ADULT PEDESTRIAN TRAFFIC TRAUMA IN CAPE TOWN

WITH SPECIAL REFERENCE TO THE ROLE OF ALCOHOL

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DECLARATION

I, Margaret Mary Peden, hereby declare that the work on which this 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.

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I acknowledge, with thanks, the guidance of my supervisors.

Signed by candidate

Signature removed

SIGNATURE

28/1/97

DATE

DEDICATED

to

All Trauma Nurses at Groote Schuur Hospital

Their dedication and commitment to the care of injured patients
has been an inspiration to the researcher.

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ABSTRACT

ADULT PEDESTRIAN TRAFFIC TRAUMA IN CAPE TOWN WITH SPECIAL REFERENCE TO THE ROLE OF ALCOHOL

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This research is a prospective, descriptive survey of adult pedestrian injuries in Cape Town. It profiles 'at risk' pedestrians and describes their injuries, injury severity and outcome. The role which alcohol plays in these collisions is threaded through the thesis. Since no study of this nature has been done in South Africa, it provides baseline data on the epidemiology, alcohol-relatedness, clinical presentation and prevention of adult pedestrian collisions in the metropole.

Data were collected prospectively on all injured pedestrians who presented consecutively, within six hours of being injured, to the Trauma Unit of Groote Schuur Hospital over a nine week period in 1993. Data were also gathered retrospectively from the state mortuary on all pedestrians who died before reaching hospital during the same time period. A total of 227 patients were included in the study. Data gathered included demographics, physiological response to injury, anatomical nature and severity of injuries as well as progress and outcome. Injuries were assessed and scored using the Abbreviated Injury Score (1990 revision) and the New Injury Severity Score. Alcohol consumption was assessed using four measures, viz. self-evaluation, clinical assessment, breath alcohol analysis and blood alcohol concentration (BAC). Data were analysed using SAS version 6.

The study recorded a very high incidence of alcohol intoxication among injured pedestrians in Cape Town. This is highly suggestive of a causal link. One hundred and forty-one patients (62.1%) were found to have positive BACs; more than 40% had BACs in excess of 0.20 g/100ml. BAC positive pedestrians were found to have more severe injuries, to require longer hospitalisation periods and to need more complex management. They consequently cost more to treat than their sober counterparts.

The comparison between the four methods of alcohol assessment revealed that self-evaluation and clinical assessment were poor screening tools. Breath alcohol analysis, using a Lion Alcolmeter S-D2, had a high degree of accuracy when compared to the BAC, which remains the 'gold standard'. It is therefore recommended that all traffic trauma patients be subjected to breath analysis.

The study also generated recommendations for the prevention of pedestrian collisions. These address pre-crash, crash and post-crash factors. Control of drunken driving and walking, as well as road safety education, particularly to pedestrians, are key issues. However, there remains a need for improved road engineering and better monitoring of the roadworthiness of vehicles.

This thesis highlights the severity of alcohol-related pedestrian injuries and the importance of preventative strategies.

GLOSSARY

The following abbreviations have been used throughout this thesis, both in text as well as figures and tables.

ABS	Anti-lock Braking System
AI	Anatomic Index
AIDS	Acquired Immune Deficiency Syndrome
AIS	Abbreviated Injury Scale
AIS 90	Abbreviated Injury Scale, 1990 Revision
ANC	African National Congress
AOD	Alcohol and Other Drugs
APACHEII	Acute Physiology and Chronic Health Evaluation II
ASCOT	A Severity Characterization of Trauma
ATLS	Advanced Trauma Life Support
AUDIT	Alcohol Use Disorder Test
BAC	Blood Alcohol Concentration
BAC +ve	Positive Blood Alcohol Concentration, i.e. $\geq$0.01 g/100ml
BAC -ve	Zero Blood Alcohol Concentration
BrAC	Breath Alcohol Concentration
BP	Blood Pressure
CAGE	Alcohol use scale
CAIS	Condensed Abbreviated Injury Scale
CDT	Carbohydrate-deficient transferrin
CERSA	Centre for Epidemiological Research in Southern Africa
CI	Confidence Interval
CMS	Cape Metropolitan Study
CRAMS	CRAMS Scale
CRIS	Comprehensive Injury Scale
CSIR	The Council for Scientific and Industrial Research
CT	Computerised Tomography
DALY	Disability Adjusted Life Years
DEF	DEFinitive Methodology
Df	Degrees of freedom
DOA	Dead on arrival
DSM-IV	Diagnostic Statistical Manual of Mental Disorders, Forth Edition
DT	Delirium Tremens
DTS	Directorate of Traffic Safety
ED	Emergency Department
FCI	Functional Capacity Index
g/100 ml	grams per 100 millilitre
GCS	Glasgow Coma Scale
GGT	Gamma-glutamyltransferase
GSH	Groote Schuur Hospital
HICDA-8	Hospital International Classification of Diseases, 8th Revision
HPT	Haemopneumothorax
ICU	Intensive Care Unit

