Aetiology and Outcome of patients burned from 2003 to 2008; managed at the Tygerberg Hospital Burns Unit, Western Cape, South Africa

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DECLARATION

I, **DRDAVID MARITZ** hereby declare that the work on which this dissertation/thesis 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. This work has not been published prior to registering for the abovementioned degree.

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Date: 31st October 2012

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This work would not have been possible without the support and understanding of my wife Emma and our two daughters Ashley and Amy.

Part A

Research Protocol

Research Proposal as submitted to the DRC and ethics committee

Aetiology and outcome of patients burned from 2003 to 2008; managed at the Tygerberg Hospital Burn Unit, Western Cape, South Africa.

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Introduction

Mortality in burn patients can be estimated by the presence or absence of a number of risk factors. The Abbreviated Burn Severity Index (ABSI) is an example of a prognostic scoring system that correlates the probabilities of survival with the presence of the following adverse prognostic factors (each scored and weighted):

- Age
- TBSA
- Female gender
- Inhalational injury
- Full thickness burns

A score of >12 estimates a probability of survival of <10%[1-3].

Many of the prognostic scoring systems in use today have been validated for use in the developed world setting and may not be applicable to the developing world setting.

There is a need in South Africa to develop a model for the objective, evidence based prediction of burns mortality[4-7]. Tygerberg Hospital Burns Unit is the only dedicated centre for the management of severely burned adult patients in the Western Cape public health system. In the setting of current resource constraints in South Africa, guidelines are needed based on objective data to decide on the best course of management for these patients. Patients unlikely to survive may be better off managed at secondary (regional) hospitals.

Literature review

The management of burns has shown substantial progress over the last two decades, especially in the developed world setting. A 1997 audit from this unit for the period 1986 to 1995 showed 452 deaths for 6052 admissions (mortality 7.5%). The majority of the patients stayed between 1 and 4 weeks with intensive / high care admissions accounting for 19.2% of patients[8].

HIV infection and AIDS have already reached epidemic proportions in South Africa. A Study conducted in this unit demonstrated that outcome of HIV positive patients without stigmata of AIDS, admitted to the intensive care unit showed no difference when compared to HIV negative patients and should be managed similarly[9]. However the HIV / AIDS epidemic continues to grow and the impact that this is currently having on the outcome of burns patients is unknown.

Alcohol, violence and other socioeconomic factors continue to make a significant contribution to the burden of disease in South Africa. A 1997 audit of patients over the age of 18 years admitted this unit found that 57% of the study group had alcohol dependence and most attributed their burns injuries to alcohol intoxication[10, 11].

Health care in South Africa is constantly struggling to provide better quality health care in a cost effective manner and this demand for accountability has made us more aware on what happens to patients. Outcomes information is an important measure of what is been done and what is actually been accomplished. They are the first step in determining the consequences of health care[12].

Aims

This study has two main aims:

- To determine the aetiology and outcome of burned patients admitted to the burn unit over a 6 year period (2003 – 2008).
- To develop an easy to use mortality prediction model for the South African setting.

Furthermore, we hope to use these results to develop a clear set of evidence based guidelines to aid in decision making within Emergency Departments.

Methods

All data from the burn unit (Age, gender, length of stay, TBSA% burn, type of injury, ICU admissions, inhalational injury and mortality) as well as microbiological data will be analysed retrospectively for the period 1st January 2003 to 31st December 2008.

An excel database will be constructed from paper based admission records kept in the burns unit. The database will not contain any personal identifiable information and will be stored on a password protected work computer belonging to the principal investigator.

Where the paper records are insufficient, a hand search through medical records will be conducted to retrieve missing information. If no written record of TBSA% is found, an estimate will be made from the burns diagram and other notes in the charts. All re-admissions, skin donors and cold burns will be excluded from the audit. An inhalational injury was defined as having occurred with evidence of facial / neck flame burns, indoor fires and with subsequent admission to the intensive care unit for ventilatory support.

A statistician will be consulted to assist with statistical analysis and will include simple descriptive analysis as well logistic regression modelling to develop the mortality prediction model.

Dissemination of results

The aim is to publish the results in a peer reviewed journal and to submit for the required MMED dissertation of Dr David Maritz at the University of Cape Town.

Ethics / Funding

Ethical approval is been sought from the division of research and development at Stellenbosch university. A separate application for the MMED dissertation of Dr David Maritz is underway through the University of Cape Town. This is an unfunded postgraduate research project from the division of Emergency Medicine of the University of Stellenbosch and University of Cape Town.

Conflicts of Interests

None

Timeframe

The aim is to complete the project by mid-2010.

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Part B

Structured Literature Review

ABSTRACT:

Rural to urban migration to major cities in South Africa continues to lead to the proliferation of informal settlements. There is little recent published data on the epidemiology of adult burns in the Western Cape, South Africa. The prediction of outcome in severe burns is important to aid in clinical decision making, improve scarce resource allocation and allow comparisons between different burn units. Age, burn size and the presence of inhalational injury have been determined to be the most important factors in predicting mortality. There is little published data on the outcome of severe burns in the Southern African region. A retrospective review of patients on the Burn Unit database was undertaken, looking at patients admitted to the Burn Unit between January 2003 and December 2008. This study discusses the characteristics and outcome of patients who were treated at the Tygerberg Burn unit. A total of 1908 patients were admitted to the burn unit during the 6 year period under review. Most fatal injuries occurred in the 20 to 40 year age group. Injuries due to shack fires and fuel stoves comprised 21% (399) of all admissions. Mortality due to these injuries comprised 28% (137) of total mortality. Gas stoves accounted for 24% with kerosene stoves accounting for 71% of injuries. The burn death rate in this study (25%) was found to have increased dramatically from the last audit done from 1986 to 1995 in which a burn death rate of 7.5% was observed. Reasons for this are explored. A stepwise logistic regression analysis was done on the derivation cohort where age, gender, TBSA% and presence of inhalational injury were identified as significant for predicting death. A mortality prediction model is presented which was internally validated on the validation cohort. An easy to use EXCEL calculator was created to estimate the probability of death.

Shack fires and injuries due to fuel stoves are a common reason for admission to the burn unit and mostly involve young male individuals. Other research from the Southern African region does not mention shack fires as a separate entity making it difficult to obtain an accurate idea of the scale of the problem. Their injuries are severe with a high mortality. The use of kerosene stoves are a major contributing factor. Recommendations include enforceable legislation to promote safer stove design, research into safer bio fuels and materials for building shacks as well promoting fire safety among schoolchildren in the community. Further research is needed to determine the impact of HIV/AIDS on the

outcome of acute burn injuries within the Southern African region. Further interventions are needed to tackle this serious public health issue. A mortality prediction model is proposed for use in the burn unit, but needs external validation before being adopted into clinical practice. Further research is needed to improve data capturing in the burn unit.

INTRODUCTION

The apartheid system has resulted in an impoverished and poorly educated generation. Unfortunately fifteen years on since the dawn of democracy in South Africa, little has changed for those who live in socio-economic poverty within informal settlements. The last two decades have seen a wave of rural to urban migration to major cities in South Africa. Previous research has described the severe injuries seen in Cape Town resulting from assault, shack fires and primus stoves (1-4)(5). In 1994 the South African government launched the Reconstruction and Development Programme that required the development of a sustainable National Electrification Programme (6). While phase one of this programme (1994-1999) was mostly successful, informal townships continue to expand at a rapid pace in most large cities, with no sustainable infrastructure to support them. Temporary labor migration patterns within South Africa post-Apartheid seem to have increased. Traditionally men have formed the majority of migrants moving to the cities looking for work, however there has been an increasing trend among females noted (7,8)(9-11). The crowded conditions, high rates of HIV/AIDS, alcohol abuse, breakup of the family unit, lack of basic sanitation and service delivery and a lack of co-ordinated emergency services most likely contribute to the high occurrence of these injuries and the high mortality observed. Many of the burn prevention strategies and the paraffin safety association of South Africa (12) are still in their infancy and it is not known how effective they have been in reducing many of these preventable injuries.

Shacks serve as a temporary or permanent home to those seeking employment in cities. It is estimated that there are almost 100 000 shacks within the City of Cape Town alone (13). They usually do not have running water or electricity, and open flame stoves are commonly used for cooking and heating. Shacks are constructed from highly combustible materials and are in close proximity to each other. Once a shack is on fire the temperature increases rapidly and destroys the shack within minutes. Within a developing region such as South Africa demand for admission to dedicated burn unit often exceeds bed availability (14). With limited resources we need to ensure that they are used in the most efficient and cost effective manner. Numerous scoring systems have been proposed to allow physicians to objectively estimate the probability of death (15-17)(18,19). Most of these are complicated models and have been derived and validated within a first world setting. Only one study has addressed this issue in the Southern African region (14). In order for a scoring system to be useful in the Southern African it must be simple and easy to apply, not require specialist tests or examinations and be derived and validated in the population where it is to be used. Tygerberg hospital has the only adult burns referral centre in the Western Cape; most referrals come from the City of Cape Town. The burn unit has 22 beds of which 6 are ICU beds with between 280 and 360 admissions per year (20).

The aim of this study is to describe the aetiology and outcome of adult burn injuries in the Western Cape admitted to the Tygerberg hospital burn unit between January 2003 and December 2008 and to derive and internally validate a mortality prediction model for use in the Southern African setting.

The aetiology and outcome of adult burns is presented as an article accepted for publication, but awaiting allocation to an issue in the Burns journal. The rest of the thesis is dedicated to the derivation and validation of a mortality prediction model for severe burns.

LITERATURE REVIEW AND RESULTS

The epidemiology and outcome of adult burn injuries

Tygerberg Hospital was established in 1972 with the major task of providing specialist burns care in the Cape Town metro pole (20). Shack fires continue to make headlines in the local press (21,22). Rural to urban migration has led to the mushrooming of informal settlements with no sustainable infrastructure to support their inhabitants. While it is impossible to obtain the actual number of shack dwellings it is estimated that about 15% of the population live in shacks compared to around 12% in 2002 (22).

The last census put the estimated actual shack count for December 2005 in the City of Cape Town at just over 98 000 (13). According to National Government there were an estimated 2.14 million shacks nationally in 2003 – an increase from 1.45 million in 1996. Between 2001 and 2003 an average of 417 shacks a day were built nationally – a total of 304 502 shacks in three years, and it is estimated that over 46 000 dwellings each year are raged to the ground as a result of fires (21)(23).

There is a small body of research into adult burn injury in the Southern African region. As mentioned in the paper by Godwin et al (5) most of the epidemiological studies both within and outside South Africa do not mention shack fires as a separate entity(24)(25,26). Burn data from Harare in Zimbabwe in 1999 mentioned the absence of shack type accommodation in the capital city, but highlighted the increase in severity of burns in lodgers renting small adjoining rooms to the main house (27). To our knowledge the paper by Godwin et al is the only paper to have addressed the issue of shack fires within informal settlements in this region. Studies have shown that in areas such as Durban and Zimbabwe, unusually high rates of self-immolation are found in females with figures of 76% to 100% of all attempted suicides (24, 28, 29). Alcohol, violence and other socioeconomic factors continue to make a significant contribution to the burden of disease in South Africa (30). A 1997 audit of patients over the age of 18 years admitted this to the Tygerberg Burn Unit found that 57% of the study group had alcohol dependence and most attributed their burns injuries to alcohol intoxication (31)(32).

There is little research into the outcome of burn injuries in HIV positive patients from the Southern African region. The available studies have produced conflicting results and are limited by small numbers. However the HIV / AIDS epidemic continues to grow and the impact that this is currently having on the outcome of burns patients in South Africa is unknown. A study conducted at the Tygerberg burn Unit in 2001 demonstrated that the outcome of HIV positive patients without stigmata of AIDS, admitted to the intensive care unit showed no difference when compared to HIV negative patients and that they should be managed similarly (33). However only 63% of patients agreed to testing and of those only 33 (5%) were HIV positive. Another study from Malawi (34) reported a two fold increase in mortality in HIV positive patients; however the study only included 40 patients with HIV. A small study of only 6 HIV positive patients from Zimbabwe (35) could not find any increase in mortality or length of hospitalisation among the HIV positive group, however earlier work from the same unit (36) demonstrated impaired graft survival in a group of 15 HIV patients. Compelling evidence from the USA investigating the effects of pre-existing medical co-morbidities on mortality and length of stay in acute burn injury (37) demonstrated that in-hospital mortality was significantly predicted by HIV/AIDS (Odds ratio=10.2) and length of hospital stay was increased by 49%. Clearly further well designed prospective studies are needed from the Southern African region to determine the true impact of HIV/AIDS on burn injury outcome.

Comprehensive and detailed data on the epidemiology of adult burns in South Africa is sparse (38). However a recent observational study in Cape Town from 2001 to 2004 has highlighted the high prevalence among middle age men. Alcohol intoxication was found in 52% of those cases aged 16+ years. Mortality rates for black Africans were found to be 17.8 times higher than that of whites and Asians, with rates for mixed race persons being 7.1 times higher than that of whites and Asians (38). These findings are not surprising given that these groups still form the vast majority of those who are socially and economically disadvantaged.

Previous research in 1993 at the New Somerset Hospital burn unit in Cape Town (now closed), 26% of admissions were as a result of shack fires (5). These patients had severe burns (mean TBSA of 31%), with over 60% sustaining some degree of inhalational injury and high mortality (40% died). Godwin et al suggested that shack fires be classified as a separate entity with predisposing factors and injury patterns different to those reported in house fires in more traditional developed areas. Factors identified in their research included accidents relating to open fires, cooking stoves, candles, alcohol and arson / assault.

Informal settlements are overcrowded and built from highly combustible materials such as plastic. This allows for rapid spread resulting in severe burns and inhalational injuries from toxic smoke (23). It is known that the use of paraffin (kerosene) and other fuels are the leading contributing factor to shack fires (23). 10% of all admissions to the TBH burn unit from 2003 to 2008 were as a result of cooking stove accidents (Table 1a). Hudson et al (3) found that 17% of all admissions were as a result of primus stove accidents in 1994. Cooking stoves were implicated in 16% of shack fire injuries at the New Somerset Hospital (NSH) burns unit in 1997(5). Data from Zimbabwe (27) and Johannesburg (25) cite primus stoves as the cause in 10% and 26% of injuries respectively. No figures were available on the contribution of shack fires and primus stoves from a recent study in the Durban (24). While it may be useful to classify shack fires separately from fuel stove accidents, the reality is that most shack fires are probably caused by fuel stoves and most stove accidents occur in informal settlements.

