*	10 (9-17)	10 (9-17.5)	4 (1-11)	*0.0001*
Blood in Urine (n=220)				
No blood	91 (41%)	55 (37%)	36 (49%)	
Trace	56 (25%)	36 (24%)	20 (27%)	*0.08*
Occult	73 (33%)	56 (38%)	17 (23%)	
Acute Abdomen (n=254)				
Absent	118 (46%)	27 (17%)	91 (98%)	0.004 (0.001-0.02)
Present	136 (54%)	134 (83%)	2 (2%)	*0.001*
Free Air (n=178)				
Absent	154 (87%)	75 (77%)	79 (99%)	0.04 (0.005-0.31)
Present	24 (13%)	23 (23%)	1 (1%)	0.002
Haemodynamics (n=248)				
Stable	210 (85%)	124 (78%)	86 (97%)	0.12 (0.04-0.41)
Unstable	38 (15%)	35 (22%)	3 (3%)	*0.001*
ISS (n=257)				
≤ 15	167 (65%)	91 (55%)	76 (82%)	0.28 (0.15-0.51)
> 15	90 (35%)	73 (45%)	17 (18%)	*0.0001*
GCS (n=257)				
≥ 13	250 (97%)	158 (96%)	92 (99%)	0.30 (0.04-2.51)
<13	7 (2%)	6 (4%)	1 (1%)	*0.27*
Time to OR or discharge (n=257)*	330 (160-3209)	182.5 (122.5-314)	3915 (2645-6440)	*0.0001*

* Median (IQR) values indicated

4.6.3 Multivariate Analysis for Selective Non-Operative Management

A multivariate logistic regression analysis was conducted to predict the relative odds of SNOM based on demographic and clinical indicators (see Appendix 5 for model selection). Low GCS was a perfect predictor of surgical intervention. In addition, the presence of an acute abdomen virtually ruled out the possibility of selective non-operative management (OR 0.005; 95% CI 0.001-0.02). Lastly, for every one-unit increase in the ISS, the odds of selective non-operative management decreased by 10%. (See Table 4.4)

Table 4.4 Best-Fit Multivariate Logistic Regression Analysis Predicting SNOM

	Odds of SNOM (95% CI)
Acute Abdomen	
Absent	1.00 (reference)
Present	0.005 (0.001-0.02)
ISS	0.90 (0.85-0.95)

4.7 Outcome Variables

4.7.1 Study Cohort

Table 4.5 illustrates the outcome variables for the study cohort. Six (2%) patients died within 24 hours of arrival to the hospital. Nine (4%) of the patients died during the entire follow-up period. The median real length of hospital stay was 5.6 days (IQR 3.5-9.6) with the billed length of hospital stay being slightly higher. Fifty-three (21%) of study cohort experienced an infection usually in the form of a localized wound, respiratory, or urinary infection requiring prolonged antibiotic treatment. Forty-six (18%) of the study cohort experienced a non-infectious complication such as a small bowel obstruction or iatrogenic injury. A further 53 patients (21%) were readmitted during the following year. Lastly, the median cost per admission was ZAR 11,750 (IQR 8,145-20,580) or USD 1,808 (IQR 1,253-3,166) using the exchange rate of 6.5 ZAR:1 USD (October 2004).

Table 4.5 Comparisons of Outcome Variables for Study Population

Variable	Total	LAP n (%)	SNOM n (%)	OR (95% CI) *P-value*
Management		164 (64%)	93 (36%)	
Mortality 24hr (n=257)				
Alive	251 (98%)	158 (96%)	93 (100%)	
Dead	6 (2%)	6 (4%)	0 (0%)	*0.09*
Mortality 1 wk (n=169)				
Alive	160 (95%)	120 (93%)	40 (100%)	
Dead	9 (5%)	9 (7%)	0 (0%)	*0.12*
Mortality during stay (n=257)				
Alive	248 (97%)	155 (95%)	93 (100%)	
Dead	9 (3%)	9 (5%)	0 (0%)	*0.03*
Infection (n=257)				
None	204 (79%)	118 (72%)	86 (92%)	0.21 (0.09-0.48)
Infection	53 (21%)	46 (28%)	7 (8%)	*< 0.001*
Complication (n=257)				
None	211 (82%)	123 (75%)	88 (95%)	0.17 (0.06-0.45)
Complication	46 (18%)	41 (25%)	5 (5%)	*< 0.001*
Overall complication (n=257)				
None	181 (70%)	98 (60%)	83 (89%)	0.18 (0.09-0.37)
Complication	76 (30%)	66 (40%)	10 (11%)	*< 0.001*
Readmission (n=248)				
No readmission	195 (79%)	119 (77%)	76 (82%)	0.74 (0.39-1.41)
Readmission	53 (21%)	36 (23%)	17 (18%)	*0.36*
Real Stay in Days (n=257)*	5.6 (3.5-9.6)	7.2 (5.1-12.7)	3.2 (2.1-5.3)	*< 0.0001*
Billed Stay in Days (n=257)*	7 (4-11)	8 (6-14)	4 (3-6)	*< 0.0001*
Cost in ZAR (n=257)*	11750 (8145-20580)	13768 (10580-28816)	6225 (4340-11560)	*< 0.0001*
Binary cost category (n=257)				
Low	129 (50%)	57 (35%)	72 (77%)	0.16 (0.09-0.28)
High	128 (50%)	107 (65%)	21 (23%)	*< 0.001*

* Median (IQR) values indicated

4.7.2 Bivariate Analysis by Management Group

Bivariate analysis by management group showed that frequencies of 24-hour mortality and 1-week mortality were not statistically different between the two management arms. However, mortality during hospital stay was significantly different with 9 patients (4%) experiencing a negative outcome with surgical intervention compared to none in the SNOM group (p=0.03). Rates of infectious and non-infectious complications were higher in the surgical groups as well. Patients undergoing SNOM were 82% less likely to have any complication compared to those undergoing surgical management (OR 0.18; 95% CI 0.09-0.37). In addition, length of hospital stays were approximately 4 days longer for surgically managed patients compared to those managed non-operatively (p<0.0001). This was consistent with higher hospital costs for patients undergoing surgery. Patients undergoing non-operative management were 84% less likely to have high costs compared to patients undergoing surgical management (OR 0.16; 95% CI 0.09-0.28). Rates of readmission were not statistically different between the two groups (see Table 4.5).

4.7.3 *Mortality During Hospital Stay: Bivariate and Multivariate Analysis*

In order to determine those variables that were influential on the mortality rate during the hospital stay, a bivariate analysis was undertaken. This analysis showed that the median systolic and diastolic blood pressure, haemoglobin level, and injury severity score differed significantly between those patients who experienced mortality during the hospital stay. In addition, patients with haemodynamic instability upon admission were 7.8 times more likely to die compared to those without haemodynamic instability (p=0.003). These results suggest that these variables may independently be associated with increased risk of mortality during hospital stay. Table 4.6 highlights the variables showing a statistically significant different between the No Mortality and Mortality groups. For a complete listing of the bivariate analysis see Appendix 6.

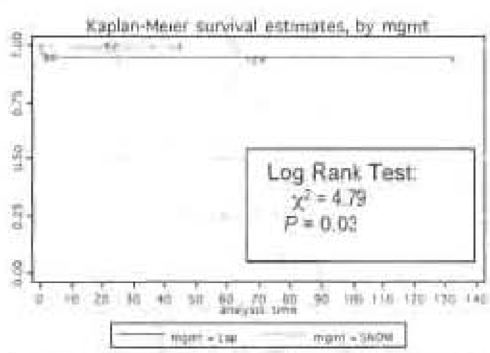
Table 4.6 Bivariate Analysis of Mortality During Hospital Stay

Variable	Total	No Mortality n (%)	Mortality n (%)	OR (95% CI) *p-value*
SBP (n=257)*	135 (118-148)	135 (119.5-149.5)	101 (88-126)	*0.03*
DBP (n=257)*	74 (64-87)	74 (65-87)	51 (41-60)	*0.01*
HGB (n=248)*	12 (10-13.5)	12 (10.5-13.5)	9.5 (7.5-10)	*0.002*
ISS (n=257)*	10 (9-17)	10 (9-16.5)	25 (10-25)	*0.04*
Haemodynamics (n=248)				
Stable	210 (85%)	206 (86%)	4 (44%)	7.80 (2.00-30.56)
Unstable	38 (15%)	33 (14%)	5 (56%)	*0.003*
Management (n=257)				
Lap	164 (64%)	155 (63%)	9 (100%)	
SNOM	93 (36%)	93 (37%)	0 (0%)	*0.03*

* Median (IQR) values indicated

In order to take into account a varying length of follow-up, as determined by the length of hospital stay, Kaplan-Meier time-to-event curves were generated for the two management groups. As can be seen in Figure 4.3, the surgical group experienced 9 negative outcomes during the follow-up period (6% mortality rate by 16 days) while the SNOM group experienced no deaths by 32 days. The median survival times are unavailable for this cohort since 50% of the population never experienced mortality.

Figure 4.3 Time-to-Event Function Analysis for Mortality During Hospital Stay



Time	LAP	SNOM
0	1.00	1.00
16	0.94 (0.89-0.97)	1.00
32	0.94 (0.89-0.97)	1.00
48	0.94 (0.89-0.97)	-
64	0.94 (0.89-0.97)	-
80	0.94 (0.89-0.97)	-
96	0.94 (0.89-0.97)	-
112	0.94 (0.89-0.97)	-
128	0.94 (0.89-0.97)	-

A Cox's Proportional Hazard Model was created to determine those characteristics most influential in affecting mortality rates during hospital stay. Unfortunately, given the absence of outcomes in the SNOM group, the hazard of death in SNOM compared to LAP was infinitely small. These results were not altered by adjustment for DBP or ISS, the two variables found by best-fit model selection (see Appendix 7).

4.7.4 Overall Complication Rate: Bivariate and Multivariate Analysis

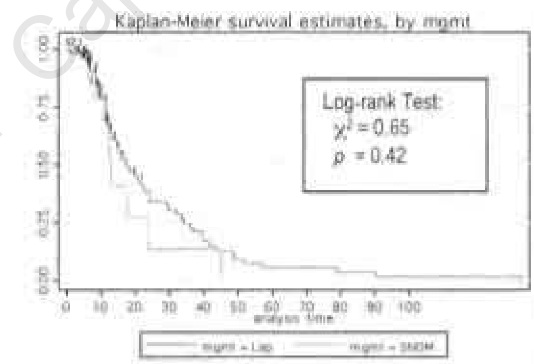
A similar multivariate logistic regression analysis was undertaken for the analysis of overall complication rate during the hospital stay. In order to determine the variables having an independent association with the overall complication rate, a bivariate analysis of demographic and clinical variables was conducted. Median respiratory rate, haemoglobin level, and injury severity score differed significantly between those patients who experienced any complication during the hospital stay compared with those who did not experience any complication. In addition, the presence of blood in the urine, an acute abdomen, and haemodynamic instability were associated with higher risk of any complication. Patients with an acute abdomen at admission were 2.95 times (OR 2.95; 95% CI 1.64-5.29) more likely to experience any complication compared to patients without an acute abdomen at presentation. In addition, haemodynamic instability increased the risk of any complication during the hospital stay by 2.48 (OR 2.48; 95% CI 1.22-5.02) times. Lastly, SNOM decreased the rate of complication by 82% (OR 0.18; 95% CI 0.09-0.37). Table 4.7 highlights the variables showing a statistically significant different between the No Complication and Complication groups. For a complete listing of the bivariate analysis see Appendix 8.