ICD	International Classification of Diseases
ICD-10	International Classification of Diseases, 10th Edition
IIS	Injury Impairment Scale
IQR	Inter-quartile range
ISS	Injury Severity Score
km/hr	Kilometre per hour
LDV	Light delivery vehicle or 'Bakkie'
MAIS	Maximum Abbreviated Injury Scale
MAST	Michigan Alcohol Screening Test
MCV	Mean Corpuscular Volume
METRO	Medical Emergency Transport and Rescue Organisation
MISS	Modified Injury Severity Scale
MRC	Medical Research Council
MTOS	Major Trauma Outcome Study
N	The overall number of the sample
n	A sub-set of the sample
NISS	New Injury Severity Score
NTRP	National Trauma Research Programme
OPD	Out Patients' Department
OR	Odds Ratio
P	Probability
PRE	PREliminary Method
Ps	Probability of survival
PTS	Paediatric Trauma Score
QALY	Quality of Adjusted Life Years
RDP	Reconstruction and Development Programme
RI	Respiratory Index
RISS	Rural Injury Surveillance Study
RR	Respiratory rate
RTA	Road Traffic Accident
RTS	Revised Trauma Score
SA	South Africa
SANCA	South African National Council on Alcoholism and Drug Dependence
SAS	Statistical Analysis System
SBP	Systolic Blood Pressure
SD	Standard Deviation
SMAST	Short Michigan Alcohol Screening Test
TS	Trauma Score
TRISS	Trauma Score - Injury Severity Score
T-RTS	Triage Revised Trauma Score
UCT	University of Cape Town
UK	United Kingdom
USA	United States of America
WHO	World Health Organisation

TERMINOLOGY

POPULATION GROUP

The Population Registration Act of 1950 created population groups in South Africa which were bounded not by natural groupings but by unscientific factors such as appearance, descent, language and behaviour (Wilson & Ramphele, 1989). The Act attempted to "define the undefinable" (Suzman, 1960), which was evidenced by the fact that it was amended 15 times between 1956 and 1986. Nevertheless, this classification system was the "corner-stone on which segregation and inequality in South Africa" were built (West & Boonzaier, 1989:185).

Since the Act was repealed in 1991 there has been much debate among scientists on whether or not to continue using the terms Asian, Black, Coloured and White. The fact of the matter is that for centuries social, economic and political institutions were structured on a racial basis. The Act also had a significant socio-economic impact on the lives of many South Africans influencing where they lived, who they married, what education and health care they received, what occupations were open to them and what income they received. Because of what has gone before, at this point in time it is still impossible to describe the daily reality for millions of South Africans in any other way (WHO, 1983) and the terms remain useful in identifying groups at risk "... so that appropriate diagnostic, remedial or prophylactic strategies can be devised" (N.C. Lee, 1989:184). The use of these groupings in this thesis does not, however, imply that the author endorses or agrees with these racist terms.

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CHAPTER ONE

WHY A STUDY ON PEDESTRIAN TRAFFIC TRAUMA?

> *"Pedestrian deaths and injuries have become a normal occurrence in the South African way of life - something we hear about every day, but believe we have little or no control over!"* (Directorate of Traffic Safety, 1992:8)

1.1 INTRODUCTION

Walking is probably the most commonly used and certainly the most widely available mode of personal transport in South Africa. The popularity of walking is reflected in two senses. It is often the only transport mode used for a trip but it is also a common link with other modes of transport since nearly all vehicular travel involves walking at some stage. Despite this, relatively little is known about walking as a mode of transport and even less is known about pedestrian collisions and safety issues.