	All admissions	Shack fires	Stoves
Total patients admitted	1908	202	197
Male, n (%)	1231 (65)	157 (77.7)	100 (50.8)
Age (yrs.) (mean ± SD)	34.3 ± 13.59	31.9 ± 10.8	35.8 ± 13.2
Age (yrs.) (range)	12 - 91	15 – 78	13 – 82
TBSA (%) (median)	15	30	15
LOS (d) (median)	14	13	19
Inhalation injury, n (%)	596 (31.2)	146 (72.3)	47 (23.8)
Non-survivors, n (%)	486 (25.5)	96 (47.5)	41 (20.8)
ICU admissions, n (%)	863 (45)	145 (71.8)	84 (42.5)
BAUX score (mean ± SD)	56.7 ± 23	67.2 ± 27	54 ± 19

Table 1a: Summary of all admissions over the 6 year period

In 1994 the South African government implemented the National Electrification Programme which wassuccessful in electrifying 2.5 million homes by 1999 (6)(39).

In 2002 the Department of Minerals and Energy (DME) took over responsibility for funding the Integrated National Electrification Programme (INEP) from the national power utility ESKOM (39). The intention of the government was to supply universal access to basic electricity services. By 2005 the INEP had achieved connections to 232 257 households at a cost of ZAR582m. Furthermore the national electricity basic services support tariff implemented aimed to bring 50KWh of free electricity to low income households. In 2004 the government approved the allocation of ZAR200m towards free basic electricity in an effort to improve living conditions. In an attempt to make paraffin/kerosene more affordable to low income groups the DME removed the VAT levy on paraffin. The electrification statistics from 2009 (40) show that up to 2009 75% of all South African households have been electrified, totalling 9 245 357 million households. The highest percentage (86%) of these is in the Western Cape Province. Since 1994 approximately 4.9m households have been electrified. These achievements are laudable but demonstrate that the solution to the problem of shack fires and kerosene related burns lies not only with the electrification of homes. Electricity is more expensive than kerosene and not immediately available in the township areas. According to the Health Systems Trust; in 2001 39% of African households, 97% of Indian and 96% of whites used electricity as their main energy source for cooking. The 2007 community survey showed that 57% of African households now used electricity for cooking (41).

Burn patients place a heavy burden on an already overstretched health system. Attempts have been made to quantify the cost of treating burn injuries in South Africa: an analysis done at the TBH burns unit from 1998 to 1999 calculated that the cost of treatment for a patient with 25% TBSA and a 20 day length of stay without any ICU treatment was USD 4531(23)(32).

This research has demonstrated that shack fires, assault and injuries due to kerosene and other accelerants contribute to a large proportion of burn patients seen at Tygerberg Hospital, in keeping with previous research (42). The young male (20-40 years) is seen at risk for these injuries (Table 1a -1d) (Fig 1a -1e). Analysis of our statistics shows that the burn death rate and admission rate has remained roughly the same over the 6 year period (Fig 1f-1i). Data from the 7th annual report of the National Injury Mortality Surveillance System 2005 in South Africa revealed that the burn death rate was 8.7 / 100 000 pop and remained almost the same over the previous 4 years (43).

	Survivors	Non-survivors	p-value
Male, n (%)	82 (80.3)	71 (73.9)	0.280
Age (yrs.) (mean ± SD)	30.5 ± 9.97	33.6 ± 11.5	0.041
TBSA (%) (mean ± SD)	18.2 ± 12.2	52.6 ± 24.2	< 0.001
LOS (d) (mean ± SD)	29.7 ± 22.8	10.1	< 0.001
Inhalation injury, n (%)	51 (50)	93 (96.8)	< 0.001
ICU admissions, n (%)	50 (49)	93 (96.8)	< 0.001
BAUX score (mean ± SD)	48.9 ± 15.2	86.3 ± 24.2	< 0.001

Table 1b: Characteristics of survivors and non-survivors in the shack fire group

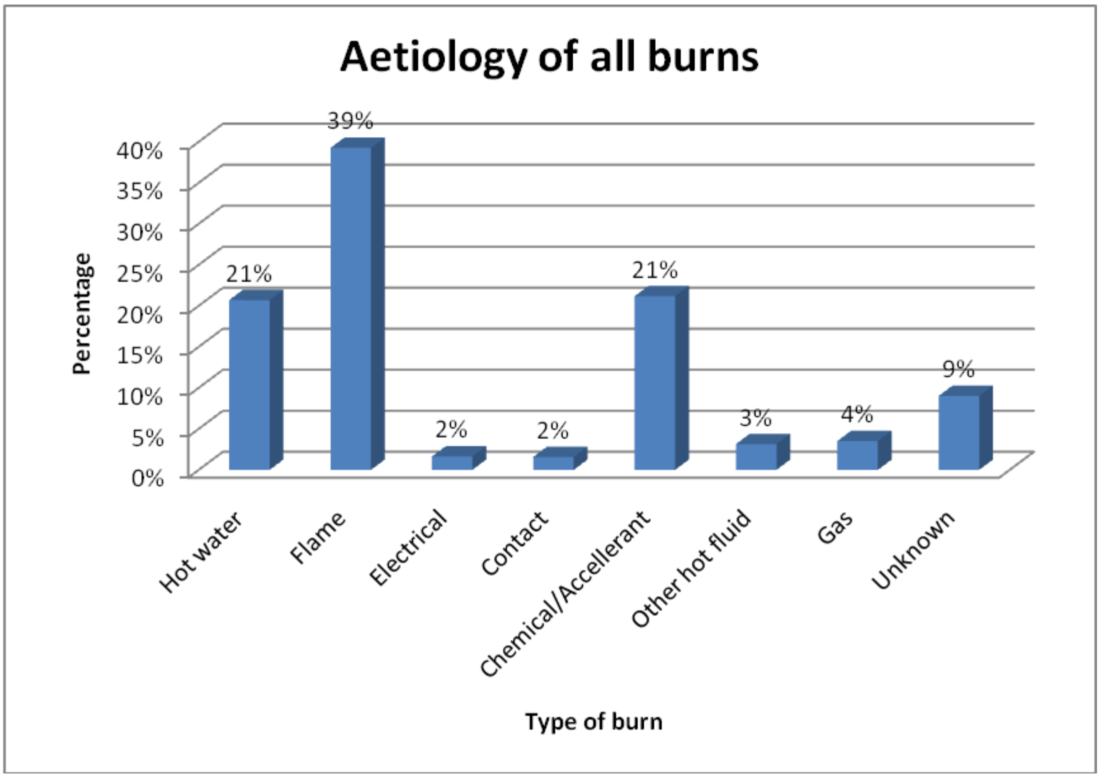

Fig 1a: Aetiology of all burns over 6 year period – type of burn

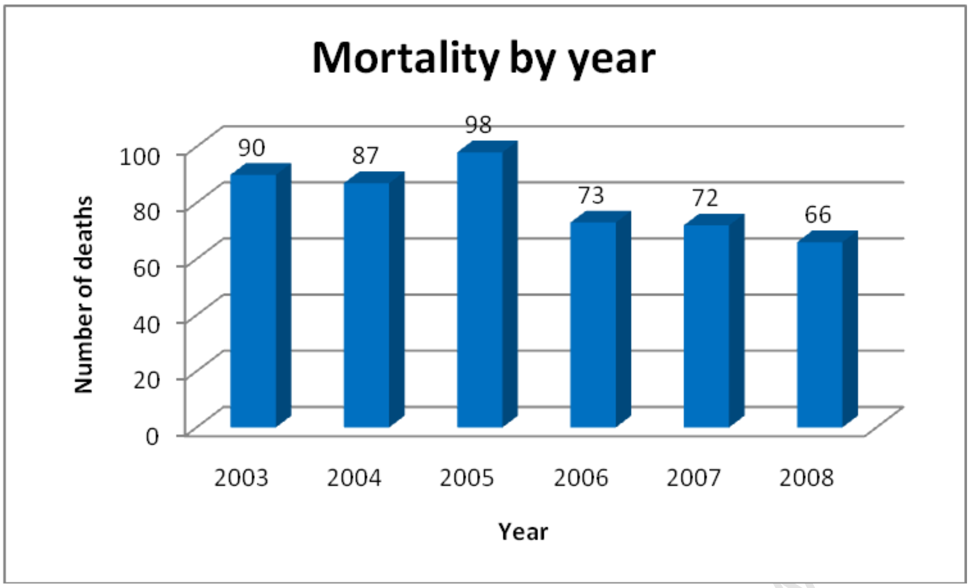

Fig 1f: Mortality by year

The last major audit done in this unit from 1985 to 1996 (44) showed that the majority of admissions (67%) were male. 18% were due to assault with 8% due to cooking stove accidents. Scalds and flame burns comprised 34% and 29% respectively. The majority of patients (56%) sustained burns between 10 to 40% TBSA. There were 13.7% of admissions with a TBSA more than 40% versus 18% in this study. In the previous audit of 6056 admissions over a 10 year period there were only 452 deaths (7.4%). This differs remarkably from our audit over 15 years later with 486 (25%) deaths being recorded over a 6 year period (Fig 1j-1m). This is in contrast with findings from other burn centres in the Southern African region. Mortality figures for 1992 to 2008 range from 9 to 22% for various centres in the region (24)(25,29,45). However at the time of the last major audit (185 to 1996), the Tygerberg Burn unit routinely admitted children from neonates onwards. There were 2273 (37%) child admissions over this period. The relative proportions of adult and child fatalities are not available for this data and thus this fatality rate of 7.4% may not be representative of the adult injuries. However in the previous audit 19% of admissions were transferred to the ICU with 45% of our admissions in this study requiring ICU management. Reasons for this are multifactorial and are explored further, but what's clear is that there has been change in the nature of the burn injuries and in the burn victims themselves seen in this unit over the last twenty years. In our opinion this is due largely to the expanding HIV /AIDS pandemic and the shift in the socio-political landscape with the large scale rural to urban migration of temporary labourers that might explain the proliferation of informal settlements seen around Cape Town. What is largely unknown at this stage is the impact of the HIV/AIDS epidemic on the outcome of burn injuries. At the time of the last audit the epidemic had not yet reached its peak with the two first cases reported in 1982(46) and a national prevalence of less than 1% in 1990 and rising to 7.5% in 1994 amongst antenatal attendees(47). HIV infection and AIDS have already reached epidemic proportions in South Africa with this country having the largest number of people living with HIV/AIDS in the world (48,49). Estimates of HIV prevalence in the Southern African region vary from 25 to 39% depending on the sub regional level studied. In 2001, South Africa with an estimated prevalence of 25.7% ranked lower than other neighbouring countries (48,49). The figures for the Western Cape province are significantly lower than the national estimates with a prevalence of 1.1% in 1994, 5.2% in 1998 and 15.4% in 2004 among antenatal clinic attendees(48). Health district surveys within the Cape Town metro pole also show a wide variation in HIV prevalence. The Khayelitsha and Gugulethu/Nyanga health districts within the Cape Town metro pole contain many informal settlements. Figures for Khayelitsha showed a HIV prevalence of 22% in 2001 and 33% in 2004, and for Gugulethu/Nyanga a prevalence of 16.1% in 2001 and 29.1% in 2004(48). These figures clearly demonstrate the increasing HIV epidemic over the last 20 years. It is unknown how many of our patients presenting to the unit is HIV positive but it is likely to reflect the prevalence in the community. Furthermore we do not know what the outcome of our HIV positive patients are compared to the HIV negative patients.

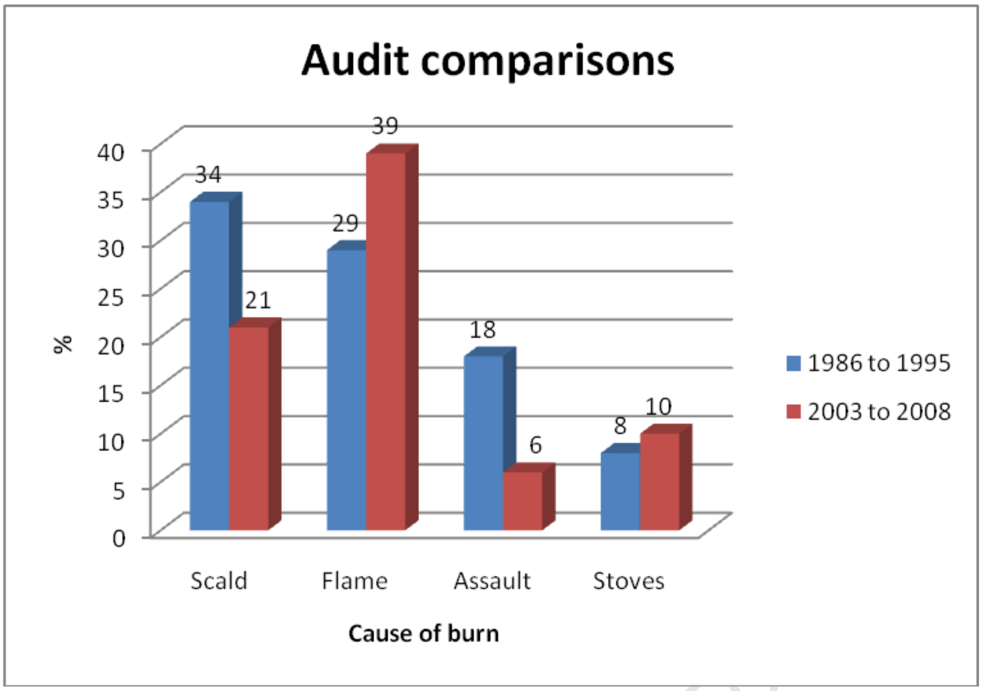

Fig 1j: Comparison of cause of burn injury between the two audit periods

	1986-1995	2003-2008
Total admissions	6056	1908
Adults	3783 (62%)	All ≥ 13yrs
Children	2273 (37%)	
Male	4087 (67%)	1231 (65%)
Female	1969 (32%)	673 (35%)
ICU admission	1164 (19%)	863 (45%)
Case fatality rate	452 (7.5%)	486 (25%)

Fig 1m: Comparison between the two audit periods

It is the opinion of the burn unit team that shack fires were not commonly seen in the Tygerberg Burn unit until the early nineties. The socio-political climate at the time in the early eighties allowed for strict control over the movement of migrant workers and others oppressed under the apartheid regime (50). With the abolition of the pass laws in 1986 (51) free movement of migrant workers, mostly from the impoverished Eastern Cape, contributed to the rapid expansion of informal settlements over the next decade within the Cape Town metro pole and the subsequent increase in shack fire injuries observed.