Table 4.7 Bivariate Analysis of Overall Complications During Hospital Stay

Variable	Total	No Complication n = 181 (70.43%)	Complication n = 76 (29.57%)	OR (95% CI) *p-value*
RR (n=73)	18 (15-20)	16 (14-20)	20 (15-26)	*0.04*
HGB (n=248)	12 (10-13.5)	12.5 (10.5-14)	11 (9.5-12.5)	*< 0.0001*
ISS (n=257)	10 (9-17)	9 (3-16)	16 (9-19)	*< 0.0001*
Blood in Urine (n=220)				
No blood	91 (42%)	69 (45 %)	22 (34%)	
Trace	56 (25%)	44 (29%)	12 (18%)	*0.006*
Occult	73 (33%)	41 (26%)	32 (48%)	
Acute Abdomen (n=254)				
Absent	118 (46%)	97 (54%)	21 (28%)	2.95 (1.64-5.29)
Present	136 (54%)	83 (46%)	53 (72%)	*< 0.001*
Haemodynamics (n=248)				
Stable	210 (85%)	154 (89%)	56 (76%)	2.48 (1.22-5.02)
Unstable	38 (15%)	20 (11%)	18 (24%)	*0.01*
Management (n=257)				
Lap	164 (64%)	98 (54%)	66 (87%)	0.18 (0.09-0.37)
SNOM	93 (36%)	83 (46%)	10 (13%)	*< 0.001*

Kaplan-Meier time-to-event curves were generated for overall complications during hospital stay for the two management groups. The median time-to-event was 12.9 days for the SNOM group compared to 17.6 days for the surgical group. As can be seen in Figure 4.3 these two curves were not statistically different curves (*p*=0.42).

Figure 4.4 Time-to-Event Function Analysis for Overall Complications During Hospital Stay



Time	LAP	SNOM
0	1.00	1.00
16	0.52 (0.40-0.63)	0.41 (0.11-0.69)
32	0.30 (0.19-0.42)	0.14 (0.01-0.44)
48	0.13 (0.06-0.24)	-
64	0.06 (0.02-0.14)	-
80	0.04 (0.01-0.11)	-
96	0.02 (0.00-0.09)	-
112	0.02 (0.00-0.09)	-
128	0.02 (0.00-0.09)	-
144	-	-

Table 4.8 summarizes the multivariate analysis for overall complication during hospital stay. Model 1 shows unadjusted Hazard Ratio. There was a 32% increase in the hazard of overall complication with SNOM compared to surgery, although this was not statistically significant. This non-significant difference persisted after adjusting for injury severity in Model 2 and after adjusting for injury severity plus age in Model 3. Model 3 contains the variables from the best-fit model. These results are consistent with the non-significant Kaplan-Meier time-to-event curves above (See Appendix 9 for model selection). According to the fully adjusted Model 3, the hazard of overall complications increased by 1 for every one unit increase in

ISS. In addition, for every one unit increase in age, the hazard of overall complication decreased by 2%.

Table 4.8 Multivariate Analysis of Overall Complications During Hospital Stay

	Model 1	Model 2	Model 3
Management			
LAP	1.00 (reference)	1.00 (reference)	1.00 (reference)
SNOM	1.32 (0.67-2.63)	1.29 (0.63-2.63)	1.25 (0.61-2.55)
ISS		1.00 (0.97-1.03)	1.00 (0.96-1.02)
Age			0.98 (0.96-1.00)

These results suggest that despite the significant association between management group and complication rate observed in crude analyses, there was no significant increase in rate of overall complication between the two management groups after taking into account the varying lengths of follow-up.

4.7.5 Cost as Binary Variable: Bivariate and Multivariate Analysis

Lastly, a bivariate analysis examined cost as a binary variable. Median heart rate, haemoglobin level, Glasgow coma scale, and injury severity score differed significantly between high cost and low cost patient. In addition, the presence of blood in the urine, an acute abdomen, and haemodynamic instability were associated with higher risk of high cost. Patients with an acute abdomen at admission were 4.64 times (OR 4.64, 95% CI 2.73-7.89) more likely to experience high cost. In addition, haemodynamic instability increased the risk of high cost by 6.58 (OR 6.58 2.64-16.41) times. Lastly, SNOM decreased the probability of a high cost hospital stay by 84% (OR 0.16; 95% CI 0.09-0.28). Table 4.9 highlights the variables showing a statistically significant different between high cost and low cost groups. For a complete listing of the bivariate analysis see Appendix 10.

Table 4.9 Bivariate Analysis of Cost of Hospital Stay

Variable	Total	Low n = (%)	High n = (%)	OR (95% CI) *p-value*
HR (n=254)*	92 (81-105)	89 (78-101)	96 (84-110)	*0.005*
HGB (n=248)*	12 (10-13.5)	12.5 (11-14)	11 (10-12.5)	*< 0.0001*
GCS (n=252)*	15 (15-15)	15 (15-15)	15 (15-15)	*0.002*
ISS (n=257)*	10 (9-17)	9 (2-10)	16 (9-19)	*< 0.0001*
Blood in Urine (n=220)				
No blood	91 (42%)	56 (51%)	35 (32%)	
Trace	56 (25%)	30 (27%)	26 (24%)	*0.001*
Occult	73 (33%)	24 (22%)	49 (44%)	
Acute Abdomen (n=254)				
Absent	118 (46%)	83 (64%)	35 (28%)	4.64 (2.73-7.89)
Present	136 (54%)	46 (36%)	90 (72%)	*< 0.001*
Haemodynamics (n=248)				
Stable	210 (85%)	116 (95%)	94 (75%)	6.58 (2.64-16.41)
Unstable	38 (15%)	6 (5%)	32 (25%)	*< 0.001*
Management (n=257)				
Lap	164 (64%)	57 (44%)	107 (84%)	0.16 (0.09-0.28)
SNOM	93 (36%)	72 (56%)	21 (16%)	*< 0.001*

* Median (IQR) values indicated

A multivariate logistic regression analysis was conducted to describe a model for cost as a binary variable based on demographic and clinical indicators. Table 4.10 summarizes the results of the analysis. Model 1 shows the unadjusted odds ratio of high cost hospital stay. Patients in the SNOM group had an unadjusted 84% decrease in the odds of high cost compared to the surgical group (OR 0.16, 95% CI 0.09-0.28). After adjusting for those variables found in the best-fit model, this decrease became statistically insignificant (OR 0.40, 95% CI 0.15-1.08). Model 2 suggests that for every one unit increase in injury severity, the odds of high cost increase by 12%. In addition, for every one unit increase in haemoglobin level, the risk of high cost decreases by 21%. The presence of an acute abdomen, while significant in the best-fit model, became insignificant once management group was added to the model (see Appendix 11 for model selection).

Table 4.10 Logistical Regression Models for Odds of High Cost

	Model 1	Model 2
Management		
LAP	1.00 (reference)	1.00 (reference)
SNOM	0.16 (0.09-0.28)	0.40 (0.15-1.08)
ISS		1.12 (1.07-1.18)
Acute Abdomen		
Negative		1.00 (reference)
Positive		1.64 (0.64-4.21)
Haemoglobin		0.79 (0.68-0.92)

4.8 Analysis Using Revised Classification Scheme

Appendix 12 shows the bivariate analysis using the revised classification scheme based on the delay to the operating theatre. The revised classification scheme resulted in the reclassification of 4 patients who were originally classified as surgically managed into the SNOM group. This had little effect on the original bivariate analysis other than to slightly decrease odds ratios. There were no significant changes to the *p*-values. As a result, multivariate analysis was not conducted with the revised scheme.

Chapter 5: Discussion

5.1 Summary of Key Findings

This retrospective cohort study found approximately one-third of patients presenting to a level I trauma centre with an abdominal gunshot wound were effectively managed non-operatively. Ninety-three of 257 (36%) abdominal gunshot wound victims were expectantly managed. Of these patients, only 5 (5%) converted to a delayed laparotomy. Of the 164 patients who were treated with immediate laparotomy, 10 (6%) underwent non-therapeutic laparotomies. Two of the 5 (40%) delayed laparotomies and 2 of 10 (20%) non-therapeutic laparotomies had post-operative complications. These numbers indicate that the clinical examination has a sensitivity and specificity of 96.9% ad 89.8%, respectively.

Comparing the two management groups, patients who were non-operatively managed tended to be less severely injured with a median ISS of 4 versus 10 ($p<0.001$). In addition, they presented with less severe signs of haemodynamic compromise. The median heart rate was lower for the SNOM group at 87 beats per minute versus 96 beats per minute ($p<0.001$); the median systolic blood pressure was higher in the SNOM group 139 mmHg versus 131 mmHg ($p = 0.02$); and the median haemoglobin level was higher in the SNOM group, 12.5 g/dL versus 11.5 g/dL ($p=0.004$). As a result, outcomes were also better for patients who were expectantly managed. Non-operatively managed patients had decreased median length of hospital stays 3.16 versus 7.23 hospital days ($p<0.001$). This decreased length of stay was associated with lower median hospital costs and 6,225 ZAR versus 13,768 ZAR ($p<0.001$). In addition, there were no deaths within the cohort of patients that were expectantly managed over the course of the hospital stay compared to 9 deaths in the group of surgically managed patients. Complications, such as infection requiring antibiotic use or iatrogenic injury, were lower in the group that was non-operatively managed (OR 0.18, 95% CI 0.09-0.37). After adjusting for injury severity score and other possible confounders, the association between non-operative management and reduced complication rate was not statistically significant (OR 1.25, 95% CI 0.61-2.55). In addition, SNOM was positively associated with a lower cost (OR 0.16, 95% CI 0.09-0.28). However, this was not statistically significant after adjusting for confounders as well (OR 0.40, 95% CI 0.15-1.08).

5.2 Rates of SNOM versus Immediate Laparotomy

The rates of SNOM versus immediate laparotomy in this study fall within the range of previously published epidemiologic studies. Previous studies showed rates of SNOM varying between 5% and 73.3%. The largest published study from the United States examined 1,856 patients admitted for abdominal gunshot wounds over an 8 year period at a major urban trauma centre. Of these patients, 42% were managed non-operatively (Velmahos, et al., 2001).