Although alcohol is linked with most types of road crashes, particular emphasis has been placed on 'drinking and driving' in South Africa over the past decades. However, since pedestrians constitute 45% of all traffic related deaths in this country (Directorate of Traffic Safety, 1992), the focus on drivers has done little, if anything, to reduce the overall traffic death rate.

International studies seem to indicate that adult pedestrians with more than 0.10 g/100ml of alcohol in their blood are usually accountable for their own injuries, whereas their sober counterparts are usually the innocent victims of traffic trauma initiated by the motorist (Kliger & Sporty, 1993; J.A. Waller, 1972). Although this statement is probably true, in South Africa there is only anecdotal evidence to support it (Directorate of Traffic Safety 1990a, 1992).

Furthermore, road traffic trauma in South Africa is arguably one of this country's most serious and preventable community health problems. Our road death rate of 11.7 per 100 million kilometres travelled is one of the highest in the world and our pedestrian traffic trauma death rate is surpassed only by Ethiopia (International Road Federation, 1991).

The epidemiology of paediatric pedestrian morbidity and mortality appears to have been fairly adequately addressed locally (Bass, Albertyn & Melis, 1992; Bass, Albertyn & Melis, 1995; Cumpsty & Howes, 1985; Cywes, 1990a; Cywes, Kibel, Bass et al., 1990b; Fowler, 1991; Kibel, Joubert & Bradshaw, 1990a; Knobel, De Villiers, Parry et al., 1984), but that of adult pedestrian morbidity appears to have been largely overlooked. Only fatal pedestrian collisions appear to have been addressed (Odendaal, 1969; Ribbens, 1989). This has led to the formulation of prevention and control strategies based either on mortality data alone or on international models, both approaches of which are less than optimal (Bradbury, 1991; Irwin, Patterson & Rutherford, 1983; Jehle & Cottington, 1988; Wyss, Rivier, Gujer et al., 1990).

Research into injured adult pedestrians in South Africa is thus long overdue.

This study was therefore undertaken to describe the epidemiology, clinical course and outcome of injured adult pedestrians in Cape Town. It furthermore defines the role that alcohol plays in these collisions and suggests an accurate method of assessing alcohol intoxication in such patients. This data will provide a baseline for the design and implementation of specific preventive and control measures and will highlight areas which require further investigation.

1.2 THE MAGNITUDE OF PEDESTRIAN TRAFFIC TRAUMA IN SA

In the USA pedestrian deaths are the second largest category of motor vehicle-related fatalities (the first being occupants) and account for 14% of all traffic-related deaths (Centers for Disease Control, 1993). This is a sharp contrast to the situation in South Africa, where pedestrian deaths are the largest category of traffic-related fatalities, accounting for between 45% and 55% of all traffic-related deaths annually, i.e. around 4 500 deaths per year (Directorate of Traffic Safety, 1993a). In Cape Town, the situation is appreciably worse than nationally. Here pedestrians account for approximately 66% of all traffic-related deaths (City of Cape Town, Traffic Department, 1992).

The pedestrian problem in South Africa is a multifaceted one. Rapid urbanisation, poor facilities for pedestrians, poor traffic education and a lack of effective law enforcement are compounded by the fact that, for a large percentage of our population, walking is the cheapest and most convenient means of transportation. A substantial increase in the number of vehicles on our roads, particularly in urban areas, over the last decade or two has not improved the situation.

Although in some circumstances pedestrian collisions may be attributed to the reckless or negligent behaviour of vehicle drivers, in many cases pedestrians are not blameless. Drinking and walking, reckless behaviour and not being visually conspicuous at night are particular problems. The saying "don't give a pedestrian a choice between a safe or convenient crossing because he will surely choose the latter" still holds true - many pedestrians in South Africa take the shortest route, even if this involves crossing a highway. The influence of alcohol is not well described, but it is thought to result in pedestrians being less likely to look before they walk, to misjudge the speed of oncoming traffic or to take chances - often with fatal consequences.

1.3 THE ALCOHOL - PEDESTRIAN RELATIONSHIP

The intoxicated pedestrian presents one of the oldest road safety hazards, yet comparatively little research has been done in this field, particularly in South Africa.