Various attempts have been made to reduce kerosene related injuries, most notably those involving legislative enforcement that requires manufacturers to sell only kerosene stoves that comply with various safety standards (52). The Paraffin Safety Association of Southern Africa was established in 1996 as a non-governmental organisation to promote the safe use of domestic kerosene (53). This organisation initiated testing into most of the commonly used kerosene stoves in 2003 as well as launching educational and public awareness projects. It continues to conduct research, stimulate national legislation and advise the South African Bureau of Standards.

Mortality prediction in severe burns: a model from a developing world setting in South Africa

In the setting of current resource constraints in South Africa, guidelines are needed based on objective data to decide on the best course of management for severely burned patients. Patients unlikely to survive may be better off managed at secondary (regional) hospitals. Health care in South Africa is constantly struggling to provide better quality health care in a cost effective manner and this demand for accountability has made us more aware on what happens to patients. Outcomes information is an important measure used in benchmarking quality performance within the health system. They are the first step in determining the consequences of health care (54).

With the improvement in outcome for severe burns seen in the last few decades in the developed world there has been an explosion of research into the development of multiple scoring systems to predict mortality(16,55-59). The references mentioned are only but a few of the many studies published. Most of these are variations of a common theme and probably have limited clinical application in real life terms. There is a small body of research into the epidemiology of adult burn injuries in the Southern African region (1-5,14,25,27). Only one study from 1998 (14) has attempted to explore the development of a prediction based upon the BAUX score along with presence of inhalational injury. However this tool was complicated and required one to subjectively grade the inhalational injury. Anecdotal evidence suggests that most practitioners here in South Africa use clinical gestalt and the

BAUX score to determine the probability of someone surviving a major burn and base their decision for admission to a burn unit for further escalation of care on these parameters. Mortality in burn patients can be estimated by the presence or absence of a number of risk factors. The Abbreviated Burn Severity Index (ABSI) is an example of a commonly used prognostic scoring system that correlates the probabilities of survival with the presence of the following adverse prognostic factors (each scored and weighted):

- Age
- TBSA
- Female gender
- Inhalational injury
- Full thickness burns

A score of >12 estimates a probability of survival of <10% (17)(60)(61). However it can be difficult to diagnose the depth of burns in the acute stage of thermal injury. Appendix C has a more detailed description on calculating the ABSI score and the scoring and weighting of each component.

The BAUX score is an example of another scoring system developed over 50 years ago(62).

Percent mortality = Age + TBSA%

It is used as a burn severity index. A value of > 75 indicates a greater than 50% probability of death(19). Each additional year of age or percent of TBSA increases the predicted percent mortality in equal measures.

Survival following burns has changed dramatically in developed nations over the last two decades. The development of antibiotics, use of early excision and grafting and advanced ICU care (especially in developed countries) has probably made this scoring tool redundant(63). Multiple studies have identified the presence of inhalational injury as a significant contributor to mortality. Recent research has attempted to include inhalational injury into the Baux score so has to retain its simplicity with the development of the revised Baux score (63):

Revised Baux score = Age + TBSA% + (17 x Inhalation; yes=1, no=0)

In this score from data on over 39000 burned patients, the presence of inhalational added 17% TBSA or 17 years to the original Baux score. This score is simple enough to be used at the bed side to provide a rough estimate of mortality.

Scoring systems are useful to aid in decision making and can be used for research purposes and quality control. These models should be easy to use and based on objective data. However many different models have been developed which are complex and their application into clinical practice is unlikely (16).

Many of the prognostic scoring systems in use today have been validated for use in the developed world setting and may not be applicable to the developing world setting. There is a need in South Africa to develop an easy to use model for the objective, evidence based prediction of burns mortality (64)(56)(65)(58). Research and clinical observations have consistently identified only three important variables that predict mortality: TBSA%, age and the presence of inhalational injury (63). Each of these variables can be easily collected and used in a simple scoring system.

Further limitations that apply to this study and many other mortality prediction models are that they have been developed and validated in a particular data set from a specific unit(63). The consequences are that this model and others may not be applicable to other burn units. For example our model will not be applicable in a European burn unit. However, given the similar patient profile in other Southern African hospitals, it may be more representative. Another significant drawback of this model and others is the absence of the inclusion of patient co-morbidities in the prediction models. As alluded to earlier we know that HIV and other pre-existing disorders contribute to the morbidity and mortality seen with burns; with HIV/AIDS, metastatic cancer, liver disease and renal disease having a particularly poor prognosis (37). Furthermore, in this study we defined inhalational injury based on the clinical circumstances surrounding the burn injury. Bronchoscopy was not used to diagnose or stage the severity of inhalational injury. Indoor fires, burns to the head and neck as well as the need for ICU admission and ventilation were used as a proxy to identify the presence of inhalational injury. The specific features of airway burns were not routinely and consistently recorded in the patient discharge summary. Thus the need for ICU admission and ventilation may have been misinterpreted as positive for inhalational injury as alluded to in another recent study (15). However as mentioned in that study, with reference to work

by Galeiras et al (66), there was a strong colleration between the need for early ventilation (versus the presence of inhalational injury) and outcome in terms of mortality in thermal injuries.
Furthermore, statistical models can only provide accurate probabilities and cannot predict death (63)(15). Thus these models need to be used cautiously in the clinical context and may find application in the context of benchmarking quality assurance standards, research and to compare outcome between units over time.

In this study female gender was associated with increased mortality and further exploration of this association is needed within the South African setting. Previous research in the burns literature has studied this association(67-70). The adjusted odds ratio for death in females versus males was 2.21 (95% CI 1.41-3.46), however no breakdown in terms of age intervals and adjustment for other potentially confounding variables was done. This may be the focus of future research to be carried out on this data base.
Three important studies (67,68,70) have all shown an up two to six fold increased risk of death in females up to the age of 60 years, with no difference seen in those older than 60 years. These findings persisted following adjustment for other confounding variables. The increased risk of death could not be fully explained by differences in the demographic characteristics, aetiology of the burn injury or burn severity. Interestingly the increased risk of death was only seen up to the age of sixty. It is postulated that the declining levels of oestrogen seen with increasing age might play a role in the increased risk of death seen in females under the age of 60 years. The study by O'keefe et al(70) showed that woman between 30 and 59 years had an increased adjusted odds of death compared with men of the same age. An earlier study by Barrow et al(71) showed a higher fatality rate in boys compared to girls, but a subsequent study(72) by the same author failed to show this gender differential in children less than 17 years. These findings are supported by experimental data but further studies are needed to explore this association in more detail. Further work is planned to investigate the gender differential here at the Tygerberg Hospital burn unit.
The area under (AUC) the receiver operator curve (ROC) can be used as a measure of the discriminatory power of prediction models used to predict mortality(15). An in depth discussion on ROC curves is beyond the scope of this work but an AUC of 0.5 = random and

1.0 = perfect discriminatory power. A prediction model with a high power to identify those with a high risk of mortality will typically have an AUC of greater than 0.8. In this study our ROC analysis performed with an AUC of 0.89 thus indicating a moderate discriminatory power.

Modern medical technological advancements have allowed us to care for severely ill or injured patients and this has been mirrored in the improving survivability of severe burns seen over the last few decades (54,73). With the development of mortality prediction models it was envisaged that clinicians would have an objective method to predict those who would die from severe injuries and reduce reliance on clinical intuition / gestalt (73). An excellent review article on the outcome measures in burns (54) highlights the shift from short term mortality outcome to longer term quality of life outcomes in the benchmarking of quality performance in the management of burns. An editorial from the same journal (73) reinforces the idea that mortality prediction models should not be used to ultimately determine whether a patient will receive full treatment or not. The interpretation of the scoring systems will depend on a number of factors such as the medical social environment of the physician and patient, resource constraints as well as underlying medical co-morbidities in the patient.

AIMS AND OBJECTIVES

The aim of this study is to describe the epidemiological and demographic data of patients admitted to the Tygerberg Hospital Burn unit from January 2003 to December 2008.

In order to achieve this aim, this study has the following objectives:

1. Undertake an analysis of admissions to the burn unit.
2. To develop and internally validate a burn injury mortality prediction model.

METHODS

A retrospective review of patients on the Burn Unit database was undertaken, looking at patients admitted to the Burn Unit between 1st January 2003 and 31st December 2008.

Setting

Tygerberg hospital has the only adult burns referral centre in the Western Cape; most referrals come from the City of Cape Town. The burn unit has 22 beds (with 6 ICU beds) and between 280 and 360 admissions per year.

The burns unit has traditionally run a paper based database of all admissions. Recently, this was transferred into an electronic format which has allowed for closer interrogation of the characteristics and clinical outcomes of these patients.

A retrospective review of patients on the Burn Unit database was undertaken, looking at patients admitted to the Burn Unit between 1st January 2003 and 31st December 2008.

Clinical care:

Clinical management was according to the unit's standardised protocols. Patients are admitted to the unit if they have burns >20% total burn surface area (TBSA)(44). Patients with less extensive wounds are admitted if the following are present:

- burns to the face,
- burns to the flexor areas,
- burns to the perineum,
- circumferential burns of the extremities
- full thickness burns with infection.

Patients with features of inhalation injury, burns >35% TBSA and elderly patients with smaller wounds and pre-existing disease are admitted to the Burn Unit's ICU at the discretion of the attending doctor.

Standardised burn unit protocols include fluid resuscitation, bedside escharotomies and burn wound care. Endotracheal intubation and ventilation is used when necessary for those with inhalational injury, facial burns and incipient or established respiratory failure. Once initial resuscitation is completed, patients are transferred to theatre for early excision and grafting.

Inclusion and Exclusion:

All acute patients were eligible for inclusion. Wound complications readmitted and skin donor patients were excluded. Only thermal, contact, electrical and chemical burns were included.

Data extraction:

Data captured included age (years), gender, burn size (percentage of total body surface area, TBSA%), cause of burn injury, presence of inhalational injury, admitting ward (intensive care or general ward), outcome (died or survived) and length of stay in hospital (days). Captured data was stored on a password protected computer belonging to the principal investigator. No patient identifiers were captured or stored in the data set.

Data analysis:

Assistance was provided by Prof Daan Nel of the Centre for Statistical Consultation at the University of Stellenbosch.

Descriptive statistics were used to determine the means, medians; SD's and ranges using STATISTICA version 8 (Stat Soft Inc. 2008) and Microsoft Office Excel 2007. Tables and figures were constructed using Microsoft Office Excel 2007.

Descriptive statistics were used to determine the means, medians; SD's and ranges using STATISTICA version 8 (StatSoft Inc. 2008) and Microsoft office Excel.

The relationships between continuous response variables (e.g. age, TBSA, LOS, Baux score) and nominal input variables (e.g. survivors and non-survivors, and between sexes) were analysed using appropriate analysis of variance (ANOVA). When the residuals from ANOVA were non-normally distributed or if ordinal response variables were compared versus a nominal input variable, non-parametric methods were used such as the Mann-Whitney U test. The relations between two nominal variables (e.g.: gender, presence of inhalational injury, mortality) were investigated with contingency tables and likelihood ratio chi-square tests.

In patients where data was missing or unknown they were excluded from the analysis. However the whole patient record was not be excluded if some data was missing. The type of burn, manner of injury and the circumstances surrounding the burn injury were determined as far as possible. Furthermore the Baux score was calculated for each patient – this rule adds the patient age to the TBSA. It is used as a burn severity index. A value of > 75 indicates a greater than 50% probability of death (19)(74).

Multivariate logistic regression analysis was used to assess the relationship between mortality and the variables associated with death. Sensitivities, specificities, odds ratios and 95% confidence intervals were reported. The discriminative power of the model was assessed by receiver-operated characteristic curve analysis, which demonstrates the sensitivity and specificity of the prediction model in a graphic way. The discriminative power is maximal when the area under the curve is 1; there is no discriminative power when the area is 0.5.

Only those patients with severe burns (TBSA greater than or equal to 20%) were used in the development of the prediction model. Data from patients admitted from 2003 to 2006 were used to derive the model (the derivation cohort). The discriminative power and predictive value of this model was validated on those patients admitted from 2007 to 2008 (the validation cohort).

Ethical approval

Approval for this research was granted by the committee for Human research at the Research Development and Support Division of the Faculty of Health Sciences, University of Stellenbosch (Reference number:N08/11/346) as well as from the ethics division of the University of Cape Town (Rec Ref: 038/2009). As this was a retrospective data base review and no patient identifying information was collected, individual patient consent was not obtained.

Part C

Results and Article Manuscript for Submission

RESULTS

Severe burns study population

In this study a patient is regarded as severely burnt if the TBSA% is greater than or equal to 20%. Only these patients were included in the study to derive a mortality prediction model which considered patients from 2003 till 2008. The 2003 to 2006 group is regarded as the derivation set while the 2007 and 2008 cohort was regarded as the validation set. The characteristics of these two cohorts is summarised in table format (Table 2-5).
There were 847 (44.4%) patients with severe burns greater than or equal to TBSA of 20%. Male patients comprised 63.4% (n=537) of this group. Overall 421 (49.7%) of the severely burnt patients died. There were 608 in the derivation cohort with 239 patients in the validation cohort. No significant differences were observed between the two cohorts.

	n	%
2003	156	18.4
2004	141	16.6
2005	160	18.9
2006	151	17.8
2007	122	14.4
2008	117	13.8
	847	
Male	537	63.4
Female	309	36.5
Missing	1	0.1
	847	
Inhalation yes	464	54.8
Inhalation no	373	44
Missing	10	1.2
	847	
Died	421	49.7
Survived	426	50.3
	847	

Table 2: Severe burns greater than or equal to 20%

	Derivation	Validation
Age mean	34.35	33.64
Age SD	13.53	13.17
Age Q25	24	24
Age median	32	31
Age Q75	42	41
TBSA mean	37.91	36.82
TBSA SD	19.42	17.93
TBSA Q25	20	22
TBSA median	30	30
TBSA Q75	45	45

Table 3: Comparison of derivation and validation cohorts

Multivariate analysis and mortality prediction model

A stepwise logistic regression with 0=Death and 1=Live as response variables was done on the derivation set and the following variables were identified as significant for predicting death: age, gender, TBSA% and presence of inhalational injury; where inhalation injury was categorized as : no=1 and yes =-1 and Gender (sex) was categorized as f=1 and m=-1. The prediction z-score for death was computed with SAS PROC logistic as:

z= - 5.2756 + 0.0459*AGE + 0.1098*TBSA% - 0.5515* INHALATION +0.3956 * SEX

The probability for death was then computed as P(z) = exp(z)/(1+exp(z)).