This study found the rate of conversion from SNOM to delayed laparotomy to be 5% and the rate of non-therapeutic laparotomy to be 6%. These results are also consistent with previously published data. Prior published data report conversion rates from SNOM to delayed laparotomy ranged from 0 to 17% (Renz and Feliciano, 1994; Demetriades, et al., 1997; Velmahos, et al., 1998). From these numbers, the clinical examination on admission was highly sensitivity and specificity for detecting intraabdominal injury. The sensitivity and specificity from this study were slightly lower than what has previously been reported in smaller studies from the United States (Velmahos, et al., 1997a; Velmahos, et al., 1997b; Velmahos, et al., 1998). It should be noted that two of the studies that reported the sensitivity of 100% had a sample size of less than 40 with no delayed laparotomies. The third study of 188 patients admitted for posterior abdominal gunshot wounds had a 3% delayed laparotomy rate; however, the 4 patients who underwent delayed laparotomy were found to have no injuries. The results of this study, combined with results from prior studies, suggest that the initial abdominal examination is a sensitive and specific test for intraabdominal injury.

5.3 Demographic Characteristics of Victims of Violence

This study examined the clinical outcomes and costs associated with the selective non-operative management of abdominal gunshot wounds at a level I trauma centre. Demographic analysis of the study population show that the overwhelming majority of victims of abdominal gunshot wounds at Groote Schuur Hospital were male, unemployed, unmarried Xhosa-speakers who were in their third decade of life. Of the demographic characteristics examined, employment status was the only feature that was significantly different between the two management groups; being unemployed increased the odds of surgical management by 95% (OR 1.95, 95% CI 1.10-3.45).

These numbers are consistent with prior studies that have examined the burden of violence globally and in South Africa (Krug, et al., 2002; Bradshaw, et al., 2006; Matzopoulos, 2004; Meel, 2004). Young men tend to be the perpetrators and victims of violence across the globe. The eventual use of violence is a multifactorial process. In one review of 282 articles published between 1985 and 1995, violence was attributed to a variety of causes ranging from easy access to firearms to environmental toxins (Winett, 1998). The most commonly accepted causes of violence in the literature are access to firearms, drug and alcohol use, poverty/unemployment, culture of violence, family breakdown, and racism (Winett, 1998; Wright, 1997; Yancy, et al., 1994).

Interestingly, this study found an association between unemployment and laparotomies. Prior studies have indicated that unemployment is associated with increased violence (Wright and Kariya, 1997; Yancy, et al., 1994; Cubbin, et al., 2000). A matched case-control study of 70 victims of assault in the United Kingdom and found that victims of assault were more likely to be unemployed (Wright and Kariya, 1997). A second study in the United States found a similar association between unemployment and risk of victimization. Cubbin, et al., (2000) examined data from 1,352 injury-related deaths in the United State's National Health Interview Survey (NHIS) and found that unemployed people had 5.7 times greater risk of mortality from homicide compared to white collar workers. All three studies concluded that unemployment increased the risk of victimization from violent trauma and unemployment. Youth without access to education, employment, or prospects for a fulfilling future are more likely to be involved in risky behaviour, putting them at risk of victimization or violent tendencies (Winett, 1998)

Within the above context, the positive association between unemployment and laparotomy appears plausible. At the same time, increased ISS was also associated with laparotomy which suggested possible confound. If people who were unemployed were more likely to be severely injured from engaging in more risky behaviour, the unadjusted association between unemployment and laparotomy would be spurious. However, further data analysis indicated that this was not the case. Unemployment was not associated with a higher ISS, indicating that unemployment was independently associated with laparotomy (data not shown).

One potential explanation is that ISS may be limited as a marker of injury severity. ISS, like all measures, is limited in that it may capture many but not all aspects of injury severity. Employment status may provide additional information on injury severity through its association with socioeconomic status. For instance, an unemployed patient may be more likely to present after a long delay because he lives further away from the trauma centre or lacks the transportation needed to reach the trauma centre. In contrast, an employed patient may have access to private emergency medical service transportation and be more likely to arrive at the trauma centre in a timely fashion. Thus, the observed employment-laparotomy association observed in this study is unlikely to be causal in nature. Rather unemployment is an added marker for unmeasured injury severity.

Another hypothesis is that unemployed patients were more likely to have a lower threshold for surgery. One cause for a lower threshold would be neurologic compromise in the form of a spinal cord injury or substance intoxication. Given the preponderance of studies associating alcohol use, violence, and unemployment, it is not unreasonable to hypothesize that unemployed patients were more likely to be neurologically impaired from alcohol or drug use. This would then lower the threshold for surgical intervention because of the decreased reliability of the abdominal examination. In this study, blood alcohol levels were not available for the patients admitted to the hospital. However, data from South Africa suggest alcohol is common associated with violent deaths. Of violent deaths in South Africa in 2003, 51% were found to be positive for alcohol. The mean blood alcohol content was 0.17g/100ml which is approximately equivalent to 3.5 standard drinks (Matzopoulos, 2004).

5.4 Clinical Predictors of Laparotomy

Several clinical features were found to be associated with immediate laparotomy. These included increased heart rate, decreased systolic and diastolic blood pressure, decreased haemoglobin level, low GCS, high ISS, presence of blood in the urine, presence of free air under the diaphragm, and haemodynamic instability. The statistically significant associations found during the bivariate analysis suggest that clinical indicators could potentially be used to distinguish candidates for SNOM.

The association of the above clinical measurements are consistent with current understanding of acute trauma physiology and management. Within the field of trauma surgery, the presence of an acute abdomen or free air under the diaphragm is a clinical indicator for surgery because they are highly specific tests for an enterotomy necessitating repair. Likewise, clinical parameters such as increased heart rate, decreased blood pressure, and decreased haemoglobin level often indicate acute blood loss and the need for surgical intervention.

Additionally, a high ISS reflects a more severe injury which is more likely to require surgical intervention. The ISS has been validated in prior studies and used in South Africa for trauma research (Navsaria, et al., 2005; Brooks, 1999; Roux and Fischer, 1992). In addition, Beverland and Rutherford (1982) calculated ISS for 875 patients suffering from gunshot wounds. These scores were plotted against mortality and found to have a significant non-linear relationship. Instances in which ISS would fail to predict surgical intervention would be for patients who arrive in extremis and ultimately fail resuscitation. In this study, such patients were excluded from the study population because they were not admitted to the hospital for at least 24 hours.

The above associations between clinical measures and laparotomy became less significant in the multivariate analysis. According to logistic regression analysis, the presence of an acute abdomen and the injury severity score were the best predictors for laparotomy. A low GCS was a prefect predictor of laparotomy. All other clinical measures became less significant in the multivariate analysis. These results are consistent with clinical decision-making. In general for surgical decision making, the main reasons for going to the operating theatre are to prevent cardiovascular compromise and reduce the risk of sepsis. Clinical measures that indicate cardiovascular compromise include haemodynamic instability as manifested by dynamic changes in vital signs over time or decreased neurologic function indicating cerebral hypoperfusion. The presence of an acute abdomen indicates peritoneal irritation. In the case of abdominal gunshot wounds, this usually arises from the leakage of gastrointestinal contents into the peritoneal cavity. Long term exposure to those gastrointestinal contents can lead to severe infection and sepsis. The ISS is an artificial measure that was created to encapsulates the clinical picture of traumatic injury based on the severity of injury in three major body regions. Thus, the presence of an acute abdomen, a low GCS, and the ISS represents a fairly comprehensive clinical picture of the risk for cardiovascular compromise and sepsis. Initial heart rate, blood pressure, and haemoglobin level, while clinically important, become less important because they do not contribute meaningfully to the creation of a clinically useful picture that can be used for decision making.

5.5 Predicting Mortality

The results of this study suggest that SNOM is a realistic option for the management of abdominal gunshot wounds based on clinical outcomes. There were no deaths within the non-operative management group. This is consistent with prior observational studies. Velmahos, et al., (1997) showed no mortality associated with SNOM of posterior abdominal gunshot wounds. In contrast, patients who underwent laparotomy had a higher rate of mortality.

Initial bivariate analysis suggested that clinical measures such as low blood pressure, low haemoglobin levels, high ISS, presence of haemodynamic instability, and immediate laparotomy were associated with mortality. However, further multivariate analysis using the Cox's Proportional Hazard Model found low diastolic blood pressure and high injury severity score to be the main drivers of the hazard of death among the factors examined. As discussed above, this is understandable from a physiologic standpoint. The more severely injured patient is more likely to experience mortality as a result of the injuries even after being taken to the operating theatre. ISS is most likely to give a comprehensive clinical picture. Initial diastolic blood pressure was a significant factor as well.

One caveat is that this multivariate regression analysis was severely limited due to the absence of outcomes in the SNOM group. The hazard of death was infinitely small compared to the immediate laparotomy group. This was not altered by adjustment for the variables found in the best-fit model.

5.6 Predicting Overall Complication

The results of this study suggest that SNOM is a realistic option because there is a no increased risk of overall complications. Factors found to be associated with increased overall complication in bivariate analysis included lower haemoglobin level, higher ISS, occult blood in the urine, presence of acute abdomen, haemodynamic instability, and immediate laparotomy. With multivariate analysis ISS and age were found to be the major contributors to the hazard of overall complication. Management was not statistically significant in determining the hazard of having a complication during the hospital stay.

To date, there have been no studies that have conducted a statistical analysis of overall complication rates between the two treatment groups. However, prior studies have suggested that there is no increase in complication rate among patients who are successfully managed non-operatively. Unfortunately, it is unclear at this time if patients who fail SNOM and receive a delayed laparotomy are at higher risk of overall complications. Much of this is due to the low numbers of conversion from SNOM to delayed laparotomy. Velmahos et at (2001) showed a 9% complication rate due to the delayed laparotomy. The majority of these complications consisted of intraabdominal abscess formation or respiratory infection leading to a significantly increased hospital stay. This contrasts with a second study examining gunshot wounds to the posterior abdomen which reported a complication rate of 34% for patients undergoing laparotomy (Velmahos, et al., 1997b). Thus, it would appear that SNOM does not increase rates of complication for patients who are successfully managed. At the same time, SNOM does increase the rate of complication for those who fail and receive a delayed laparotomy.

5.7 Predicting Higher Costs

The results of this study suggest that SNOM is a realistic option for the management of abdominal gunshot wounds because there is a no increased cost associated with SNOM. In fact, surgically managed patients experienced relatively higher costs compared to non-operatively managed patients. After adjusting for ISS, presence of acute abdomen, and haemoglobin levels, the trend remained but the statistical significance disappeared. These findings suggest that patients who are not severely injured should be considered for SNOM given all the benefits seen in clinical outcomes and the potential cost savings. For patients who are severely injured, the decision to choose SNOM versus immediate laparotomy becomes less important since severity of injury is the dominant predictive factor of both clinical outcomes and financial cost. That the severity of the injury is the driving factor appears logical. More severely injured patients will require greater hospital resources in terms of nursing staff, professional staff, medication use, and laboratory studies. While considerations for the length of time in the operating theatre would suggest more severe injuries would takes more time in the operating theatre, this factor is negated based on the

Uniform Patient Fee Schedule. The UPFS uses the same cost for an emergency laparotomy costs regardless of time spent in the operating theatre.