Alcohol appears to play a significant role in most traffic trauma in South Africa (Van der Spuy, 1991a). It has been found to be an attributable factor in non-fatally injured drivers (Van Kralingen, Whittaker, Van der Spuy et al., 1991), fatally injured drivers (City of Cape Town, Traffic Department, 1992; 1993) and fatally injured pedestrians (Van der Spuy, 1993). However, no local data is available on the relationship between alcohol and non-fatally injured pedestrians.

There are three tasks which a pedestrian has to perform in order to safely cross a road. The first is a sensory task of perception; the second, a mental task involving judgement and decision-making; while the third is the actual task of physical performance (Nel, 1979). According to Older and Grayson (1974) there are six basic stages in crossing a street and these are depicted in the model below (Figure 1.1).

In the real world it is possible that some of these stages may be left out, combined or repeated before the task is eventually completed. However, omitting any of the stages compromises a pedestrian's performance and can increase the probability of a collision.

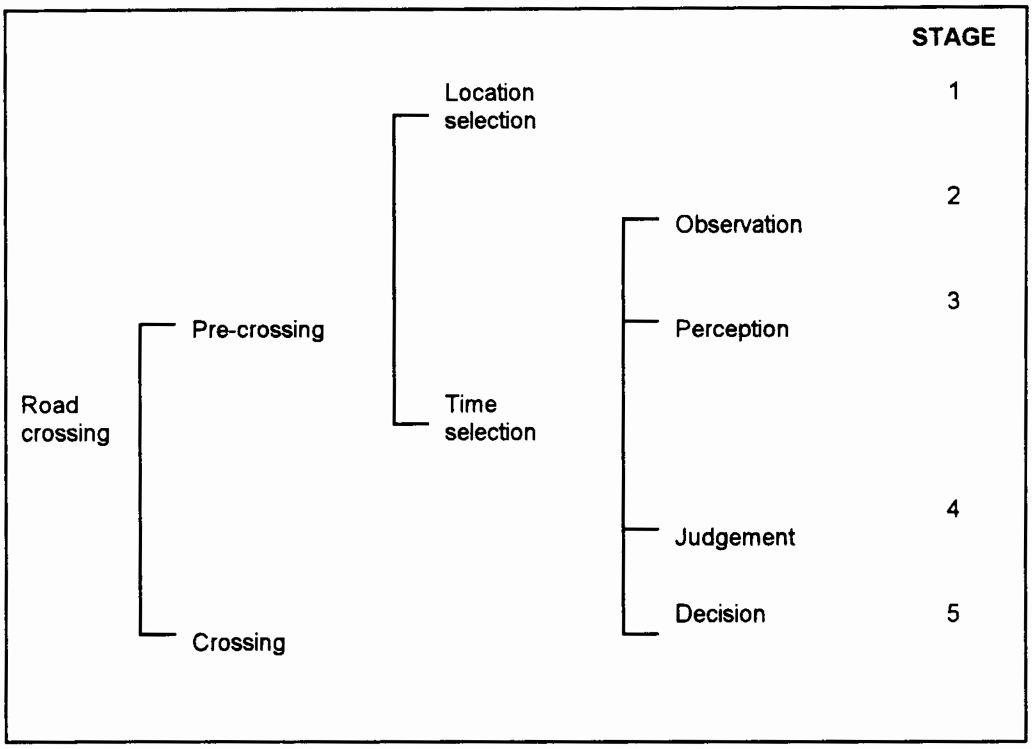

Figure 1.1 : The Older and Grayson model depicting basic stages in street crossing

Alcohol affects people in different ways. In the stage of mild intoxication a person usually feels good and may be euphoric. The emotional responses are exaggerated but physically the person feels relaxed. As the concentration of alcohol in the blood stream increases, mental clouding occurs. There are also alterations in thought processes and judgement becomes impaired. At high Blood Alcohol Concentration (BAC) levels most people have a feeling of increased power and ability but in reality their mental and physical efficiency are markedly reduced. At BAC levels in excess of 0.1 g/100ml most people tend to have a staggering gait, speech is slurred and simple physical movements are clumsily executed. At a BAC level of 0.2 g/100ml most people require help in walking.