The following graph gives these probabilities on the vertical axis for different observed values of z on the horizontal axis (Fig 6).

Higher values of z indicate larger probability for death. Two selection criteria may be used to predict death namely :

(i) Predict Death if the probability P(z) >0.5

(ii) Predict death if $Z>z_0$ where z_0 is the z cut-off value from the ROC curve of the derivation set .

This cut- off value z_0 is determined as that value which gives the largest specificity and sensitivity as determined from a receiver operator characteristics curve (ROC) analysis. This value was now determined as z_0 =0.0967 (AUROC of 0.89) with a more comprehensive ROC analysis involving all the derivation observations and not just using 30 cut-off points. See the ROC curve in the graph, where this value is indicated (Fig 7) (Table 6).

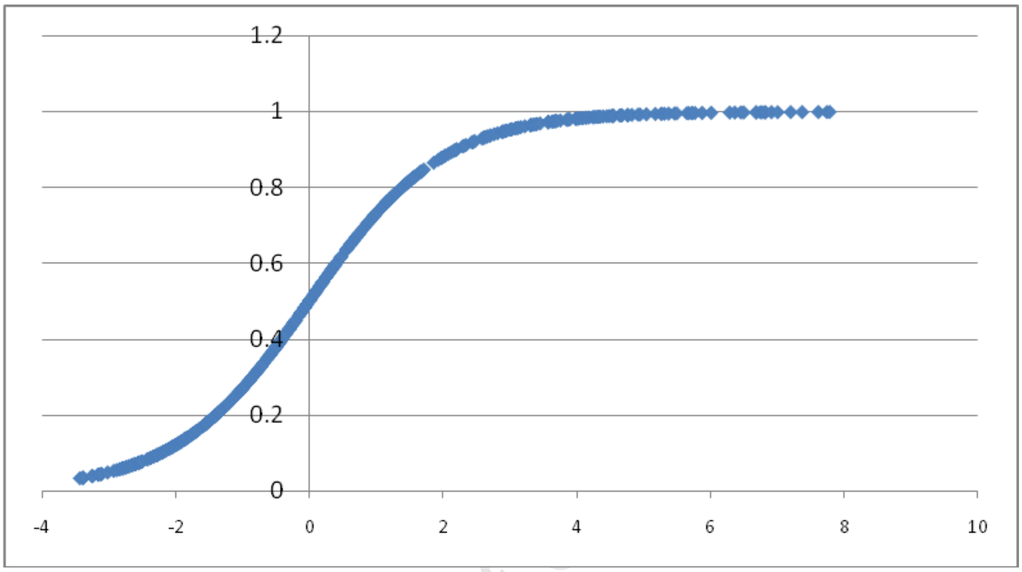

Fig 6: The probability of death P (z) (vertical axis) plotted against the z-score for death (horizontal axis).

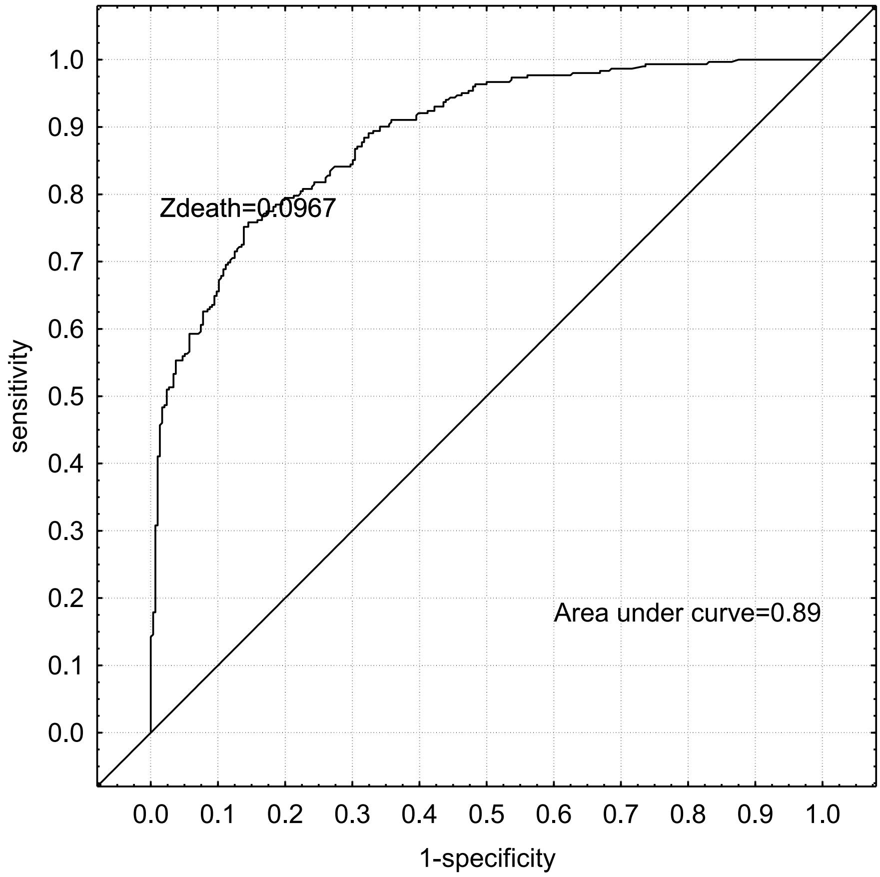

Fig 7: Scatter plot of sensitivity against 1-specifity (ROC)

The sensitivity and specificity of the model obtained on the **derivation set** of patients are: (Appendix A)

Sensitivity = 75.5% (95% CI: 70.6-80.3%), Specificity = 85.5% (95% CI: 81.5-89.5%), using the cut-off value z_0 =0.0967 as the criterion. (PPV 84.1%, NPV 77.4%, LR+ 5.1, LR- 0.2)

The sensitivity and specificity of the model obtained on the **validation set** of patients are: (Appendix A)

Sensitivity = 75.4% (95% CI: 67.5-83.3), Specificity = 82.3% (95% CI: 75.5-89%), using the cut-off value z_0 =0.0967 as the criterion. (PPV 79.6, NPV 78.5%, LR+ 4.2, LR- 0.2)

A decision calculator (In Excel) was constructed to easily enable one to estimate the probability of death in the setting of severe burns greater than or equal to 20% TBSA (Fig 8).

ENTER THE FOLLOWING INFO OF THE PATIENT:		
AGE	22	
TBSA%	32	
INHALATION	Y	
SEX	F	
	Zdeath	0.195
	P(DEATH)	0.549
	PREDICT	DEATH
	ROC PREDICT	DEATH

Fig 8: Mortality prediction calculator for severe burns

LIMITATIONS

In addition to the limitations inherent with retrospective chart reviews a number of other important limitations were identified in this study. There were a total of 147 admissions with incomplete data. However the whole patient record was not excluded if some data was missing. There were a number of unknown variables not accounted for. For example, no information is available for the time of injury until start of definitive care – this is likely to vary widely as many areas have poor access to emergency services, some would have had long waits at the district clinics and thus it is impossible to comment on the when definitive resuscitation commenced. Another factor not assessed was the standard of care each patient received between the district hospitals and Tygerburg Hospitals – a wide range of health care professionals with different skill sets are present at district hospitals with no uniform policy in place. However a formal policy is present at Tygerburg hospital and all treatments are supervised by Surgical and Emergency Medicine Registrars. It is unknown what effect these two variables have on the outcome of burns. Additionally in 26 cases the outcome was unknown and in 33 cases the presence or absence of inhalational injury was not known. The presence or absence of inhalational injury is determined from clinical parameters, circumstances surrounding the injury and the need for ICU admission for mechanical ventilation. Features of airway burns were inconsistently recorded in the patients' notes. The requirement for mechanical ventilation may have been falsely attributed to airway / inhalational injury, thus the presence of inhalational injury may be overrepresented in this population. Bronchoscopy is not used as is done in many first world units. Previous research has demonstrated the association between the need for early ventilation and mortality in burn injuries(15,66). In 89 of these admissions the register entry for the cause of burn was unknown. It was not possible to determine the TBSA% in 41 admissions and the length of stay was unknown in 39 admissions. This study has highlighted deficiencies in data capturing within the unit. Currently a paper based system is being used to capture demographic data. However in South Africa no uniform classification system is in place to describe the type of burn, manner and circumstances surrounding the burn injury. It was left up to the investigators to further classify the injuries. As a result, in 9% of cases the type of burn was unknown (hot water, flame etc.). We were unable to determine the manner of injury (accident, assault or suicide) in 58.5% of admissions. The circumstances surrounding the burn injury was unknown in 56% of admissions. It is our impression that many of these injuries were as a result of dwelling fires, fuel stove accidents or assault. Thus when interpreting these result one has to bear in mind that the true incidence of these injuries may be very underestimated. Well it may be useful to classify fuel stove and shack fire injuries separately the reality is that most shack fires are likely to have started as a cooking/stove accident. Making this distinction is problematic as most fuel stove accidents in our opinion occur within informal settlements.In addition to the above limitations onehas to bear in mind that this model is representative of and derived from a single unit. However it is likely that the Tygerberg cohort isrepresentative of other units within the Southern African region. Although the patients may be similar it is not possible to comment on the standard of care and resources available to care for the patients. Furthermore this model does not account for any existing medical and social co-morbidities, of which there are many. One has to cautiously interpret the results of this study bear in mind the possible influence of these co-morbidities on the outcome of acute burn injuries. Finally the need for ventilation was used as a proxy for the presence of inhalational injury. Without bronchoscopy it is difficult to accurately diagnose and grade the severity of the inhalational injury. However the need for early ventilation in the setting of acute burn injury is associated with increased mortality

RECOMMENDATIONS

In light of the findings described earlier and the various shortcomings inherent in burn prediction models, this model cannot be recommended for use in current clinical practice except for use as a tool in research, quality assurance and to compare outcomes between units. Far simpler and easier to use scoring systems exist such as the revised BAUX score described earlier. The absence of any scoring systems that take into account the pre-existing medical co-morbidities, social circumstances and other important factors make the use of the many scoring systems out there of little clinical relevance outside of the research arena. Clinical gestalt and awareness of other medical, social and resource constraints will continue to play a role in determined the likelihood of an individual surviving a severe burn here in the South African setting. Further studies should aim to validate the usefulness of the revised BAUX score and this model in the South African setting.

CONCLUSIONS

There has been significant increase in burn mortality noted over the last 20 years. Our patients have changed and are more critical. Reasons for this are multifactorial but it is likely that the HIV/AIDS pandemic and the expansion of informal settlements have a significant role to play. Shack fires, assault and injuries due to fuel stoves are a common reason for admission to the burns unit and mostly involve young individuals. In keeping with previous research, their injuries are severe with a high mortality and the young male patient seems to be at particularly high risk. The use of kerosene stoves are a major contributing factor. These injuries place a huge economic burden on an already overstretched health system and are largely preventable. Government and other private organisations must make it a priority to improve housing and electrification and promote education and implement legislation in the safe use of kerosene stoves. Further research is needed into safer alternatives, improving stove design and promoting legislation and research into fire resistant clothing / bedding. Continued education of the community is needed through community awareness projects. More work needs to be done to improve the quality of data capturing in the burn unit to ensure the usefulness of the data. As a start a useful uniform classification system is needed to classify burn injuries in the South African setting as well as the development of a user friendly and cost effective data capturing system for all South African burn units. Further well designed prospective studies are needed to determine the outcome of HIV infected patients in the Southern African region.

An initial attempt to derive a scoring system to predict mortality in acute burn injuries within South Africa is presented. However a number of limitations exist and further work is needed to refine and validate an ideal scoring system for clinical and research purposes. An important caveat is that mortality prediction models should not be used to ultimately determine whether a patient will receive full treatment or not. The interpretation of the scoring systems will depend on a number of factors such as the medical social environment of the physician and patient, resource constraints as well as underlying medical co-morbidities in the patient

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Appendix A: ROC analysis for mortality prediction model

Derivation data using ROC analysis

ROC predDEATH	DEATH	DEATH
0	228	43
1	74	253
All Grps	302	296

To calculate diagnostic accuracy parameters from a 2x2 table

Enter numbers of patients in the highlighted cells:

	Gold standard (death)		
Test	**Positive**	**Negative**	
Disease +	228	43	271
Disease -	74	253	327
		n =	598

Calculated Diagnostic Accuracy Parameters:

Sample size =	598			
Prevalence =	0.453			
PPV =	0.841	Positive predictive value (PPV)		
NPV =	0.774	Negative predictive value (NPV)	Lower CI Limi	Upper CI Limit
Sensitivity=	0.755	95% CI(Sens)=	0.706	0.803
Specificity =	0.855	95% CI(Spec)=	0.815	0.895
LR + result=	5.197			
LR - result=	0.287	Accuracy=	80.4%	

Estimation of 95% CI; known sample size, disease prevalence, sensitivity and specificity*

4 variables required - enter data in highlighted cells:

Total sample size	598			
Prevalence (0-1)	0.453		**Lower Limit**	**Upper Limit**
Sensitivity (0-1)	0.755	**95% CI**	0.704	0.806
Specificity (0-1)	0.855	**95% CI**	0.817	0.893

***NB: Read limitations of CI estimations for small sample sizes and sensitivity /specificity >0.9 or <0.1**

Calculation of Likelihood Ratios from known Sensitivity and Specificity

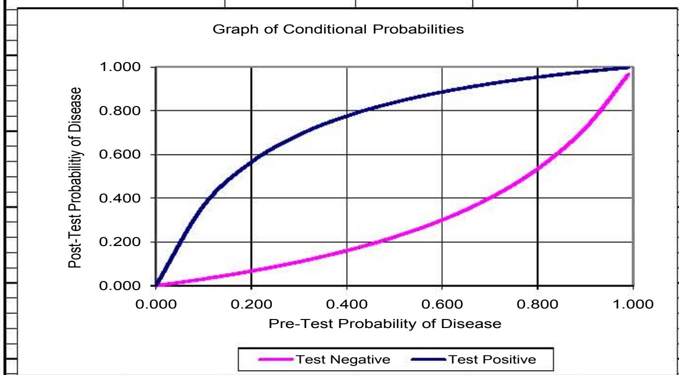
Sensitivity (0-1)	0.755
Specificity (0-1)	0.855
LR +ve test =	**5.197**
LR -ve test =	**0.287**

Table and Graph of Conditional Probabilities

Pre-Test Probability (Pre-TP), Post-Test Probability (Post-TP), Pre-Test Odds (Pre-TO), Post-Test Odds (Post-TO) are fixed.
Likelihood Ratios of Positive and Negative Tests are linked to the cells calculated from Sensitivity and Specificity above (C40, C41)
See Estimation of 95% CI; known sample size, disease prevalence, sensitivity and specificity*; C40, C41)

TABLE OF CONDITIONAL PROBABILITIES

Pre-TP	Pre-TO	Post-TO +ve	**Post-TP +ve**	Post-TO -ve	**Post-TP -ve**
0.990	99.000	514.501	**0.998**	28.381	**0.966**
0.900	9.000	46.773	**0.979**	2.580	**0.721**
0.800	4.000	20.788	**0.954**	1.147	**0.534**
0.700	2.333	12.126	**0.924**	0.669	**0.401**
0.600	1.500	7.795	**0.886**	0.430	**0.301**
0.500	1.000	5.197	**0.839**	0.287	**0.223**
0.400	0.667	3.465	**0.776**	0.191	**0.160**
0.300	0.429	2.227	**0.690**	0.123	**0.109**
0.200	0.250	1.299	**0.565**	0.072	**0.067**
0.100	0.111	0.577	**0.366**	0.032	**0.031**
0.000	0.000	0.000	**0.000**	0.000	**0.000**



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Extra X or Y axis gridlines may be added by clicking on the chart, selecting "Chart" from the toolbar and going to "Chart Options" - Gridlines. Place the cursor on the point where the Pre-Test Probability gridline intersects the Test +ve or Test -ve line to obtain the post-test probability of disease in your patient.