No study to date has analyzed individual costs as an outcome for SNOM in a developing country setting. The majority of studies examining the cost of gunshot wounds came out of the United States in the late 1980s and early 1990s during a period of burgeoning violence. These studies looked at aggregate annual hospital costs and charges with an emphasis on differentiating the source of payment – private insurance versus public funds (Martin, et al., 1988; Coben and Steiner, 2003; Cook, et al., 1999; Vassar and Kizer, 1996). The total costs for 131 firearms related injuries in 1984 at San Francisco General Hospital in the United States was USD 905,809 at an average cost of USD 6915 per patient with public sources paying 85.6% of this total cost (Martin, et al., 1988). Other studies have also shown that public sources of funding pay the brunt of violence-related injuries, as greater than 50% of victims tended to be on publicly financed health insurance programs and 20-30% of victims were completely uninsured (Coben and Steiner, 2003; Cook, et al., 1999; Vassar and Kizer, 1996). In South Africa, Allard and Burch (2005) found the average cost of treating abdominal gunshot wounds to be USD 1,467 or ZAR 10,269.

The results of this study suggest that SNOM has the potential to reduce the costs of treating violence related injuries. First, approximately one-third of abdominal gunshot wounds were successfully managed without going to the operating theatre. This in itself saved ZAR 3,755 per patient. At the same time, this savings was not diverted to further imaging studies or pharmacopoeia. The majority of patients who were non-operatively managed did not require other treatments as reflected in the median hospital cost of ZAR 6,225. This is rough half of the median cost of patient who were surgically managed. These savings are supported by prior studies. Velmahos, et al., (2001) found a 14% rate of unnecessary laparotomies using SNOM. However, the authors projected a 47% rate of unnecessary laparotomies using a protocol of mandatory laparatomy. They conclude that a policy of SNOM saved the hospital USD 9.5 million over the 8 year period and reduced the number of hospital days by 3,560.

5.8 Limitations

5.8.1 Confounding by Indication

This study, like all observational studies, is limited by the potential for confounding by indication. This type of confounding, also known as treatment selection bias, occurs because of the inherent differences in patients who undergo a treatment compared to those who do not in a clinical setting. The indication for treatment is often difficult to characterize because it is a combination of several factors that contribute to the physician's decision-making process. Unfortunately, this indication is usually present in the treatment group and is usually associated with future health outcomes. Thus, a situation is created where the indication is a confounder for the outcome (Signorello, et al., 2002). Observational studies of interventions have frequently been criticized because of their potential for such confounding by indication. In this study, patients were selected to receive non-operative management based on a clinical presentation upon arrival to the trauma centre. Patients who were haemodynamically stable without peritoneal signs were non-operatively managed. These patients were also more likely to have better outcomes in terms of mortality, overall complication, and lower hospital costs. However, the question is whether the positive association between treatment and outcome is the result of the treatment or the confounding based on indications for selective non-operative management.

A wide variety of statistical instruments have been proposed and tested in the analysis of observational studies in an attempt to reduce this treatment selection bias (Johnston, 2001; Austin, et al., 2006; Sturmer, et al., 2006). Traditionally, stratification, matching, and multivariate regression analysis have been used to control for confounding. More recently, the use of propensity scores and other instrumental variables have been used with varying acceptance.

In this study, we attempted to find a scoring system that would account for injury severity and thus reduce treatment selection bias. Three systems were considered: the RTS, the ISS, and the penetrating abdominal trauma index (PATI). In this study, the RTS was not an option as the vast majority of the patient did not have a respiratory rate noted on the trauma admission sheet. Thus, a retrospective RTS was not computable for the majority of patients in this cohort. The penetrating abdominal trauma index (PATI) was also considered in this case.

However, the PATI was developed for patients whose only source of injury was penetrating abdominal trauma (Moore et al, 1980). Few of the patients in this cohort had isolated abdominal injuries making the ISS a more valid measure of injury severity in this patient population that often had multiple gunshot injuries.

Thus, the ISS was used in an attempt to control for confounding by indication. The ISS has been used in a wide variety of outcomes studies to stratify participant by injury severity. Originally, designed as a stratification tool for injuries associated with motor vehicle crashes, the ISS has since been applied to other trauma scenarios. Beverland and Rutherford (1982) examined the validity of the ISS when applied to gunshot wounds and found a positive non-linear relationship between ISS and mortality. In our study, the ISS was used to control for confounding by indication within a multivariate regression analysis. It was found to be highly correlated with mortality, overall complication rates, and hospital costs. Its inclusion into the multivariate regression reduced the initial association between treatment and outcome, indicating its effectiveness in eliminating confounding by indication.

5.8.2 Differential Misclassification Information Bias

While the ISS was effective at reducing confounding by indication in this study, it also provided a potential source of information bias. Because it is a retrospectively calculated measure based on degree of injury, ISS is most accurate with direct visualization. This means that surgical exploration (or alternatively post mortem examination) is the gold standard. For patient who do not undergo an operation, imaging studies such as CT scans or MRIs provide additional information regarding the extent of injury. In this particular study, however, most patients did not have an abdominal CT scan or MRI. Chest x-rays were the most common modality of imaging. This variability in the accuracy of the ISS calculation could have led to differential misclassification bias. Patients who were treated with laparotomy were more likely to have accurate ISS calculations. Patients who were treated non-operatively were more likely to have inaccurate ISS calculations. Moreover, these calculations were more likely to be underestimates of the true value.

For example, in the case of renal trauma, grades of injury depend on the depth of injury, disruption of the collection system, and vascular compromise (see Table 5.1). Using the ISS scoring system, a patient presenting to the trauma centre with haemodynamic instability and a suspicion of a renal injury based on bullet trajectory will be taken to the operating theatre for exploration. The ISS will be calculated directly based on the observed pathology. More likely than not, the ISS will be 25 since current literature suggests that grade IV renal injuries often present in stable condition and can be successfully managed non-operatively (Buckley and McAninch, 2006). On the other hand, a patient presenting with haemodynamic stability and suspicion for a renal injury will be treated non-operatively. The ISS calculation cannot be accurately determined without further imaging. As a result, the clinician is forced to estimate the ISS which could 4, 9, or 16 depending on the assumption of a grade I-IV injury. Given the range of possible values, non-operatively managed patients will most likely be underestimated due to the biases of the observer for a patient who is haemodynamically stable.

Thus, in this scenario, patients taken to the operating theatre have the more accurate and relatively high ISS while patients who are non-operatively managed have the less accurate relatively low ISS that is underestimated. If this occurs systematically for all the patients, the association found between ISS and treatment is likely to be exaggerated during the statistical analysis. Additionally, because the ISS is exaggerated at the extremes according to treatment group, ISS is likely to dilute any effect of management in the multivariate analysis.

Table 5.1 Renal Injury Scale, from Boffard (2003)

Grade	Type of Injury	Description of Injury	AIS-90
I	Contusion	Microscopic or gross haematuria, urologic studies normal	2
	Haematoma	Subcapsular, non-expanding without parenchymal laceration	2
II	Haematoma	Non-expanding, perirenal haematoma confined to renal retroperitoneum	2
	Laceration	<1.0 cm parenchymal depth of renal cortex without urinary extravasation	2
III	Laceration	>1.0 cm parenchymal depth of renal cortex without collection system rupture or urinary extravasation	3
IV	Laceration	Parenchymal laceration extending through renal cortex, medulla and collection system	4
	Vascular	Main renal artery or vein injury with contained haemorrhage	4
V	Laceration	Completely shattered kidney	5
	Vascular	Avulsion of renal hilum that devascularizes kidney	5

5.8.3 Selection Bias

A third source of systematic bias in this study arises from a selection bias that eliminated the most severely injured patients who would have had the least costly hospitalization. According to one study conducted in the United States, the average cost for patients admitted for firearm-injuries was almost ten times the cost of the average cost for patients seen only in the emergency room because their injuries were minor or because they expired. (Max and Rice, 1993) In order to be included in this study, participants must have been admitted to the hospital for greater than 24 hours. Thus, this study may have excluded the least costly but most severely injured patients. The omission of these patients would have increased the association between cost and outcomes.

5.8.4 Other Limitations

Longer follow-up period would have been helpful in determining clinical outcomes regarding mortality and morbidity. This study was particularly limited because of the inability to follow-up with the participants outside of the hospital stay. It is quite possible that participants who were non-operatively managed had subsequent injuries that were managed elsewhere and where thus not accounted for in this study. There is the possibility that patients who were non-operatively managed and discharged home may have had complications at home and expired at home. There was no follow-up to verify that patients who were discharged survived.

5.9 Implication for Policy

5.9.1 Benefit of SNOM

The results of this study suggest a possible role for SNOM in the management of abdominal gunshot wounds in South Africa. SNOM does not increase mortality or overall complication rates in patients who are successfully managed. In addition, there does not appear to be an increased risk of mortality in patient who fail non-operative management and undergo a delayed laparotomy. Moreover, patients who undergo SNOM have shorter median lengths of hospital stay and lower median hospital costs compared to patients who are operatively managed. The analysis from this study shows that injury severity is actually the driver for all three outcomes. Thus, it would appear that SNOM would be a cost effective method of treatment for those patients who are not severely injured. For patients who are more severely injured, management does not play a significant role in either clinical outcome or financial cost. This suggest that a protocol for SNOM based on a real time calculation of the ISS would be beneficial in any trauma centre. This would allow for more efficient use of personnel in the trauma centre.

5.9.2 Targeting Victims of Violence for Preventive Measures

The results of this study highlight the sub-population at greatest risk of victimization from and perpetration of violence in South Africa. Numerous studies have shown that young, unmarried, unemployed males are at risk of violence. While this study focused on a policy for tertiary prevention of violence through the reduction of morbidity and mortality, it also suggests possible primary and secondary prevention activities. Patients in the hospital are a captivated audience, allowing opportunities for education and intervention.

The integration of primary prevention interventions by public health leaders with tertiary prevention by medical care providers during the patients' hospital stay has proven useful in other settings. For example, comprehensive home safety education interventions using pamphlets and verbal instruction have been used successfully in the waiting areas of emergency departments as a preventive measure for unintentional injuries within the pediatric population (Posner, et al., 2004). Other home safety education interventions have used high-tech interactive kiosks or educational videos with varied success as well (Gielen, et al., 2007; Kelly, et al., 2003). Similar educational interventions could be used for violence prevention.

5.10 Future Direction of Research

The original intent of this study was to examine a protocol of SNOM to determine if SNOM could decrease financial costs without increasing negative clinical outcomes. Potential sources of increased costs would have included imaging studies such as serial CT scans to monitor for evolution of a surgical abdomen or increased complexity resulting from a delayed laparotomy. In terms of negative clinical outcomes, a policy of SNOM might potentially exacerbate surgical scenarios by allowing a small, easily repairable injury to fester and develop into overt peritonitis and possible sepsis. For example, a patient with a small perforation in the colon who is taken to the operating theatre immediately upon arrival to the trauma centre is most likely to have a short operation and short hospital stay. However, if that same patient is allowed to wait until he develops diffuse peritonitis, his operating theatre time will be greatly increased and his hospital stay may be long, complicated, and requiring of intensive care for sepsis. He may also have increased risk of premature death.