It is therefore obvious that at relatively low BAC levels the task of crossing a road and walking in general becomes affected. In fact, as can be seen in Figure 1.2, the relative risk of a pedestrian being involved in a collision is four to five times the normal at a BAC level of 0.16 g/100ml and rises exponentially thereafter (Clayton, Booth & McCartny, 1977).

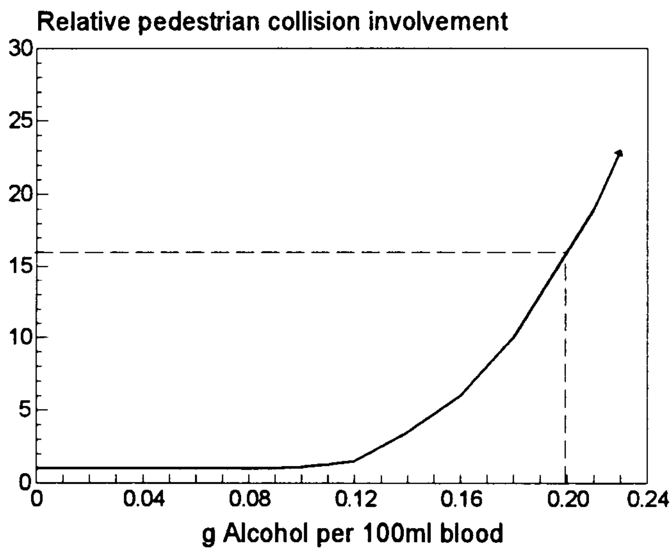

Figure 1.2 : Relative risk of being involved in a pedestrian collision

Once a pedestrian collision has occurred and a patient presents to hospital it is essential to find out whether he/she is intoxicated since a considerable number of these patients have significantly raised BAC levels which may complicate their diagnosis, particularly if they have a concurrent head injury. In these cases it is important to know not only whether alcohol is present in the blood but also to what degree.

Since 1973 it has been a statutory offence to drive a vehicle in South Africa with a BAC equal to or greater than 0.08 g/100ml. This, together with stricter law enforcement and significant 'don't drink and drive' campaigns, has had some effect in reducing the problem of drunken driving. But because of the high proportion of pedestrians involved in traffic trauma and the possibility that the pedestrian, the driver or both may be intoxicated at the time of the collision, addressing the problem among drivers alone will have little impact on reducing the overall number of traffic-related injuries and deaths in South Africa.

Alcohol is thus an important determinant for the likelihood of a motor vehicle colliding with a pedestrian (or vice versa) and also influences the outcome of pedestrians injured in traffic trauma. Studies in the USA indicate that intoxicated pedestrians are prone to suffer severe injuries and subsequently require long hospitalisation (Jurkovich, Rivara, Gurney et al., 1992; Jurkovich, Rivara, Gurney et al., 1993). Acute intoxication also appears to alter the initial assessment of the patient, resulting in more, and often unnecessary, invasive diagnostic and therapeutic procedures being performed (Jurkovich et al., 1992). Consequently these patients place a greater economic burden on the State as well as a significant demand on hospital and health care resources. For instance, it was estimated that pedestrian deaths alone annually cost the State and the taxpayer approximately R1 109.3 million in the early 1990s (Directorate of Traffic Safety, 1992).

It is therefore imperative that the pedestrian problem be addressed so that prevention and control strategies may be aimed at both the driver and the pedestrian.

1.4 THE RATIONALE FOR THIS PROSPECTIVE STUDY

The present study is the first specifically designed survey of its kind to address the relationship between alcohol and non-fatally injured pedestrians in South Africa. In the past the Directorate of Traffic Safety (Odendaal, 1969) and the Centre for Scientific and Industrial Research (Ribbens, 1986; 1989) have conducted retrospective studies based on mortality data. These studies lacked basic data on injured patients, including the type of injury sustained, the severity of the injury, the role of alcohol and the costs of treatment.