Validation data using ROC analysis

	predDEATH ROC	DEATH	DEATH
	0	86	22
	1	28	102
	All Grps	114	124

To calculate diagnostic accuracy parameters from a 2x2 table

Enter numbers of patients in the highlighted cells:

		Gold standard (death)		
pred death	**Test**	**Positive**	**Negative**	
	Disease +	86	22	108
	Disease -	28	102	130
			n =	238

Calculated Diagnostic Accuracy Parameters:

Sample size =	238				
Prevalence =	0.454				
PPV =	0.796	Positive predictive value (PPV)			
NPV =	0.785	Negative predictive value (NPV)		Lower CI Limi	Upper CI Limit
Sensitivity=	**0.754**		95% CI(Sens)=	0.675	0.833
Specificity =	**0.823**		95% CI(Spec)=	0.755	0.890
LR + result=	4.252				
LR - result=	0.299		**Accuracy=**	**79.0%**	

Estimation of 95% CI: known sample size, disease prevalence, sensitivity and specificity*

4 variables required - enter data in highlighted cells:

Total sample size	238			
Prevalence (0-1)	0.454		**Lower Limit**	**Upper Limit**
Sensitivity (0-1)	0.754	**95% CI**	0.673	0.836
Specificity (0-1)	0.823	**95% CI**	0.757	0.888

***NB: Read limitations of CI estimations for small sample sizes and sensitivity /specificity >0.9 or <0.1**

Calculation of Likelihood Ratios from known Sensitivity and Specificity

Sensitivity (0-1)	0.754
Specificity (0-1)	0.823
LR +ve test =	**4.252**
LR -ve test =	**0.299**

Table and Graph of Conditional Probabilities

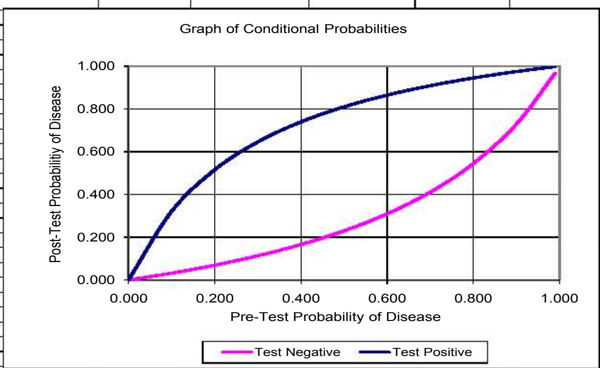
Pre-Test Probability (Pre-TP), Post-Test Probability (Post-TP), Pre-Test Odds (Pre-TO), Post-Test Odds (Post-TO) are fixed.

Likelihood Ratios of Positive and Negative Tests are linked to the cells calculated from Sensitivity and Specificity above (C40, C41)

See Estimation of 95% CI; known sample size, disease prevalence, sensitivity and specificity*; C40, C41)

TABLE OF CONDITIONAL PROBABILITIES

Pre-TP	Pre-TO	Post-TO +ve	**Post-TP +ve**	Post-TO -ve	**Post-TP -ve**
0.990	99.000	420.947	**0.998**	29.560	**0.967**
0.900	9.000	38.268	**0.975**	2.687	**0.729**
0.800	4.000	17.008	**0.944**	1.194	**0.544**
0.700	2.333	9.921	**0.908**	0.697	**0.411**
0.600	1.500	6.378	**0.864**	0.448	**0.309**
0.500	1.000	4.252	**0.810**	0.299	**0.230**
0.400	0.667	2.835	**0.739**	0.199	**0.166**
0.300	0.429	1.822	**0.646**	0.128	**0.113**
0.200	0.250	1.063	**0.515**	0.075	**0.069**
0.100	0.111	0.472	**0.321**	0.033	**0.032**
0.000	0.000	0.000	**0.000**	0.000	**0.000**



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Appendix B: Tables and figures

	n	%
Cooking appliances	199	10.4%
Shack fires	202	10.6%
House fires	104	5.5%
Motor vehicle accidents	19	1.0%
Cigarettes / candles	11	0.6%
Epilepsy / drugs	18	0.9%
Occupational	19	1.0%
Explosion	25	1.3%
Cable theft	3	0.2%
Lightning	1	0.1%
Unknown	1072	56%
Electric stoves / heaters	28	1.5%
Domestic cooking	21	1.1%
Assault / self-immolation	173	9%
Miscellaneous	13	0.9%

Table 1c: Aetiology of all burns over 6 year period – circumstances of injury

	n	**%**
Accident	**616**	**32.3%**
Intentional assault	**109**	**5.7%**
Intentional self-harm	**66**	**3.5%**
Undetermined	**1117**	**58.5%**