In order to elucidate the true clinic effect of a protocol of SNOM, future research might focus on a subgroup analysis comparing patients who are non-operatively managed but undergo a delayed laparotomy and patients who undergo a laparotomy that is non-therapeutic. This might be best carried out as a case-control study as the numbers of delayed laparotomy and non-therapeutic laparotomy are extremely small. This comparison will more clearly explore the clinical complications associated with each treatment protocol. At the same time, the analysis should be undertaken as part of a larger analysis since false negative and false positive rates may vary considerably depending on the sensitivity and specificity of the abdominal examination. Thus, it may be that a delayed laparotomy has significantly worse clinical outcomes and financial costs than a non-therapeutic mandatory laparotomy. However, if rates of delayed laparotomy are considerably lower than rates of non-therapeutic laparotomies because of high sensitivity and low specificity testing, the over-abundance of non-therapeutic laparotomies may offset the poor clinical outcomes of a few delayed laparotomies.

Further investigation into the trauma response system is also necessary to determine systematic changes that could potentially improve patient outcomes. Unpublished data from Groote Schuur Hospital suggest that mean time from site of injury to emergency laparotomy is 10.5 hours. Average time from injury to arrival at Groote Schuur Hospital was 5.13 hours, ranging between 0.75 and 22 hours. Average time from arrival to the operating theatre was 5.5 hours, ranging between 0.5 to 20 hours. Much of the delay can be attributed to the decentralized hospital system in which secondary community hospitals act as the frontline for trauma. When the secondary community hospitals are unable to provide adequate care for patients, they are transferred to GSH (Smith and Nicol, 2003). These transit times can have a great impact on clinical outcomes and may have affected the outcomes of this study by indirectly improving the sensitivity and specificity of the abdominal examination. Further studies should be done to take into account the delay in first trauma assessment. Such information would be helpful in determining the optimal length of time at which the patient should be triaged into SNOM versus laparotomy.

Lastly, given the role of unemployment, alcohol and drugs on violence, broad-based social interventions need to be studied that target male youth. This could be in the form of mass media campaigns against drugs and alcohol, community development projects, or anti-violence campaigns within the schools.

5.11 Conclusion

This study contributes to the growing body of evidence regarding the use of selective non-operative management for abdominal gunshot wounds. It provides a more comprehensive data analysis that compares clinical outcomes and financial costs for SNOM versus immediate laparotomy. These results will hopefully be useful in the development of more streamlined trauma centre triage and treatment protocols which will make more efficient use of hospital personnel. These results suggest that a policy of SNOM does not increase the mortality rate or overall complication rate while reducing costs compared to treating patients with immediate surgery.

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Appendix 1. Data Extraction Form for Systematic Review

1	Authors	
2	Publication Year	
3	Country	
4	Study Design	
5	Population	
6	Hospital	
7	Period of Study	
8	Sample Size	
9	Univariate Analysis	
10	Management Analysis	
11	Outcomes Examined	

Appendix 2. Data Collection Form for Cohort Study

☐ SNOM
☐ Laparotomy

	Study Number		

Demographics	DOB		
	Age		Years
	Sex	☐MALE ☐FEMALE	M = 0; F = 1
	Primary Language	☐ENGLISH ☐XHOSA ☐AFRICAANS ☐OTHER ______ ☐N/A	E = 1; X = 2; A = 3; O = 4; N/A = 9
	Residential area		Dummy variable
	Postal Code		Dummy variable
	Marital status	☐Married ☐Single/divorced ☐Co-habitating ☐N/A	
	Employed?	☐Yes ☐No ☐N/A	
	Occupation		
	Monthly Income		

	Date of Admission		Day/month/year
	Date of Discharge		Day/month/year
	Total hospital stay		Days

Clinical Findings on Admission	Arrival	☐Direct ☐Transferred ☐Other	
	HR:	BP: RR:	
	Hb:	GCS: ☐Pregnant	
	Urine blood	☐negative ☐trace ☐occult	
	Injury 1:	Location: ______ AIS: ______	
	Injury 2:	Location: ______ AIS: ______	
	Injury 3:	Location: ______ AIS: ______	
	ISS		
	PATI		
	RTS	RR: ______ SBP: ______ GCS: ______	
	Admission assessment:	Acute abdomen: ☐Yes ☐No ☐Unknown Focal tenderness: ☐Yes ☐No ☐Unknown Haemo instability: ☐Yes ☐No ☐Unknown Free air: ☐Yes ☐No ☐Unknown Other: ______	
Surgery	Surgeon		
	Anesthetist		
	Start time		
	End time		

	Surgical findings		
	Surgical procedure		

Dx and Tx for Costing	Blood Tests	___ FBC ___ UEG ___ Type&Cross ___ Hgb ___ Others	
	Radiology	___ CXR ___ AXR ___ PXR ___ LODOX ___ U/S ___ CT ABD ___ Other ______	
	Theater Time		Minutes
	Days in Ward		Days
	Days in High-care Unit		Days
	Days in ICU		Days
	Pharma + Blood products	___ FFP ___ PRBCs ___ Platelets ___ Triple Abx + Morphine + Panadeine ___ Other ______	

Outcome	Early Mortality (within 24 hr)	☐Alive ☐Dead	
	Late Mortality (after 1 wk of admission)	☐Alive ☐Dead	
	Overall Mortality from AGSW	☐Yes ☐No Date: ______	
	Infection?	☐Yes ☐No	
	Other complications?	☐Yes ☐No	
	Total # of hospital days for AGSW		
	Total # of operations during hosp stay		

Appendix 3. Sample Cost Calculation According to Uniform Patient Fee Schedule 2005 unless otherwise specified.

	Cost (ZAR)
Accommodations (per 24-hr)	
General Ward	930
High Care Ward	2,110
Intensive Care Unit	4,080
Minor Procedures (including facility fee and specialist fee)	
Category A	365
Category B◇	467
Category C◇	608
Theatre (including facility fee and specialist fee)	3,755
Blood Products*	
Fresh Frozen Plasma	539
Packed Red Blood Cells	550
Platelets	470
Cryoprecipitate	321
Imaging (including facility fee and specialist fee)	
Category A	105
Category B	280
Category C	1,340
MRI◇	3,477

*From the Western Province Blood Transfusion Service 2005
◇From Uniform Patient Fee Schedule, 2006

Classification of Minor Procedures

Category A	Electrocardiogram, sigmoidoscopy, esophagoscopy
Category B	Gastroscopy
Category C	Embolization

Classification of Imaging Studies

Category A	Simple plain film x-ray of chest, abdomen, pelvis
Category B	Imaging requiring use of contrast material or more complex technical skill: Barium enema/swallow, intravenous pyelogram, cystogram, ultrasound, Doppler, vessel imagery
Category C	Computed tomography with or without contrast

Appendix 4. Completeness of Data Table

	Variable	# Recorded	% complete
Demo	Age	257	100.0
	Gender	257	100.0
	Language	235	91.4
	Marital Status	213	82.9
	Employment	231	89.9
Clinical Indicators	Mode of Arrival	249	96.9
	HR	254	98.8
	SBP	257	100.0
	DBP	257	100.0
	RR	73	28.4
	HGB	249	96.9
	GCS	252	98.1
	ISS	257	100.0
	RTS	73	28.4
	UrineBlood	220	85.6
	Acute Abdo	254	98.8
	Free Air	178	69.3
	Haemodynamic	248	96.5
	Delay	257	100.0
	Management	257	100.0
Outcomes	Mortality 24hr	257	100.0
	Mortality 1wk	169	65.8
	Mortality Hsp	256	99.6
	Infection	257	100.0
	Complication	257	100.0
	Readmit	248	96.5
	Realstay	257	100.0
	Billedstay	257	100.0
	Cost	257	100.0

Appendix 5. Step-wise Selection for Best-Fit Logistic Regression Model Predicting Management

		Model	Obs	LR Test		AIC	Comparison
				χ^2	p		
One-Variable Model	A	Age	152	1.48	0.2232	199.0912	v. constant
	B	Gender	152	2.14	0.1430	198.4301	v. constant
	C	Lang	152	0.01	0.9342	200.5682	v. constant
	D	Marr	152	0.67	0.4138	199.9071	v. constant
	E	Employ	152	2.70	0.1006	197.8797	v. constant
	F	Moarr	152	3.66	0.0558	196.9179	v. constant
	G	HR	152	7.24	0.0071	193.3374	v. constant
	H	SBP	152	2.91	0.0881	197.6662	v. constant
	I	DBP	152	3.71	0.0542	196.8675	v. constant
	K	Hgb	152	2.85	0.0913	197.7234	v. constant
	L	GCS	152	0.00	-	191.4789	v. constant
	M	GCS2 (binary)	152	0.00	-	197.7139	v.constant
	N	Urine	152	2.65	0.2655	199.9226	v. constant
	O	ISS	152	40.94	0.0000	159.6329	v. constant
	P	ISS2	152	12.26	0.0005	188.3106	v. constant
	Q	**Acute**	**152**	**106.83**	**0.0000**	**93.74463**	**v. constant**
	R	Haemo	152	9.86	0.0017	190.7139	v. constant
Two Variable Model	AA	Acute+Age	152	0.17	0.6793	95.57374	v. Q
	BB	Acute+Gender	152	2.00	0.1578	93.74906	v. Q
	CC	Acute+Lang	152	0.00	0.9711	95.74331	v. Q
	DD	Acute+Marr	152	0.12	0.7296	95.62511	v. Q
	EE	Acute+Employ	152	0.01	0.9341	95.73779	v. Q
	FF	Acute+Moarr	152	0.01	0.9294	95.73679	v. Q
	GG	Acute+HR	152	0.61	0.4352	95.1357	v. Q
	HH	Acute+SBP	152	0.09	0.7661	95.65615	v. Q
	II	Acute+DBP	152	0.53	0.4664	95.21419	v. Q
	KK	Acute+Hgb	152	0.13	0.7237	95.61961	v. Q
	NN	Acute+Urine	152	1.98	0.3722	95.76792	v. Q
	OO	**Acute+ISS**	**152**	**11.64**	**0.0006**	**84.10378**	**v. Q**
	PP	Acute+ISS2	152	6.47	0.0110	89.27195	v. Q
	RR	Acute+Haemo	152	1.34	0.2472	94.40578	v. Q
Three Variable Model	AA	Acute+ISS+Age	152	0.57	0.4502	85.53351	v. OO
	BB	Acute+ISS+Gender	152	1.56	0.2111	84.5399	v. OO
	CC	Acute+ISS+Lang	152	0.53	0.4687	85.57664	v. OO
	DD	Acute+ISS+Marr	152	0.38	0.5390	85.72632	v. OO
	EE	Acute+ISS+Employ	152	0.07	0.7849	86.02928	v. OO
	FF	Acute+ISS+Moarr	152	0.11	0.7421	85.99547	v. OO
	GG	Acute+ISS+HR	152	0.60	0.4380	85.50225	v. OO
	HH	Acute+ISS+SBP	152	0.00	0.9571	86.10088	v. OO
	II	Acute+ISS+DBP	152	0.17	0.6790	85.9325	v. OO
	KK	Acute+ISS+Hgb	152	0.13	0.7140	85.96949	v. OO
	NN	Acute+ISS+Urine	152	2.13	0.3444	85.97212	v. OO
	RR	Acute+ISS+Haemo	152	0.23	0.6318	85.87412	v. OO