Two recent studies by the National Trauma Research Programme (NTRP), viz. The Cape Metropolitan Study (CMS) (National Trauma Research Programme, 1990) and the Rural Injury Surveillance Study (RISS) (De Wet, Van der Spuy, Abrahams et al., 1994), revealed that alcohol played a significant role in pedestrian injuries. However, both these studies were limited because only clinical judgement was employed to assess alcohol intoxication and therefore the results are an underestimate of the true incidence. The CMS showed that 33.2% of non-fatally injured pedestrians were intoxicated, while RISS found that 39.9% of such patients were intoxicated. Although these results give some indication of the role which alcohol plays, the present study has the advantage of being prospective, controlled and of using objective instruments to assess alcohol intoxication.

1.5 THE RESEARCH QUESTION AND AIMS OF THE STUDY

The primary research question was: Does alcohol play a role in adult pedestrian traffic trauma in Cape Town?

The study had a number of aims, including:

- to profile the injured adult pedestrian involved in traffic trauma;
- to describe the nature and severity of the injuries sustained by patients;
- to assess the incidence of alcohol intoxication in pedestrians involved in collisions; and
- to offer suggestions for the control of these collisions.

A subsidiary aim of the study was to assess the accuracy of a modified Lion Alcolmeter S-D2 breath analysis apparatus against the gold standard of BAC measured by means of gas chromatography.

The overall objective of the study was thus to obtain practical data on injured adult pedestrians so that priorities for future research and preventive strategies may be formulated in order to address this significant public health problem.

1.6 THE STRUCTURE OF THIS THESIS

1.6.1 THESIS OBJECTIVES

The principal objective of this thesis is that it may be used as an epidemiological database on non-fatal adult pedestrian injuries in South Africa.

It furthermore aims to report, succinctly and in a 'user friendly' manner, the descriptive data collected during the study as well as to provide additional background information which will contribute to the interpretation and understanding of the results. It also attempts to clarify the role which alcohol plays in non-fatal adult pedestrian traffic trauma and to offer some potential solutions to this problem, as well as identifying priorities for future research.

1.6.2 THE PRESENTATION OF THE THESIS

The next three chapters will present an extensive literature review. Chapter Two looks at the epidemiological basis for traffic trauma prevention and describes the 'Haddon Matrix' (Haddon, 1972), the model on which this thesis is based, in some depth. Chapter Three is devoted to reviewing the international literature on traffic trauma, with particular reference to adult pedestrian traffic trauma and the role of alcohol, with the intention of comparing the results to those obtained in the present study. Literature from both developed and developing countries is reviewed, although the latter is scant.

The fourth chapter is a more specific literature review of traffic trauma in South Africa. Some previous research done on the topic of pedestrian collisions in Cape Town (largely paediatric) is introduced and data from available sources in Cape Town are presented and their limitations are defined.

Chapter Five discusses the research methodology and study design for this investigation.

The results are presented within the framework of the 'Haddon Matrix' (Haddon, 1972). Precrash factors such as alcohol intoxication, patient demographics, where and when the collision occurred, etc. are addressed in Chapter Six.

Chapter Seven presents a comprehensive discussion of commonly used methods of injury severity assessment and coding. The strengths and weaknesses of selected assessment tools and their applicability to the South African setting are discussed.

Crash factors such as injuries and injury severity are addressed in Chapter Eight, followed by postcrash factors, such as management, disability and rehabilitation, as well as the medical costs incurred by injured pedestrians, in Chapter Nine. Each of these chapters of results includes a discussion section.

The subsequent two chapters are devoted to fulfilling the subsidiary aim of the study, which was to assess the accuracy of the Lion Alcolmeter S-D2 (Lion Laboratories Ltd) as an alcohol assessment tool. Chapter Ten presents an overview of the literature on selected alcohol assessment tools, while Chapter Eleven presents the results of the four methods of assessing alcohol intoxication used in this study. The latter chapter concludes with a section on the usefulness of the Lion Alcolmeter S-D2 as an adjunct to clinical assessment and makes some recommendations for its regular use in trauma care.

Chapter Twelve concludes the thesis by discussing the significant risk factors for adult pedestrians identified in this study and makes suggestions for appropriate prevention and control strategies. A brief section is included to indicate how data obtained from this study has already been implemented in prevention strategies.

1.7 CHAPTER SUMMARY

This chapter outlines the need for baseline data on adult pedestrian traffic trauma in Cape Town and the rationale for this prospective study on the role of alcohol in these collisions.