Table 1d: Aetiology of all burns over 6 year period – manner of injury

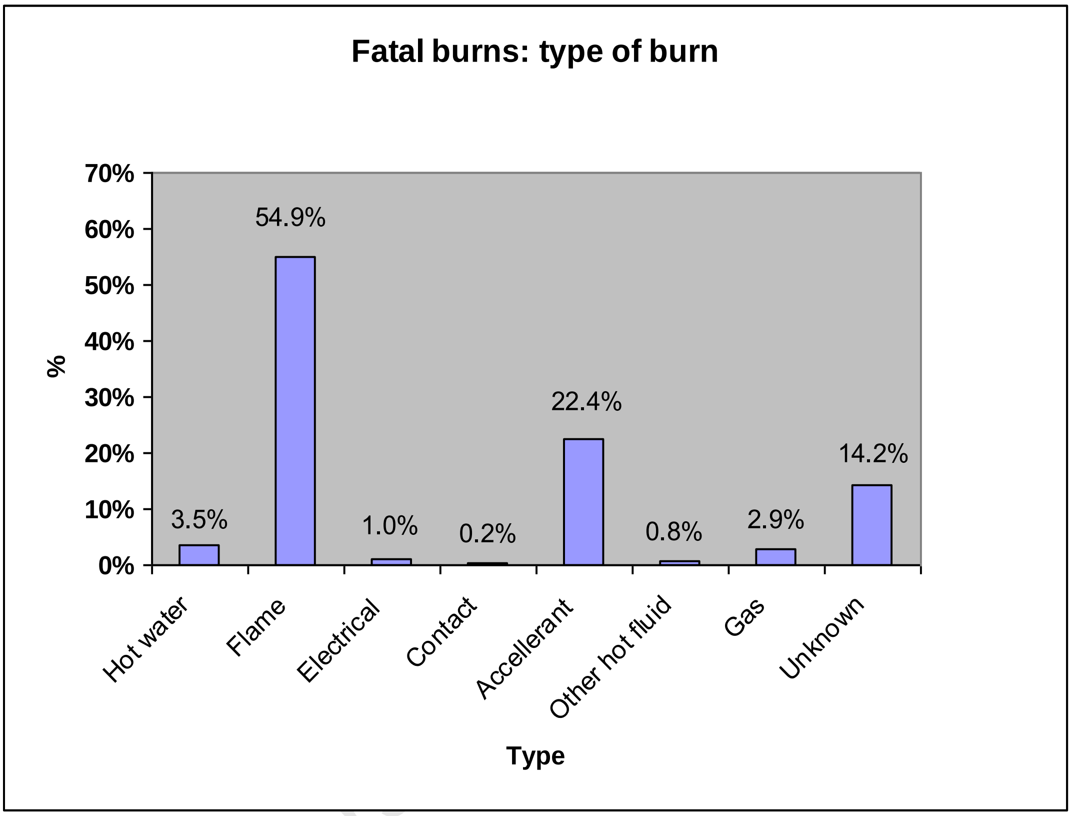

Fig 1b: Fatal burns over 6 year period – type of burn

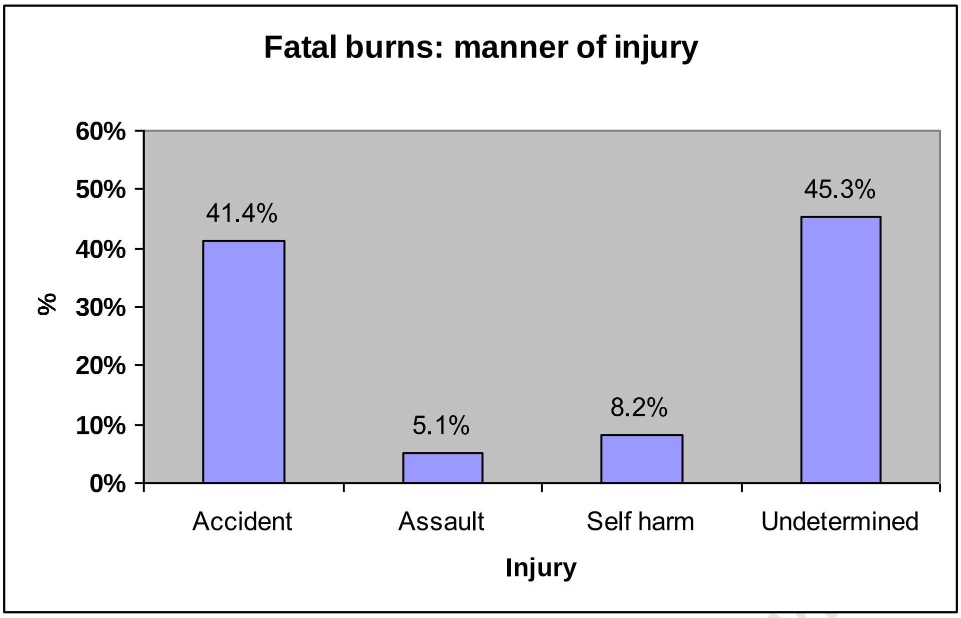

Fig 1c: Fatal burns over 6 year period – manner of injury

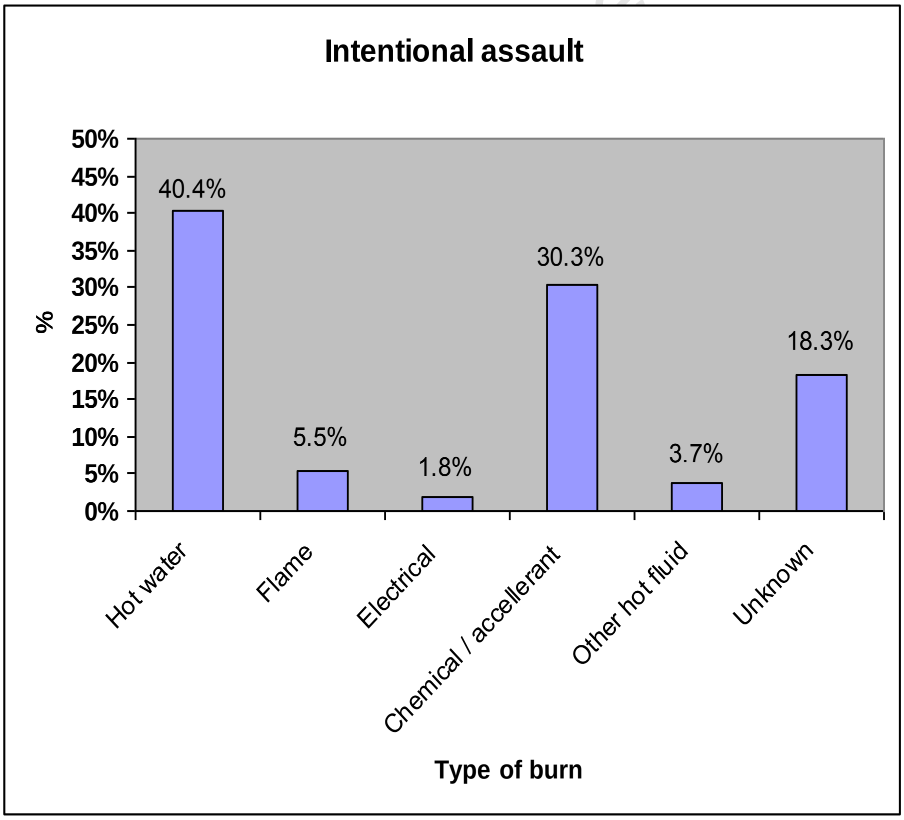

Fig 1d: Intentional assault over 6 year period – type of burn

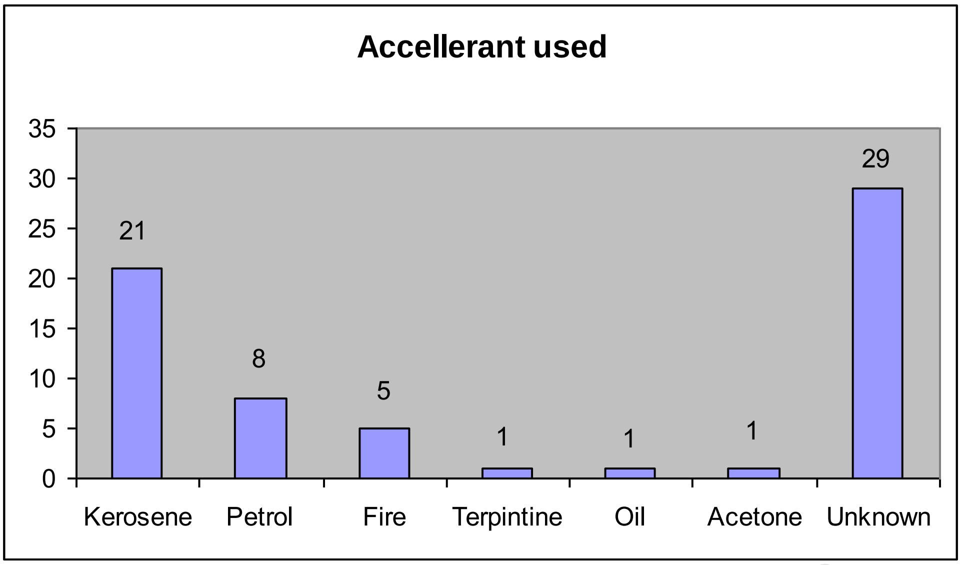

Fig 1e: Intentional self-harm over 6 year period – type of accelerant

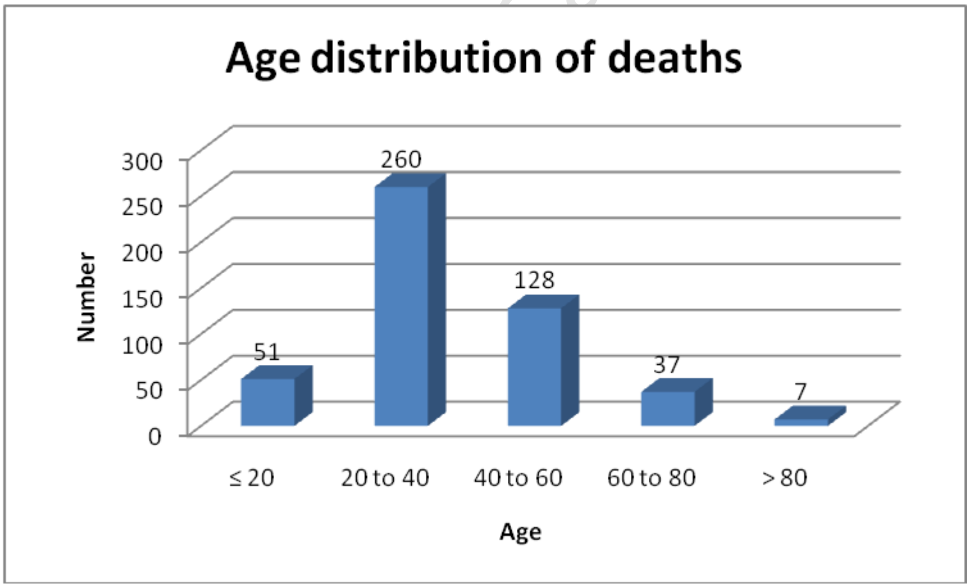

Fig 1g: Age distribution of deaths

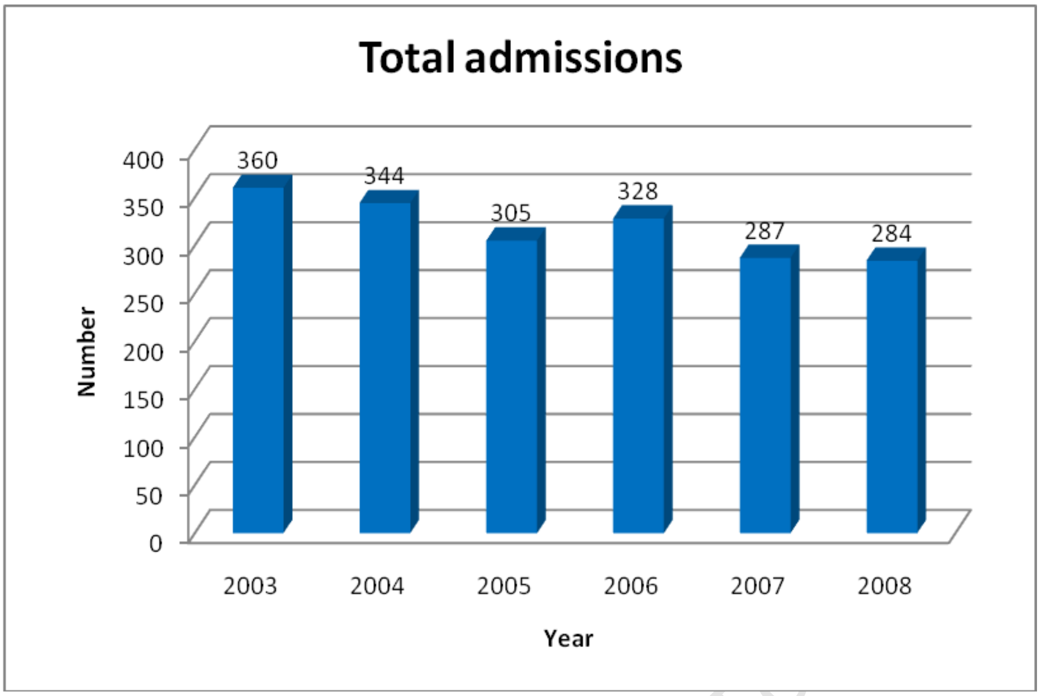

Fig 1h: Yearly admissions

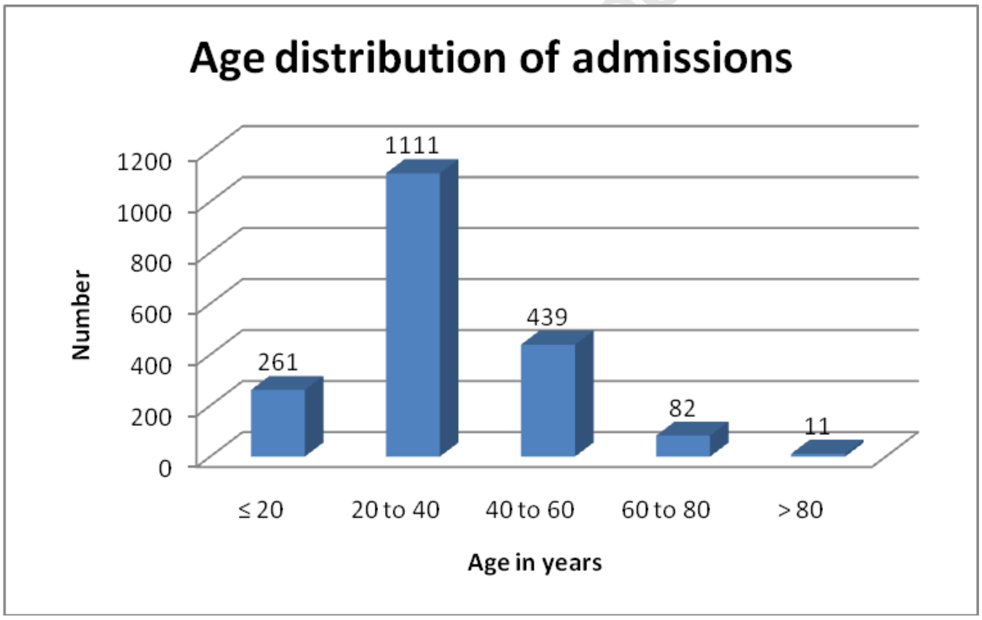

Fig 1i: Age distribution of all admissions

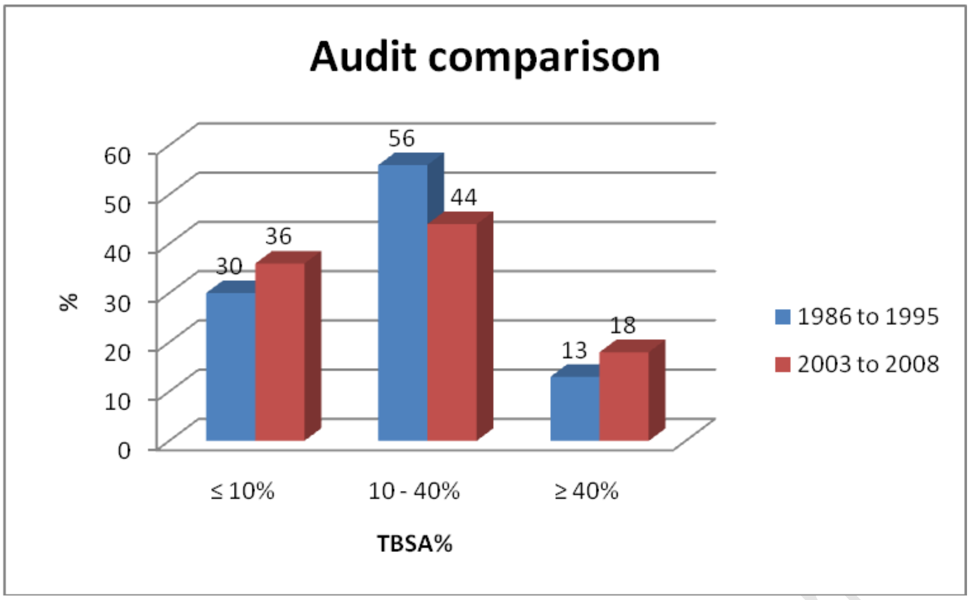

Fig 1k: Comparison of the TBSA% between the two audit periods

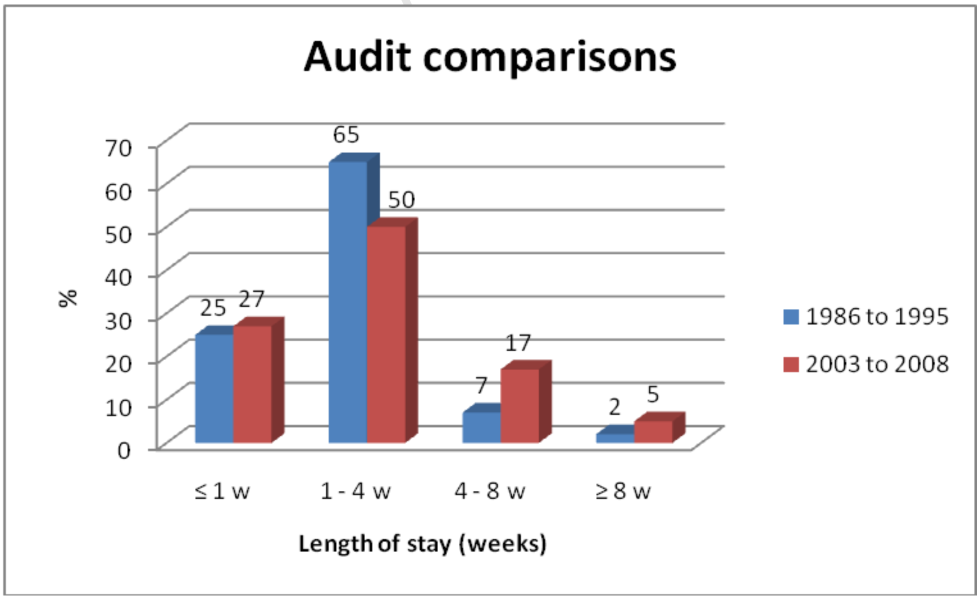

Fig 1l: Comparison of the LOS between the two audit periods

	n	%
2003	156	25.7
2004	141	23.2
2005	160	26.3
2006	151	24.9
Male	392	64.5
Female	215	35.4
Missing	1	0.2
Inhalation yes	331	54.4
Inhalation no	269	44.2
Missing	8	1.3
Died	297	48.9
Survive	311	51.2

Table 4: Derivation cohort

	n	%
2007	122	51
2008	117	48.9
Male	145	60.7
Female	94	39.3
Inhalation yes	133	55.6
Inhalation no	104	43.5
Missing	2	0.8
Died	124	51.8
Survived	115	48.1

Table 5: Validation cohort

	1 sensitivit	2 1-specific	3 specificit	4 pvp	5 pvn	6 Zdeath
Optir	**0.758278**		**0.85473**	**0.841912**	**0.776074**	**0.0967**
2						
3	1	1	0	0.505017		
4	1	0.972973	0.027027	0.511864	1	-3.2482
5	0.993377	0.777027	0.222973	0.566038	0.970588	-2.2716
6	0.993377	0.773649	0.226351	0.567108	0.971014	-2.2402
7	0.870861	0.314189	0.685811	0.738764	0.838843	-0.7128
8	0.870861	0.310811	0.689189	0.740845	0.839506	-0.685
9	0.774834	0.182432	0.817568	0.8125	0.780645	-0.0688
10	0.774834	0.179054	0.820946	0.815331	0.78135	-0.067
11	0.774834	0.175676	0.824324	0.818182	0.782051	-0.0392
12	0.774834	0.172297	0.827703	0.821053	0.782748	-0.0374
13	0.771523	0.172297	0.827703	0.820423	0.780255	-0.0356
14	0.771523	0.168919	0.831081	0.823322	0.780952	-0.0001
15	0.768212	0.165541	0.834459	0.825623	0.77918	0.0035
16	0.758278	0.148649	0.851351	0.838828	0.775385	0.0819
17	0.758278	0.14527	0.85473	0.841912	0.776074	0.0935
18	**0.754967**	**0.14527**	**0.85473**	**0.841328**	**0.7737**	**0.0967**
19	0.751656	0.14527	0.85473	0.840741	0.771341	0.0971
20	0.748344	0.138514	0.861486	0.846442	0.770393	0.1539
21	0.721854	0.135135	0.864865	0.844961	0.752941	0.207
22	0.5	0.023649	0.976351	0.955696	0.656818	1.4846
23	0.496689	0.023649	0.976351	0.955414	0.655329	1.4864
24	0.493377	0.023649	0.976351	0.955128	0.653846	1.5146
25	0.490066	0.023649	0.976351	0.954839	0.65237	1.5178
26	0.331126	0.010135	0.989865	0.970874	0.591919	2.9353
27	0.327815	0.010135	0.989865	0.970588	0.590726	2.9534
28	0.324503	0.010135	0.989865	0.970297	0.589537	3.001
29	0.321192	0.010135	0.989865	0.97	0.588353	3.0253
30	0.317881	0.010135	0.989865	0.969697	0.587174	3.0271
31	0.31457	0.010135	0.989865	0.969388	0.586	3.0307
32	0.307947	0.010135	0.989865	0.96875	0.583665	3.0857
33	0.307947	0.006757	0.993243	0.978947	0.584493	3.1207
34	0.069536	0	1	1	0.512998	5.7262
35	0.009934	0	1	1	0.497479	7.375
36	0.006623	0	1	1	0.496644	7.6172
37	0.003311	0	1	1	0.495812	7.744
38	0	0	1	1	0.495812	7.7863

Table 6: Indication of the sensitivities and specificities achieved on the derivation set from this ROC curve

Ethical Approval Documents

Appendix C: Abbreviated Burn Severity Index Score Breakdown

The ABSI was first suggested as a scoring tool to predict the mortality and outcome of burn patients in 1982. The scoring system was derived using a data set of 590 patients from two burn units (1). A recent external validation on 2813 patients (2) confirmed that the predictive value of each of the defined ABSI variables was found to be highly significant. The score is calculated by adding the points for each variable and using this to calculate the probability of survival (Table 1 below).