Appendix 6. Bivariate Analysis of Mortality During Hospital Stay

	Variable	Total	ALIVE n (%)	DEAD n (%)	OR (95%CI) *p-value*
	Management (n=257)		248 (96.50%)	10 (3.50%)	
Demographics	Age (n=257)	25 (21-33)	25 (21-32.5)	30 (26-36)	*0.06*
	Gender (n=257)				
	Male	234 (91.05%)	226 (91.13%)	8 (88.89%)	1.28 (0.15-10.75)
	Female	23 (8.95%)	22 (8.87%)	1 (11.11%)	*0.82*
	Language (n=235)				
	Xhosa	171 (72.77%)	166 (72.81%)	5 (71.43%)	1.07 (0.20-5.66)
	Other	64 (27.23%)	62 (27.19%)	2 (28.57%)	*0.94*
	Marital Status (n=213)				
	Single	182 (85.45%)	177 (85.51%)	5 (83.33%)	1.18 (0.13-10.46)
	Other	31 (14.55%)	30 (14.49%)	1 (16.67%)	*0.88*
	Employ Status (n=231)				
	Unemployed	159 (68.83%)	154 (68.75%)	5 (71.43%)	0.88 (0.17-4.65)
	Employed	72 (31.17%)	70 (31.25%)	2 (28.57%)	*0.88*
Clinical Indicators	Mode of Arrival (n=249)				
	Direct	49 (19.68%)	48 (19.92%)	1 (12.50%)	1.74 (0.21-14.49)
	Transfer	200 (80.32%)	193 (80.08%)	7 (87.50%)	*0.61*
	HR (n=254)	92 (81-105)	91 (81-105)	102 (93-116)	*0.07*
	SBP (n=257)	135 (118-148)	135 (119.5-149.5)	101 (85-126)	*0.03*
	DBP (n=257)	74 (64-87)	74 (65-87)	51 (41-60)	*0.01*
	RR (n=73)	18 (15-20)	17 (14.5-20)	20 (20-20)	*0.49*
	HGB (n=248)	12 (10-13.5)	12 (10.5-13.5)	9.5 (7.5-10)	*0.002*
	GCS (n=252)	15 (15-15)	15 (15-15)	15 (15-15)	*0.54*
	ISS (n=257)	10 (9-17)	10 (9-16.5)	25 (10-25)	*0.04*
	Blood in Urine (n=220)				
	No blood	91 (41.36%)	90 (42.65%)	1 (11.11%)	
	Trace	56 (25.45%)	52 (24.64%)	4 (44.44%)	*0.11*
	Occult	73 (33.18%)	69 (32.70%)	4 (44.44%)	
	Acute Abdo (n=254)				
	Absent	118 (46.46%)	117 (47.76%)	1 (11.11%)	7.31 (0.90-59.35)
	Present	136 (53.54%)	128 (52.24%)	8 (88.89%)	*0.06*
	Free Air (n=178)				
	Absent	154 (86.52%)	152 (87.36%)	2 (50.00%)	6.91 (0.93-51.58)
	Present	24 (13.48%)	22 (12.64%)	2 (50.00%)	*0.06*
	Haemodynamics (n=248)				
	Stable	210 (84.68%)	206 (86.19%)	4 (44.44%)	7.80 (2.00-30.56)
	Unstable	38 (15.32%)	33 (13.81%)	5 (55.56%)	*0.003*
	ISS (n=257)				
	≤ 15	167 (64.98%)	164 (66.13%)	3 (33.33%)	3.90 (0.95-16.00)
	> 15	90 (35.02%)	84 (33.87%)	6 (66.67%)	*0.06*
	GCS (n=252)				
	≥ 13	245 (97.22%)	237 (97.53%)	8 (88.89%)	4.94 (0.53-45.97)
	<13	7 (2.72%)	6 (2.47%)	1 (11.11%)	*0.16*
	Delay (n=257)	330 (160-3209)	366 (165-3292.5)	105 (55-173)	*0.0003*
	Mgmt (n=257)				
	Lap	164 (63.81%)	155 (62.50%)	9 (100.00%)	
	SNOM	93 (36.29%)	93 (37.50%)	0 (0.00%)	*0.03*

Appendix 7. Step-wise Selection for Best-Fit Cox's Proportional Hazards Model for Mortality During Hospital Stay

				LR Test			
		Model	Obs	χ^2	*P*	AIC	Comparison
One-Variable Model	A	Age	152	0.86	0.3546	60.22122	v. constant
	B	Gender	152	1.10	0.2953	59.98286	v. constant
	C	Lang	152	0.17	0.6832	60.91172	v. constant
	D	Marr	152	0.05	0.8221	61.02773	v. constant
	E	Employ	152	0.74	0.3901	60.33956	v. constant
	F	Moarr	152	2.41	0.1204	58.6661	v. constant
	G	HR	152	0.33	0.5667	60.75011	v. constant
	H	SBP	152	2.56	0.1094	58.51537	v. constant
	I	DBP	152	3.51	0.0610	57.56851	v. constant
	K	Hgb	152	4.74	0.0294	56.33447	v. constant
	L	GCS	152	0.74	0.3910	58.34244	v. constant
	M	GCS2 (binary)	152	0.09	0.7649	60.98889	v.constant
	N	Urine	152	1.86	0.3939	61.21488	v. constant
	O	**ISS**	**152**	**8.93**	**0.0028**	**52.14835**	**v. constant**
	P	ISS2	152	2.34	0.1261	58.73899	v. constant
	Q	Acute	152	1.60	0.2055	59.47563	v. constant
	R	Haemo	152	5.21	0.0224	55.86466	v. constant
	T	Mgmt	152	4.70	0.0302	56.38102	v. constant
Two Variable Model	AA	ISS+Age	152	1.51	0.2185	52.63428	v. O
	BB	ISS+Gender	152	1.45	0.2284	52.69775	v. O
	CC	ISS+Lang	152	0.01	0.9126	54.13629	v. O
	DD	ISS+Marr	152	0.23	0.6351	53.92311	v. O
	EE	ISS+Employ	152	0.83	0.3611	53.31412	v. O
	FF	ISS+Moarr	152	2.79	0.0950	51.35999	v. O
	GG	ISS+HR	152	0.48	0.4899	53.67164	v. O
	HH	ISS+SBP	152	1.74	0.1871	52.408	v. O
	II	**ISS+DBP**	**152**	**3.01**	**0.0829**	**51.14194**	**v. O**
	KK	ISS+Hgb	152	1.59	0.2080	52.56292	v. O
	LL	ISS+GCS	152	-	-	-	v. O
	MM	ISS+GCS2	152	0.04	0.8456	54.11045	v. O
	NN	ISS+Urine	152	0.43	0.8049	55.71433	v. O
	QQ	ISS+Acute	152	0.16	0.6876	53.98664	v. O
	RR	ISS+Haemo	152	2.16	0.1415	51.98703	v. O
	TT	ISS +Mgmt	152	2.06	0.1514	52.0907	v. O
Three Variable Model	AAA	ISS+DBP+Age	152	1.57	0.2107	51.57506	v. II
	BBB	ISS+DBP+Gender	152	1.05	0.3045	52.08764	v. II
	CCC	ISS+DBP+Lang	152	0.03	0.8744	53.11694	v. II
	DDD	ISS+DBP+Marr	152	0.28	0.5973	52.8628	v. II
	EEE	ISS+DBP+Employ	152	0.77	0.3817	52.37872	v. II
	FFF	ISS+DBP+Moarr	152	-	-	-	v. II
	GGG	ISS+DBP+HR	152	0.06	0.8000	53.07776	v. II
	HHH	ISS+DBP+SBP	152	0.00	0.9850	53.14158	v. II
	KKK	ISS+DBP+Hgb	152	0.29	0.5878	52.84821	v. II
	NNN	ISS+DBP+Urine	152	0.47	0.7907	54.67216	v. II
	QQQ	ISS+DBP+Acute	152	0.03	0.8582	53.11003	v. II
	RRR	ISS+DBP+Haemo	152	0.43	0.5120	52.71198	v. II
	TTT	ISS+DBP+Mgmt	152	1.85	0.1738	51.29169	v. II
	Z	ISS+DBP+Mgmt+ISS_Mgmt	152	1.85	0.3965	53.29169	v. II
	Y	ISS+DBP+Mgmt+DBP_Mgmt	152	1.85	0.3965	53.29169	v. II

* Interaction terms between two variables.

Appendix 8. Bivariate Analysis of Overall Complications During Hospital Stay

	Variable	Total	No Complication n = 181 (70.43%)	Complication n = 76 (29.57%)	OR (95%CI) *p-value*
Demographics	Age (n=257)	25 (21-33)	25 (20-33)	26.5 (21.5-33.5)	*0.11*
	Gender (n=257)				
	Male	234 (91.05%)	167 (92.27%)	67 (88.16%)	1.60 (0.66-3.88)
	Female	23 (8.95%)	14 (7.73%)	9 (11.84%)	*0.30*
	Language (n=235)				
	Xhosa	171 (72.77%)	123 (73.21%)	48 (71.64%)	1.08 (0.58-2.03)
	Other	64 (27.23%)	45 (26.79%)	19 (28.36%)	*0.81*
	Marital Status (n=213)				
	Single	182 (85.45%)	129 (87.16%)	53 (81.54%)	1.54 (0.70-3.39)
	Other	31 (14.55%)	19 (12.84%)	12 (18.46%)	*0.29*
	Employ Status (n=231)				
	Unemployed	159 (68.83%)	107 (66.88%)	52 (73.24%)	0.74 (0.40-1.37)
	Employed	72 (31.17%)	53 (33.12%)	19 (26.76%)	*0.34*
Clinical Indicators	Mode of Arrival (n=249)				
	Direct	49 (19.68%)	31 (17.82%)	18 (24.00%)	0.69 (0.36-1.32)
	Transfer	200 (80.32%)	143 (82.18%)	57 (76.00%)	*0.26*
	HR (n=254)	92 (81-105)	90 (80-101)	99 (86-115)	*0.0004*
	SBP (n=257)	135 (118-148)	135 (120-148)	134 (117-149)	*0.62*
	DBP (n=257)	74 (64-87)	74 (65-87)	75 (64-88.5)	*0.59*
	RR (n=73)	18 (15-20)	16 (14-20)	20 (15-26)	*0.04*
	HGB (n=248)	12 (10-13.5)	12.5 (10.5-14)	11 (9.5-12.5)	*< 0.0001*
	GCS (n=252)	15 (15-15)	15 (15-15)	15 (15-15)	*0.32*
	ISS (n=257)	10 (9-17)	9 (3-16)	16 (9-19)	*< 0.0001*
	Blood in Urine (n=220)				
	No blood	91 (41.36%)	69 (44.81 %)	22 (33.33%)	
	Trace	56 (25.45%)	44 (28.57%)	12 (18.18%)	*0.006*
	Occult	73 (33.18%)	41 (26.62%)	32 (48.48%)	
	Acute Abdo (n=254)				
	Absent	118 (46.46%)	97 (53.89%)	21 (28.38%)	2.95 (1.64-5.29)
	Present	136 (53.48%)	83 (46.11%)	53 (71.62%)	*< 0.001*
	Free Air (n=178)				
	Absent	154 (86.52%)	123 (89.13%)	31 (77.50%)	2.38 (0.95-5.95)
	Present	24 (13.48%)	15 (10.87%)	9 (22.50%)	*0.06*
	Haemodynamics (n=248)				
	Stable	210 (84.68%)	154 (88.51%)	56 (75.68%)	2.48 (1.22-5.02)
	Unstable	38 (15.32%)	20 (11.49%)	18 (24.32%)	*0.01*
	ISS (n=257)				
	≤ 15	167 (64.98%)	133 (73.48%)	34 (44.74%)	3.42 (1.96-5.99)
	> 15	90 (35.02%)	48 (26.52%)	42 (55.26%)	*< 0.001*
	GCS (n=257)				
	≥ 13	250 (97.28%)	176 (97.24%)	74 (97.37%)	0.92 (0.18-4.87)
	<13	7 (2.72%)	5 (2.76)	2 (2.63%)	*0.93*
	Delay (n=257)	330 (160-3209)	590 (175-3605)	200 (122.5-412.5)	*0.0001*
	Mgmt (n=257)				
	Lap	164 (63.81%)	98 (54.14%)	66 (86.84%)	0.18 (0.09-0.37)
	SNOM	93 (36.19%)	83 (45.86%)	10 (13.16%)	*< 0.001*