Variable		**Score**
Gender	Male Female	1 0
Age	0-20	1
	21-40	2
	41-60	3
	61-80	4
	81-100	5
Inhalation injury	Yes	1
Full thickness burns	Yes	1
TBSA%	1-10	1
	11-20	2
	21-30	3
	31-40	4
	41-50	5
	51-60	6
	61-70	7
	71-80	8
	81-90	9
	91-100	10

ABSI Score	**Severity**	**Prob. of survival**
2-3	Very low	≥ 99%
4-5	Moderate	98%
6-7	Moderately severe	80-90%
8-9	Serious	50-70%
10-11	Severe	20-40%
12-13	Maximum	≤ 10%

Table 1: Abbreviated Burn Severity Index Score breakdown. Adapted from *Forster et al* (2).

1. Tobiasen J, Hiebert JM, Edlich RF. The Abreviated burn severity score. Ann Emerg Med 1982; 11: 260-2.
2. Forster NA, Zingg M, Haile SR et al. 30 years later – Does the ABSI need revision? Burns 2011; 37: 958-963.

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The aetiology of adult burns in the Western Cape, South Africa

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ABSTRACT

Rural to urban migration to major cities in South Africa continues to lead to the proliferation of informal settlements. There is little recent published data on the epidemiology of adult burns in the Western Cape, South Africa. A retrospective review of patients on the Burn Unit database was undertaken, looking at patients admitted to the Burn Unit between January 2003 and December 2008. This study discusses the characteristics and outcome of patients who were treated at the Tygerburg Burn unit. A total of 1908 patients were admitted to the burn unit during the 6 year period under review. Most fatal injuries occurred in the 20–40 year age group. Injuries due to shack fires and fuel stoves comprised 21% (399) of all admissions. Mortality due to these injuries comprised 28% (137) of total mortality. Gas stoves accounted for 24% with kerosene stoves accounting for 71% of injuries. The burn death rate in this study (25%) was found to have increased dramatically from the last audit done from 1986 to 1995 in which a burn death rate of 7.5% was observed. Reasons for this are explored. It is likely that those with HIV/AIDS have poorer outcomes. Shack fires and injuries due to fuel stoves are a common reason for admission to the burn unit and mostly involve young male individuals. Other research from the Southern African region does not mention shack fires as a separate entity making it difficult to obtain an accurate idea of the scale of the problem. Their injuries are severe with a high mortality. The use of kerosene stoves are a major contributing factor. Recommendations include enforceable legislation to promote safer stove design, research into safer bio fuels and materials for building shacks as well promoting fire safety among schoolchildren in the community. Further research is needed to determine the impact of HIV/AIDS on the outcome of acute burns within the Southern African region.

1. Introduction

Previous research has described the severe injuries seen in Cape Town resulting from assault, shack fires and primus stoves [1–5]. In 1994 the South African government launched the Reconstruction and Development Programme (RDP) that required the development of a sustainable National Electrification Programme (NEP) [6]. While phase one of this programme (1994–1999) was mostly successful, informal townships continue to expand at a rapid pace in most large cities, with no sustainable infrastructure to support them. Temporary labour migration patterns within South Africa post Apartheid seem to have increased. Traditionally men have formed the majority of

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migrants moving to the cities looking for work, however there has been an increasing trend among females noted [7–11]. The crowded conditions, high rates of HIV/AIDS, alcohol abuse, breakup of the family unit, lack of basic sanitation and service delivery and a lack of co-ordinated emergency services most likely contribute to the high occurrence of these injuries and the high mortality observed. Many of the burn prevention strategies and the paraffin safety association of South Africa [12] are still in their infancy and it is not known how effective they have been in reducing many of these preventable injuries.

Shacks serve as a temporary or permanent home to those seeking employment in cities. It is estimated that there are almost 100 000 shacks within the City of Cape Town alone [13]. They usually do not have running water or electricity, and open flame stoves are commonly used for cooking and heating. Shacks are constructed from highly combustible materials and are in close proximity to each other. Once a shack is on fire the temperature increases rapidly and destroys the shack within minutes. Tygerburg hospital has the only adult burns referral centre in the Western Cape; most referrals come from the City of Cape Town. The burn unit has 22 beds (with 6 ICU beds) and between 280 and 360 admissions per year [14].

The aim of this study is to describe the aetiology and outcome of adult burns in the Western Cape admitted to the Tygerburg hospital burn unit between January 2003 and December 2008.

2. Methods

A retrospective review of patients on the Burn Unit database was undertaken, looking at patients admitted to the Burn Unit between 1st January 2003 and 31st December 2008. Approval for this research was granted by the committee for Human research at the Research Development and Support Division of the Faculty of Health Sciences, University of Stellenbosch (Reference number: N08/11/346) as well as from the ethics division of the University of Cape Town (Rec Ref: 038/2009).

2.1. *Inclusion and exclusion*

All patients were eligible for inclusion. All re-admissions, cold burns and skin donor patients were excluded.

2.2. *Data extraction*

Extracted data included age (in years), gender, burn size (as percentage of total body surface area, TBSA%), cause of thermal injury (type of burn, manner of injury and circumstances surrounding injury), presence or absence of inhalational injury, admitting area (as intensive care bed or general bed), outcome (as died or survived) and length of stay in hospital (in days).

2.3. *Data analysis*

Descriptive statistics were used to determine the means, medians; SD's and ranges using STATISTICA version 8 (Stat Soft Inc. 2008) and Microsoft Office Excel 2007. Figures and tables were constructed using Microsoft Office Excel 2007.

In patients where data was missing or unknown they were excluded from the analysis. However the whole patient record was not be excluded if some data was missing. The type of burn, manner of injury and the circumstances surrounding the burn were determined as far as possible. Furthermore the Baux score was calculated for each patient – this rule adds the patient age to the TBSA. It is used as a burn severity index. A value of >75 indicates a greater than 50% probability of death [15,16].

3. Results

A total of 1908 patients were admitted to the burn unit during the 6 year period under review (Table 1). There were a total of 147 admissions with incomplete data. Overall 45% of patients were admitted directly to the ICU and 486 deaths (25.5%) were recorded. 44.4% of the patients sustained between 10 and 40% TBSA. Hot water scalds, flame burns and chemical/accelerant burns comprised 20, 39 and 21% respectively to the type of burn (Fig. 1). Accidental burns comprised 32% with intentional injuries and intentional self harm 5.7% and 3.5% respectively.

In this study a total of 399 (20.9%) patients were admitted with injuries due to shack fires and cooking stoves. Overall 137 of these patients died as a result of their injuries. This group comprised almost a third (28%) of the total mortality for the six year period. Shack fires accounted for 10.6% (202) of all admissions. A further 10.4% of burns were documented as accidents involving cooking appliances (Table 1). Gas stoves accounted for 24% with paraffin

Table 1 – Summary of all admissions over the 6 year period.

	All admissions	Shack fires	Stoves
Total patients admitted	1908	202	197
Male, *n* (%)	1231 (65)	157 (77.7)	100 (50.8)
Age (yrs) (mean ± SD)	34.3 ± 13.59	31.9 ± 10.8	35.8 ± 13.2
Age (yrs) (range)	12–91	15–78	13–82
TBSA (%) (median)	15	30	15
LOS (d) (median)	14	13	19
Inhalation injury, *n* (%)	596 (31.2)	146 (72.3)	47 (23.8)
Non-survivors, *n* (%)	486 (25.5)	96 (47.5)	41 (20.8)
ICU admissions, *n* (%)	863 (45)	145 (71.8)	84 (42.5)
BAUX score (mean ± SD)	56.7 ± 23	67.2 ± 27	54 ± 19

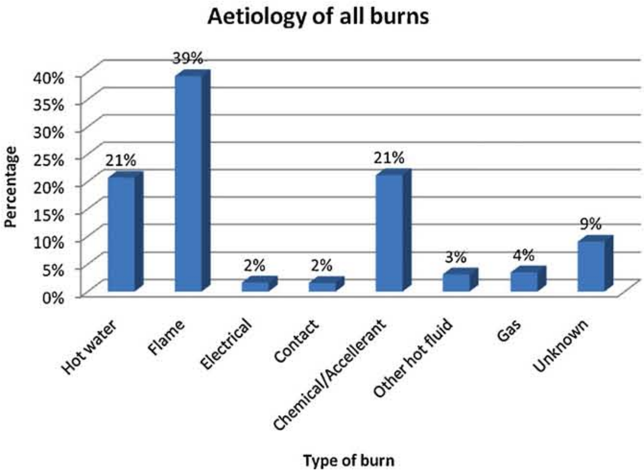

Fig. 1 – Aetiology of all burns over 6 year period – type of burn.

stoves accounting for 71% of injuries. House fire burns comprised 5.5% of admissions as they occurred in traditional western style homes in more affluent areas.

Flame injuries contributed to 54.9% of fatal burns with accelerants and hot water comprising 22.45% and 3.5% respectively. Most fatal burns were accidental (41%) with 5% and 8% due to assault and self harm respectively. Hot water was used in 40% of assaults with chemicals/accelerants in 30% of cases. 64% of assault victims were male with 22.9% of the victims sustaining fatal injuries. 57.6% of self harm injuries were female. 60% of these patients sustained fatal injuries. Kerosene was the most commonly used accelerant in intentional self harm injuries.

Yearly mortality and admissions are represented graphically (Figs. 2 and 3). 57% of deaths were male. The 20–40 year age group comprised most of the admissions (n = 1111, 58%), as well as most deaths (n = 260, 53%) (Figs. 4 and 5). The median number of days until death was 7 days with a mean age of 37 years and a median TBSA of 40%.

4. Discussion

Tygerberg hospital was established in 1972 with the major task of providing specialist burns care in a developing world setting

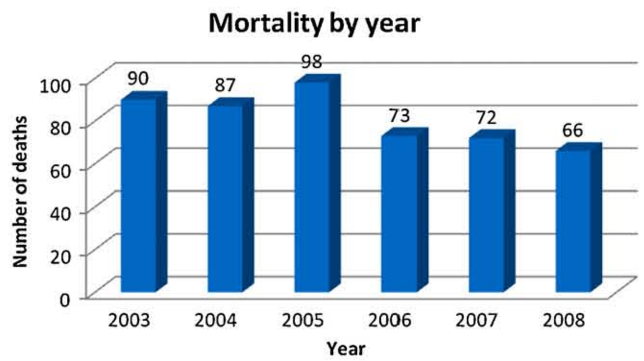

Fig. 2 – Mortality by year.

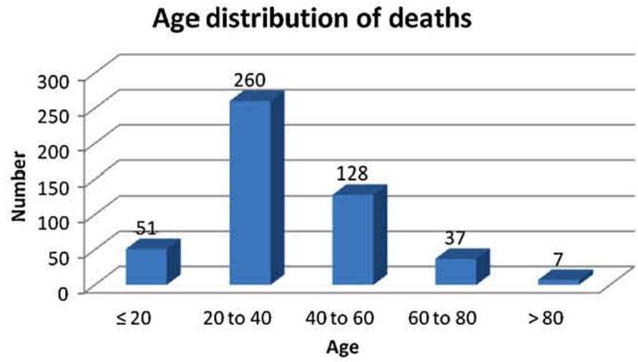

Fig. 3 – Age distribution of deaths.

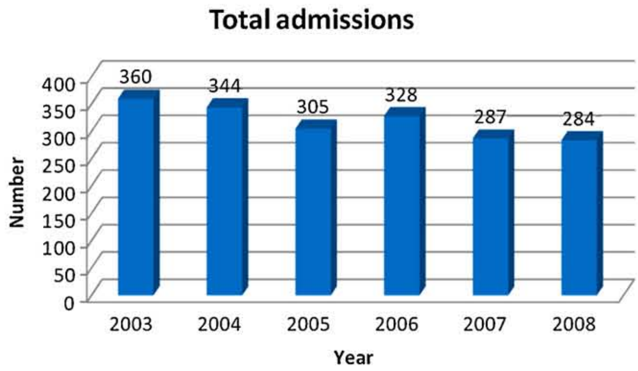

Fig. 4 – Yearly admissions.

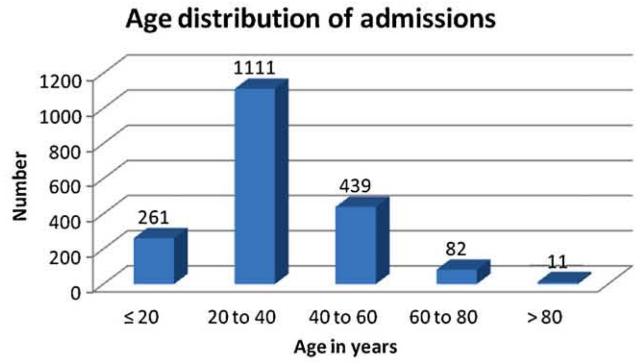

Fig. 5 – Age distribution of all admissions.

[14]. Shack fires continue to make headlines in the local press [17,18]. Rural to urban migration has led to the mushrooming of informal settlements with no sustainable infrastructure to support their inhabitants. While it is impossible to obtain the actual number of shack dwellings it is estimated that about 15% of the population live in shacks compared to around 12% in 2002 [18].

The last census put the estimated actual shack count for December 2005 in the City of Cape Town at just over 98 000 [13]. According to National Government there were an estimated 2.14 million shacks nationally in 2003 – an increase from 1.45 million in 1996. Between 2001 and 2003 an average of 417 shacks a day were built nationally – a total of 304 502 shacks in three years, and it is estimated that over 46 000 dwellings each year are raged to the ground as a result of fires [17,19].

There is a small body of research regarding adult burn injuries in the Southern African region. Many of the findings in this study are in keeping with that research. However there are a number of important differences to mention. As mentioned in the paper by Godwin et al. [5] most of the epidemiological studies both within and outside South Africa do not mention shack fires as a separate entity [20–22]. Burn data from Harare in Zimbabwe in 1999 mentioned the absence of shack type accommodation in the capital city, but highlighted the increase in severity of burns in lodgers renting small adjoining rooms to the main house [23]. To our knowledge the paper by Godwin et al. is the only paper to have addressed the issue of shack fires within informal settlements in this region. Studies have shown that in areas such as Durban and Zimbabwe, unusually high rates of self immolation are found in females with figures of 76% to 100% of all attempted suicides [20,24,25]. Alcohol, violence and other socioeconomic factors continue to make a significant contribution to the burden of disease in South Africa. A 1997 audit of patients over the age of 18 years admitted to this unit found that 57% of the study group had alcohol dependence and most attributed their burns injuries to alcohol intoxication [26,27].