Appendix 9. Step-wise Selection for Best-Fit Cox's Proportional Hazards Model for Overall Complications During Hospital Stay

		Model	Obs	LR Test χ^2	LR Test *p*	AIC	Comparison
One-Variable Model	**A**	**Age**	**152**	**3.93**	**0.0474**	**285.2512**	**v. constant**
	B	Gender	152	1.02	0.3119	288.159	v. constant
	C	Lang	152	0.03	0.8535	289.1475	v. constant
	D	Marr	152	3.64	0.0562	285.5368	v. constant
	E	Employ	152	1.97	0.1608	287.2148	v. constant
	F	Moarr	152	0.03	0.8730	289.1561	v. constant
	G	HR	152	0.29	0.5923	288.8949	v. constant
	H	SBP	152	1.65	0.1985	287.5284	v. constant
	I	DBP	152	0.89	0.3451	288.2901	v. constant
	K	Hgb	152	2.56	0.1093	286.6167	v. constant
	L	GCS	152	0.90	0.3431	288.2827	v. constant
	M	GCS2	152	1.37	0.2417	287.8111	v. constant
	N	Urine	152	4.64	0.0984	286.5438	v. constant
	O	ISS	152	3.72	0.0536	285.4567	v. constant
	P	ISS2	152	3.70	0.0545	285.4832	v. constant
	Q	Acute	152	0.84	0.3582	288.3376	v. constant
	R	Haemo	152	0.88	0.3491	288.3048	v. constant
	T	Mgmt	152	0.19	0.6629	288.9916	v. constant
Two-Variable Model	BB	Age+Gender	152	0.88	0.3486	286.3726	v. A
	CC	Age+Lang	152	0.75	0.3868	286.5023	v. A
	DD	Age+Marr	152	0.63	0.4274	286.6213	v. A
	EE	Age+Employ	152	0.64	0.4250	286.6148	v. A
	FF	Age+Moarr	152	0.01	0.9227	287.2418	v. A
	GG	Age+HR	152	0.93	0.3354	286.3232	v. A
	HH	Age+SBP	152	1.50	0.2205	285.75	v. A
	II	Age+DBP	152	0.78	0.3758	286.4669	v. A
	KK	Age+Hgb	152	1.42	0.2330	285.8286	v. A
	LL	Age+GCS	152	0.12	0.7251	287.1275	v. A
	MM	Age+GCS2	152	0.31	0.5750	286.9368	v. A
	NN	Age+Urine	152	4.17	0.1245	285.0849	v. A
	OO	**Age+ISS**	**152**	**5.99**	**0.0144**	**281.2654**	**v. A**
	PP	Age+ISS2	152	5.23	0.0221	282.0164	v. A
	QQ	Age+Acute	152	1.41	0.2358	285.8459	v. A
	RR	Age+Haemo	152	0.76	0.3842	286.4939	v. A
	TT	Age+Mgmt	152	0.32	0.5745	286.936	v. A
Three-Variable Model	BBB	Age+ISS+Gender	152	1.82	0.1779	281.4501	v. OO
	CCC	Age+ISS+Lang	152	0.39	0.5315	282.8738	v. OO
	DDD	Age+ISS+Marr	152	0.71	0.3993	282.555	v. OO
	EEE	Age+ISS+Employ	152	0.53	0.4677	282.738	v. OO
	FFF	Age+ISS+Moarr	152	0.00	0.9724	283.2642	v. OO
	GGG	Age+ISS+HR	152	1.23	0.2679	282.0381	v. OO
	HHH	Age+ISS+SBP	152	1.22	0.2701	282.0494	v. OO
	III	Age+ISS+DBP	152	1.46	0.2265	281.8025	v. OO
	KKK	Age+ISS+Hgb	152	1.87	0.1714	281.3951	v. OO
	LLL	Age+ISS+GCS	152	0.63	0.4256	282.6307	v. OO
	MMM	Age+ISS+GCS2	152	1.02	0.3123	282.2445	v. OO
	NNN	Age+ISS+Urine	152	1.74	0.4186	283.5235	v. OO
	QQQ	Age+ISS+Acute	152	0.89	0.3443	282.3709	v. OO
	RRR	Age+ISS+Haemo	152	1.86	0.1736	281.4138	v. OO
	TTT	Age+ISS+Mgmt	152	0.01	0.9229	283.256	v. OO
Interaxn	Z	Age+ISS+Mgmt+Age*ISS	152	1.09	0.5808	284.1786	v. OO
	Y	Age+ISS+Mgmt+Age*Mgmt	152	1.45	0.4853	283.8195	v. OO
	X	Age+ISS+Mgmt+Iss*Mgmt	152	0.01	0.9950	285.2555	v. OO

* Interaction terms between two variables.

Appendix 10. Bivariate Analysis of Cost of Hospital Stay

	Variable	Total	Low n = (%)	High n = (%)	OR (95%CI) *p-value*
Demographics	Age (n=257)	25 (21-33)	25 (20-34)	25 (21-32.5)	*0.49*
	Gender (n=257)				
	Male	234 (91.05%)	118 (91.47%)	116 (90.62%)	1.11 (0.47-2.62)
	Female	23 (8.95%)	11 (8.53%)	12 (9.38%)	*0.81*
	Language (n=235)				
	Xhosa	171 (72.77%)	86 (71.07%)	85 (74.56%)	0.84 (0.47-1.49)
	Other	64 (27.23%)	35 (28.93%)	29 (25.44%)	*0.55*
	Marital Status (n=213)				
	Single	182 (85.45%)	94 (85.45%)	88 (85.44%)	1.00 (0.47-2.15)
	Other	31 (14.55%)	16 (14.55%)	15 (14.56%)	*1.00*
	Employ Status (n=231)				
	Unemployed	159 (68.83%)	75 (65.22%)	84 (72.41%)	0.71 (0.41-1.25)
	Employed	72 (31.17%)	40 (34.78%)	32 (27.59%)	*0.24*
Clinical Indicators	Mode of Arrival (n=249)				
	Direct	49 (19.68%)	23 (18.40%)	26 (20.97%)	0.85 (0.45-1.59)
	Transfer	200 (80.32%)	102 (81.60%	98 (79.03%)	*0.61*
	HR (n=254)	92 (81-105)	89 (78-101)	96 (84-110)	*0.005*
	SBP (n=257)	135 (118-148)	135 (124-150)	132.5 (114.5-148)	*0.13*
	DBP (n=257)	74 (64-87)	76 (66-88)	72 (60-86)	*0.10*
	RR (n=73)	18 (15-20)	16 (14-20)	18 (15-24)	*0.24*
	HGB (n=248)	12 (10-13.5)	12.5 (11-14)	11 (10-12.5)	*< 0.0001*
	GCS (n=252)	15 (15-15)	15 (15-15)	15 (15-15)	*0.002*
	ISS (n=257)	10 (9-17)	9 (2-10)	16 (9-19)	*< 0.0001*
	Blood in Urine (n=220)				
	No blood	91 (41.36%)	56 (50.91%)	35 (31.82%)	
	Trace	56 (25.45%)	30 (27.27%)	26 (23.64%)	*0.001*
	Occult	73 (33.18%)	24 (21.82%)	49 (44.55%)	
	Acute Abdo (n=254)				
	Absent	118 (46.46%)	83 (64.34%)	35 (28.00%)	4.64 (2.73-7.89)
	Present	136 (53.54%)	46 (35.66%)	90 (72.00%)	*< 0.001*
	Free Air (n=178)				
	Absent	154 (86.52%)	90 (90.91%)	64 (81.01%)	2.34 (0.97-5.69)
	Present	24 (13.48%)	9 (9.09%)	15 (18.99 %)	*0.06*
	Haemodynamics (n=243)				
	Stable	210 (84.68%)	116 (95.08%)	94 (74.60%)	6.58 (2.64-16.41)
	Unstable	38 (15.32%)	6 (4.92%)	32 (25.40%)	*< 0.001*
	ISS (n=257)				
	≤ 15	167 (64.98%)	109 (84.50%)	58 (45.31%)	6.58 (3.65-11.87)
	> 15	90 (35.02%)	20 (15.50%)	70 (54.69%)	*< 0.001*
	GCS (n=257)				
	≥ 13	250 (97.22%)	123 (98.40%)	122 (96.06%)	2.52 (0.48-13.24)
	<13	7 (2.78%)	2 (1.60%)	5 (3.94%)	*0.28*
	Delay (n=257)	330 (160-3209)	2100 (200-3859)	210 (140-520)	*< 0.0001*
	Mgmt (n=257)				
	Lap	164 (63.81%)	57 (44.19%)	107 (83.59%)	0.16 (0.09-0.28)
	SNOM	93 (36.19%)	72 (55.81%)	21 (16.41%)	*< 0.001*

Appendix 11. Step-wise Selection for Best-Fit Logistic Regression Model for Cost of Hospital Stay

		Model	Obs	LR Test		AIC	Comparison
				χ^2	*P*		
One-Variable Model	A	Age	152	0.56	0.4535	214.1549	**v. constant**
	B	Gender	152	0.08	0.7717	214.6325	v. constant
	C	Lang	152	0.04	0.8472	214.6796	v. constant
	D	Marr	152	1.39	0.2379	213.3239	v. constant
	E	Employ	152	0.12	0.7299	214.5975	v. constant
	F	Moarr	152	0.19	0.6665	214.531	v. constant
	G	HR	152	2.48	0.1152	212.2354	v. constant
	H	SBP	152	6.18	0.0129	208.5326	v. constant
	I	DBP	152	4.65	0.0310	210.0651	v. constant
	K	Hgb	152	19.95	0.0000	194.7671	v. constant
	L	GCS	144	-0.00	-	201.1817	v. constant
	M	GCS2	151	-0.00	-	211.3238	v. constant
	N	Urine	152	8.00	0.0183	208.715	v. constant
	O	**ISS**	**152**	**47.99**	**0.0000**	**166.7231**	**v. constant**
	P	ISS2	152	29.21	0.0000	185.5039	v. constant
	Q	Acute	152	32.20	0.0000	182.5147	v. constant
	R	Haemo	152	13.86	0.0002	200.856	v. constant
	T	Mgmt	152	29.21	0.0000	185.5039	v. constant
Two-Variable Model	AA	ISS+Age	152	0.07	0.7958	168.6561	v. O
	BB	ISS+Gender	152	0.10	0.7476	168.6196	v. O
	CC	ISS+Lang	152	0.00	0.9457	168.7185	v. O
	DD	ISS+Marr	152	1.14	0.2854	167.5821	v. O
	EE	ISS+Employ	152	0.01	0.9084	168.7099	v. O
	FF	ISS+Moarr	152	0.01	0.9259	168.7145	v. O
	GG	ISS+HR	152	0.99	0.3188	167.7292	v. O
	HH	ISS+SBP	152	2.41	0.1205	166.3127	v. O
	II	ISS+DBP	152	1.48	0.2232	167.2395	v. O
	KK	ISS+Hgb	152	10.18	0.0014	158.5413	v. O
	NN	ISS+Urine	152	0.52	0.7727	170.2074	v. O
	QQ	**ISS+Acute**	**152**	**13.89**	**0.0002**	**154.833**	**v. O**
	RR	ISS+Haemo	152	5.10	0.0239	163.6199	v. O
	TT	ISS +Mgmt	152	8.02	0.0046	160.6997	v. O
Three-Variable Model	AAA	ISS+Acute+Age	152	0.07	0.7882	168.8563	v. QQ
	BBB	ISS+Acute+Gender	152	0.16	0.6903	156.6742	v. QQ
	CCC	ISS+Acute+Lang	152	0.01	0.9104	168.9159	v. QQ
	DDD	ISS+Acute+Marr	152	0.59	0.4443	168.3434	v. QQ
	EEE	ISS+Acute+Employ	152	0.39	0.5332	168.5403	v. QQ
	FFF	ISS+Acute+Moarr	152	0.63	0.4276	168.2992	v. QQ
	GGG	ISS+Acute+HR	152	0.05	0.8013	168.8652	v. QQ
	HHH	ISS+Acute+SBP	152	1.66	0.1979	167.2705	v. QQ
	III	ISS+Acute+DBP	152	1.00	0.3180	167.9314	v. QQ
	KKK	**ISS+Acute+Hgb**	**152**	**9.96**	**0.0016**	**146.8745**	**v. QQ**
	NNN	ISS+Acute+Urine	152	0.71	0.7006	158.1213	v. QQ
	RRR	ISS+Acute+Haemo	152	2.98	0.0841	153.8487	v. QQ
	TTT	ISS+Acute+Mgmt	152	0.05	0.8280	156.7858	v. QQ
Four-Variable Model	AAAA	ISS+Acute+Age	152	0.63	0.4274	148.2447	v. KKK
	BBBB	ISS+Acute+Gender	152	0.06	0.8002	148.8105	v. KKK
	CCCC	ISS+Acute+Lang	152	0.10	0.7519	148.7746	v. KKK
	DDDD	ISS+Acute+Marr	152	0.36	0.5471	148.512	v. KKK
	EEEE	ISS+Acute+Employ	152	0.86	0.3528	148.011	v. KKK
	FFFF	ISS+Acute+Moarr	152	0.82	0.3650	148.0539	v. KKK
	GGGG	ISS+Acute+HR	152	0.04	0.8339	148.8305	v. KKK
	HHHH	ISS+Acute+SBP	152	0.43	0.5142	148.4489	v. KKK
	IIII	ISS+Acute+DBP	152	0.16	0.6922	148.7178	v. KKK
	NNNN	ISS+Acute+Urine	152	0.39	0.8224	150.4835	v. KKK
	RRRR	ISS+Acute+Haemo	152	1.79	0.1808	147.0833	v. KKK
	TTTT	ISS+Acute+Mgmt	152	0.05	0.8243	148.8252	v. KKK

Appendix 12. Bivariate Analysis Using Revised Classification Scheme.

	Variable	Total	LAP2 n=160 (62.26%)	SNOM2 n= 97 (37.74%)	OR (95%CI) *p-value*
Demographics	Age (n=257)	25 (21-33)	24 (21-32.5)	27 (20-34)	*0.75*
	Gender (n=257)				
	Male	234 (91.05%)	146 (91.25%)	88 (90.72%)	1.07 (0.44-2.57)
	Female	23 (8.95%)	14 (8.75%)	9 (9.28%)	*0.89*
	Language (n=235)				
	Xhosa	171 (72.77%)	107 (74.83%)	64 (69.57%)	1.30 (0.73-2.33)
	Other	64 (27.23%)	36 (25.17%)	28 (30.43%)	*0.38*
	Marital Status (n=213)				
	Single	182 (85.45%)	112 (86.15%)	70 (84.34%)	1.16 (0.53-2.50)
	Other	31 (14.55%)	18 (13.85%)	13 (15.66%)	*0.71*
	Employ Status (n=231)				
	Unemployed	159 (68.83%)	106 (73.61%)	53 (60.92%)	1.79 (1.01-3.16)
	Employed	72 (31.17%)	38 (26.39%)	34 (39.08%)	*0.05*
Clinical Indicators	Mode of Arrival (n=249)				
	Direct	49 (19.68%)	32 (20.65%)	17 (18.09%)	1.18 (0.61-2.27)
	Transfer	200 (80.32%)	123 (79.35%)	77 (81.91%)	*0.62*
	HR (n=254)	92 (81-105)	96 (86-109)	86 (76-98)	*0.0001*
	SBP (n=257)	135 (118-148)	130.5 (115-147.5)	139 (126-151)	*0.03*
	DBP (n=257)	74 (64-87)	73 (61-84)	76 (67-91)	*0.013*
	RR (n=73)	18 (15-20)	18 (15-20)	16 (14-20)	*0.70*
	HGB (n=248)	12 (10-13.5)	11.5 (10-13)	12.5 (11-14)	*0.002*
	GCS (n=252)	15 (15-15)	15 (15-15)	15 (15-15)	*0.007*
	ISS (n=257)	10 (9-17)	10 (9-17.5)	5 (1-11)	*< 0.0001*
	Blood in Urine (n=220)				
	No blood	91 (41.36%)	55 (37.67%)	36 (48.65%)	
	Trace	56 (25.45%)	36 (24.66%)	20 (27.03%)	*0.12*
	Occult	73 (33.18%)	55 (37.67%)	18 (24.32%)	
	Acute Abdo (n=254)				
	Absent	118 (46.46%)	24 (15.29%)	94 (96.91%)	0.006 (0.002-0.02)
	Present	136 (53.54%)	133 (84.71%)	3 (3.09%)	*< 0.001*
	Free Air (n=178)				
	Absent	154 (86.52%)	73 (76.84%)	81 (97.59%)	0.08 (0.02-0.36)
	Present	24 (13.48%)	22 (23.16%)	2 (2.41%)	*0.001*
	Haemodynamics (n=248)				
	Stable	210 (84.68%)	120 (77.42%)	90 (96.77%)	0.11 (0.03-0.38)
	Unstable	38 (15.32%)	35 (22.58%)	3 (3.23%)	*< 0.001*
	ISS (n=257)				
	≤ 15	167 (64.98%)	88 (55.0%)	79 (81.44%)	0.028 (0.15-0.51)
	> 15	90 (35.02%)	72 (45.0%)	18 (18.56%)	*< 0.001*
	GCS (n=257)				
	≥ 13	250 (97.28%)	154 (96.25%)	96 (98.97%)	0.28 (0.03-2.33)
	<13	7 (2.72%)	6 (3.75%)	1 (1.03%)	*0.24*
	Delay (n=257)	330 (160-3209)	180 (120-300)	3900 (2635-6440)	*< 0.0001*
Outcomes	Mortality 24hr (n=257)				
	Alive	251 (97.67%)	154 (96.25%)	97 (100.0%)	
	Dead	6 (2.33%)	6 (3.75%)	0 (0.00%)	*0.09*
	Mortality 1 wk (n=169)				
	Alive	160 (94.67%)	116 (92.80%)	44 (100.0%)	
	Dead	9 (5.33%)	9 (7.20%)	0 (0.00%)	*0.11*
	Mortality during stay (n=256)				
	Alive	246 (96.09%)	149 (93.71%)	97 (100.0%)	
	Dead	10 (3.91%)	10 (6.29%)	0 (0.00%)	*0.02*
	Infection (n=257)				
	None	204 (79.38%)	115 (71.88%)	89 (91.75%)	0.23 (0.10-0.51)
	Infection	53 (20.62%)	45 (28.12%)	8 (8.25%)	*< 0.001*
	Complication (n=257)				
	None	211 (82.10%)	121 (75.62%)	90 (92.78%)	0.24 (0.10-0.56)
	Complication	46 (17.90%)	39 (24.38%)	7 (7.22%)	*0.001*

Variable	Total	LAP2 n=160 (62.26%)	SNOM2 n= 97 (37.74%)	OR (95%CI) *p-value*
Overall complication (n=257)				
None	181 (70.43%)	96 (60.0%)	85 (87.63%)	0.21 (0.11-0.42)
Complication	76 (29.57%)	64 (40.0%)	12 (12.37%)	*< 0.001*
Readmission (n=248)				
No readmission	195 (78.63%)	116 (76.82%)	79 (81.44%)	0.76 (0.40-1.43)
Readmission	53 (21.37%)	35 (23.18%)	18 (18.56%)	*0.39*
Real Stay (n=257)	5.6 (3.5-9.6)	7.02 (4.99-12.59)	3.20 (2.23-5.45)	*< 0.0001*
Billed Stay (n=257)	7 (4-11)	8 (6-14)	4 (3-6)	*< 0.0001*
Cost (n=257)	11750 (8145-20580)	13768 (10580-28816)	6515 (4340-11775)	*< 0.0001*
Bin_Cost (n=257)				
Low	129 (50.2%)	57 (35.6%)	72 (74.2%)	0.19 (0.11-0.34)
High	128 (49.8%)	103 (64.4%)	25 (25.8%)	*< 0.001*