The last major audit done in this unit from 1985 to 1996 [28] showed that the majority of admissions (67%) were male. 18% were due to assault with 8% due to cooking stove accidents. Scalds and flame burns comprised 34% and 29% respectively. The majority of patients (56%) sustained burns between 10 and 40% TBSA. 13.7% of admissions had a TBSA more than 40% versus 18% in this study. In the previous audit of 6056 admissions over a 10 year period there were only 452 deaths (7.4%). This differs remarkably from our audit over 15 years later with 486 (25%) deaths being recorded over a 6 year period. This is also in contrast with findings from other burn centres in the Southern African region. Mortality figures for 1992–2008 range from 9 to 22% for various centres in the southern african region [20,21,25,29]. However at this time the unit routinely admitted children from neonates onwards. There were 2273 (37%) child admissions over this period. The relative proportions of adult and child fatalities are not available for this data and thus this fatality rate of 7.4% may not be representative of the adult injuries. However in the previous audit 19% of admissions were transferred to the ICU with 45% of our admissions requiring ICU management. Reasons for this are multifactorial and are explored further, but what's clear is that there has been change in the nature of the burns and in the burn victims themselves seen in this unit over the last twenty years. In our opinion this is due largely to the expanding HIV/AIDS pandemic and the shift in the socio-political landscape with the large scale rural to urban migration of temporary labourers that might explain the proliferation of informal settlements seen around Cape Town. What is largely unknown at this stage is the impact of the HIV/AIDS epidemic on the outcome of burns. At the time of the last audit the epidemic had not yet reached its peak with the two first cases reported in 1982 [30] and a national prevalence of less than 1% in 1990 and rising to 7.5% in 1994 amongst antenatal attendees [31]. HIV infection and AIDS have already reached epidemic proportions in South Africa with this country having the largest number of people living with HIV/AIDS in the world [32,33]. Estimates of HIV prevalence in the Southern African region vary from 25 to 39% depending on the sub regional level studied. In 2001, South Africa with an estimated prevalence of 25.7% ranked lower than other neighbouring countries [32,33]. The figures for the Western Cape province are significantly lower than the national estimates with a prevalence of 1.1% in 1994, 5.2% in 1998 and 15.4% in 2004 among antenatal clinic attendees, demonstrating a clear increase over a 14 year period from 1990 to 2004 [32]. Health district surveys within the Cape Town metro pole also show a wide variation in HIV prevalence. The Khayelitsha and Gugulethu/Nyanga health districts within the Cape Town metro pole contain many informal settlements. Figures for Khayelitsha showed a HIV prevalence of 22% in 2001 and 33% in 2004, and for Gugulethu/Nyanga a prevalence of 16.1% 2001 and 29.1% in 2004 [32]. These figures clearly demonstrate the increasing HIV epidemic over the last 20 years. It is unknown how many of our patients presenting to the unit are HIV positive but it is likely to reflect the prevalence in the community. Furthermore we do not know what the outcome of our HIV positive patients is compared to the HIV negative patients.

Shack fires were not commonly seen in the Tygerburg Burn unit until the early nineties. The socio-political climate at the time in the early eighties allowed for strict control over the movement of migrant workers and others oppressed under the apartheid regime [34]. With the abolition of the pass laws in 1986 [35] free movement of migrant workers, mostly from the impoverished Eastern Cape, lead to the rapid expansion of informal settlements over the next decade within the Cape Town metro pole and the subsequent increase in shack fire injuries observed.

There is little research into the outcome of burns in HIV positive patients from the Southern African region. The available studies have produced conflicting results and are limited by small numbers. However the HIV/AIDS epidemic continues to grow and the impact that this is currently having on the outcome of burns patients in South Africa is unknown. A Study conducted in this unit in 2001 demonstrated that the outcome of HIV positive patients without stigmata of AIDS, admitted to the intensive care unit showed no difference when compared to HIV negative patients and should be managed similarly [36]. However only 63% of patients agreed to testing and of those only 33 (5%) were HIV positive. Another study from Malawi [37] reported a two fold increase in mortality in HIV positive patients, however the study only included 40 patients with HIV. A small study of only 6 HIV positive patients from Zimbabwe [38] could not find any increase in mortality or length of hospitalisation among the HIV positive group, however earlier work from the same unit [39] demonstrated impaired graft survival in a group of 15 HIV patients. Compelling evidence from the USA investigating the effects of pre-existing medical co morbidities on mortality and length of stay in acute burn injuries [40] demonstrated that in-hospital mortality was significantly predicted by HIV/AIDS (OR = 10.2) and length of hospital stay was increased by 49%. Clearly further well designed prospective studies are needed from the Southern African region to determine the true impact of HIV/AIDS on burn injury outcome.

Comprehensive and detailed data on the epidemiology of adult burns in South Africa is sparse [41]. However a recent observational study in Cape Town from 2001 to 2004 has highlighted the high prevalence among middle age men. Alcohol intoxication was found in 52% of those cases aged 16+ years. Mortality rates for black Africans were found to be 17.8 times higher than that of whites and Asians, with rates for mixed race persons being 7.1 times higher than that of whites and Asians [41]. These findings are not surprising given that these groups still form the vast majority of those who are socially and economically disadvantaged.

Previous research in 1993 at the New Somerset Hospital burn unit in Cape Town (now closed), 26% of admissions were as a result of shack fires [5]. These patients had severe burns (mean TBSA of 31%), with over 60% sustaining some degree of inhalational injury and high mortality (40% died). Godwin et al. suggested that shack fires be classified as a separate entity with predisposing factors and injury patterns different to those reported in house fires in more traditional developed areas. Factors identified in their research included accidents relating to open fires, cooking stoves, candles, alcohol and arson/assault. Informal settlements are overcrowded and built from highly combustible materials such as plastic. This allows for rapid spread resulting in severe burns and inhalational injuries from toxic smoke [19]. It is known that the use of paraffin (kerosene) and other fuels are the leading contributing factor to shack fires [19]. 10% of all admissions to the TBH burn unit from 2003 to 2008 were as a result of cooking stove accidents (Table 1). Hudson et al. [3] found that 17% of all admissions were as a result of primus stove accidents in 1994. Cooking stoves were implicated in 16% of shack fire injuries at the New Somerset Hospital burns unit in 1997 [5]. Data from Zimbabwe [23] and the Johannesburg region of South Africa [21] cite primus stoves as the cause in 10% and 26% of injuries respectively. No figures were available on the contribution of shack fires and primus stoves from a recent study in the Durban region of South Africa [20]. While it may be useful to classify shack fires separately from fuel stove accidents, the reality is that most shack fires are probably caused by fuel stoves and most stove accidents occur in informal settlements.

This research has demonstrated that shack fires, assault and injuries due to kerosene and other accelerants contribute to a large proportion of burn patients seen at Tygerburg Hospital, in keeping with previous research [42]. The young male (20–40 years) is seen at risk for these injuries. Analysis of our statistics show that the burn death rate and admission rate has remained roughly the same over the 6 year period (Figs. 2–5). Data from the 7th annual report of the National Injury Mortality Surveillance System 2005 in South Africa revealed that the burn death rate was 8.7/100 000 pop and remained almost the same over the previous 4 years [43].

In 1994 the South African government implemented the National Electrification Programme [6,44]. In an attempt to make paraffin/kerosene more affordable to low income groups the Department of minerals and energy affairs removed the VAT levy on paraffin [44]. Despite these achievements there are still limits to the ability to achieve the electrification targets. The electrification statistics from 2009 [45] show that up to 2009 75% of all South African households have been electrified, totalling 9 245 357 million households. The highest percentage (86%) of these is in the Western Cape Province. Since 1994 approximately 4.9 m households have been electrified. These achievements are laudable but demonstrate that the solution to the problem of shack fires and kerosene related burns lies not only with the electrification of homes. Electricity is more expensive than kerosene and not immediately available in the township areas. According to the Health Systems Trust; in 2001 39% of African households, 97% of Indian and 96% of whites used electricity as their main energy source for cooking. The 2007 community survey showed that 57% of African households now used electricity for cooking [46].

Various attempts have been made to reduce kerosene related injuries, most notably those involving legislative enforcement that requires manufacturers to sell only kerosene stoves that comply with various safety standards [47]. The Paraffin safety association of Southern Africa was established in 1996 as a non-governmental organisation to promote the safe use of domestic kerosene [48]. This organisation initiated testing into most of the commonly used kerosene stoves in 2003 as well as launching educational and public awareness projects. It continues to conduct research, stimulate national legislation and advise the South African Bureau of Standards.

5. Recommendations

The solution to this problem is complex and does not only involve the electrification of households. Social upliftment and education together with a dedicated commitment from Government to promote and implement the use of safe stoves, fuel storage and distribution will go a long way to solve some of these problems. The further development and promotion of research into viable and safer alternatives such as ethanol gels, LPG stoves, solar panels and strategies to prevent the contamination of paraffin with petrol is also needed. Ongoing research to promote a radical change in stove design and legislation to enforce the use of safe stoves is sorely needed [19]. In the meantime, much can be done to prevent shack fires, such as improving the fire safety regulatory requirements within informal settlements. This may include installation of sufficient fire hydrants, fire breaks between shacks and adequate access routes for emergency vehicles [49]. Interventions to address these issues could include:

- Research into economical fire resistant building materials for shacks.
- Educational posters with imaginative photographs dissuading people from constructing shacks with inflammable materials.
- Statutory warnings on flame stoves and consumer awareness of legal action against stove manufacturers if accidents are a result of a manufacturing defect.

- Improved stove design and campaigns to compel users to return to designated service stations for free service of the stove.
- Active fire safety campaigning at school level to educate learners on the dangers of kerosene and indoor fires.
- Campaigns to promote research into alternative safer bio-fuels, stoves and shack design through university fellowships.

6. Limitations

Besides the inherent flaws and bias seen in retrospective record reviews, a number of other important limitations were identified in this study. There were a total of 147 admissions with incomplete data. However the whole patient record was not excluded if some data was missing. There were a number of unknown variables. For example in 26 cases the outcome was unknown and in 33 cases the presence or absence of inhalational injury was not known. The presence or absence of inhalational injury is determined from clinical parameters and the circumstances surrounding the injury. Bronchoscopy is not used as is done in many first world units. In 89 of these admissions the register entry for the cause of burn was unknown. It was not possible to determine the TBSA% in 41 admissions and the length of stay was unknown in 39 admissions. This study has highlighted deficiencies in data capturing within the unit. Currently a paper based system is being used to capture demographic data. However in South Africa no uniform classification system is in place to describe the type of burn, manner and circumstances surrounding the burn. It was left up to the investigators to further classify the injuries. As a result, in 9% of cases the type of burn was unknown (hot water, flame etc.). We were unable to determine the manner of injury (accident, assault or suicide) in 58.5% of admissions. The circumstances surrounding the burn was unknown in 56% of admissions. It is our impression that many of these injuries were as a result of dwelling fires, fuel stove accidents or assault. Thus when interpreting these result one has to bear in mind that the true incidence of these injuries may be very underestimated. Well it may be useful to classify fuel stove and shack fire injuries separately the reality is that most shack fires are likely to have started as a cooking/stove accident. Making this distinction is problematic as most fuel stove accidents in our opinion occur within informal settlements.

7. Conclusions

There has been significant increase in burn mortality noted over the last 20 years. Our patients have changed and are more critical. Reasons for this are multifactorial but it is likely that the HIV/AIDS pandemic and the expansion of informal settlements have a significant role to play. Shack fires, assault and injuries due to fuel stoves are a common reason for admission to the Tygerburg Hospital burn unit and involve mostly young individuals. In keeping with previous research, their injuries are severe with a high mortality and the young male patient seems to be at particularly high risk. The use of kerosene stoves are a major contributing factor. These injuries place a huge economic burden on an already overstretched health system and are largely preventable. Government and other private organisations must make it a priority to improve housing and electrification and promote education and implement legislation in the safe use of kerosene stoves. Further research is needed into safer alternatives and to improving stove design. Continued education of the community is needed through community awareness projects. More work needs to be done to improve the quality of data capturing in the burn unit to ensure the usefulness of the data. As a start a useful uniform classification system is needed to classify burns in the South African setting as well as the development of a user friendly and cost effective data capturing system for all South African burn units. Further well designed prospective studies are needed to determine the outcome of HIV infected patients in the Southern African region.

Conflict of interest statement

There are no conflicts of interest to declare.

I am working as a resident in the division of emergency medicine. I have rotated through the Tygerburg Hospital burn unit.

This work forms part of my master's thesis (MMED – Emergency medicine) at the University of Cape Town (Student number MRTDAV015).

This work was presented in part as a poster presentation at the 2009 congress of the Emergency Medicine Society of South Africa (EMSSA) in Cape Town.

Fees paid for statistical consultation came from funds within the division of emergency medicine.

Summary:

What is already known on this topic?

- Burns are among the top ten external causes of death in South Africa. They place a heavy burden on an already overstretched health system and are mostly preventable. The use of kerosene stoves are a major contributing factor. Recent burn prevention campaigns have been implanted to address these problems.

What question this study addressed?

- What is the aetiology and outcome of burns admitted to the Tygerburg Hospital burn unit from 2003 to 2008?

What this paper adds?

- Shack fires and burns due to kerosene stoves are still a common reason for admission to the burn unit. They have a high mortality and involve mostly young individuals. There has been an increase in the burn death rate observed over the last fifteen years due to the changes observed in our patients and in the nature of their injuries. Data capturing in the unit needs improvement with the development of standardised classification template to describe the injuries.

How might this change clinical practice?

- This will not change clinical practice but those treating shack fire burns in developing countries need to be aware that these injuries have a high morbidity and mortality. It is likely that those with HIV/AIDS have poorer outcomes but more research is needed to explore this association. More needs to be done to prevent these injuries from occurring through improving the safety of kerosene stoves, educating the public on the dangers of flame/kerosene stoves and providing basic affordable electricity or alternative energy sources to those in poor socioeconomic conditions. Attempts to improve data capturing in developing countries and the creation of a national and regional burn registry will allow for better quality control and research into burn epidemiology and prevention.

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