It also outlines the objectives and organisation of this thesis.

CHAPTER TWO

AN EPIDEMIOLOGICAL BASIS FOR TRAFFIC TRAUMA PREVENTION

> *"... If some responsible member of the medical profession had gone out in 1910 and asked a very simple question concerning one of the early automobile crashes - not what caused the crash, but what caused the injuries - we would have had the ability to prevent at least 300,000 driver deaths in the years that followed."* (Haddon, quoted in Baker, 1987:345).

2.1 INTRODUCTION

As long ago as 1949 Gordon noted that injuries were equally susceptible to epidemiological approaches since 'accidents' as a health problem of populations conformed to the "... same biologic laws as did disease processes and regularly evidence[d] comparable behavior" (Gordon, 1949:504). And yet it was not until the mid 1980's that this approach was implemented in some countries (Baker, 1983).

South Africa lagged somewhat behind countries like the USA, UK and Sweden with regard to applying epidemiological principles to injuries. It was not until 1987 that local epidemiology per sé had developed to the stage where a Centre for Epidemiological Research in Southern Africa (CERSA) at the Medical Research Council (MRC) became established. One of the first projects undertaken by CERSA was to define the causes of morbidity and mortality in South Africa. This study showed that 36% of the potential years of life lost due to premature deaths in people aged 1 - 64 years were due to non-natural causes, and that non-natural causes of death ranked second overall to circulatory diseases (Bradshaw, Botha, Joubert et al., 1987). As a result of these startling figures the National Trauma Research Programme (NTRP) was launched by the MRC later that same year.

2.2 'ACCIDENT' VERSUS INJURY

One of the reasons for the worldwide delay in acknowledging the role that epidemiology plays in the description, and thus the control, of injuries was a lack of consensus on the cause of injuries and, in fact, on the use of the word 'accident' per sé.

The word 'accident' implies, according to the *Oxford English Dictionary*, that an event is without apparent cause, is unexpected, is unforeseen and therefore "... outside a person's control" (Alexander, 1949:357). It conveys "... a mixture of ideas: injury, property loss, unexpected events, and unintended results" (Loimer, Dr iur & Guarnieri, 1996:106). Furthermore the word 'accident' has biblical connotations, i.e. an act of God. One such example comes from Exodus 21:12-13 which states "Anyone who hits a man so hard he dies shall surely be put to deal. But if it is accidental - an act of God - and not intentional, then I will appoint a place where he can run and get protection" (The Living Bible, 1971).

'Accidents' are, in the true sense of the word, quite rare. Unintentional injuries, or the more correct but unfamiliar word 'non-intentional' injuries (M. Klein & Van der Walt, 1985:657), have identifiable causes and are thus preventable.

With this concept in mind, it becomes obvious that unintentional injuries are a public health problem amenable to scientific research-based strategies (Wigglesworth, 1977). Although the word 'injury' was proposed in order to "... replace the ambivalent, misleading anachronism 'accident'" (Doege, 1978:509), the continued use of the word 'accident' has hampered the progress of injury prevention because it induces an attitude of acceptance and complacency (Greensher, 1984). According to Evans (1993:1438) "more precise terminology would help doctors to reduce harm" .

2.3 FRAMEWORKS FOR DESCRIBING TRAFFIC TRAUMA

2.3.1 ACCIDENT PRONENESS

Injuries have traditionally been seen as a behavioural problem, rather than as a public health problem. This probably relates to the fact that for many years injury data was kept by police departments and not by health systems.

Behavioural scientists suggested that there are certain personality traits which lead to accident proneness or "the tendency of a person to become frequently involved in accidents in any situation, ... this tendency ..., being due to some mental attribute of the person concerned" (Sampson, 1971:913).

Studies by these behavioural scientists showed that accident prone children, as opposed to other children, had significantly different E scores on the Eysenck Personality Inventory, indicating a high degree of extroversion (Viney, 1971) as well as a tendency to be daring, impulsive, poorly disciplined, attention-seeking and aggressive (Manheimer & Mellinger, 1967; Mellinger & Manheimer, 1967).

Similar studies conducted in adults indicated that so called accident prone adults tended to be impulsive, governed by short-term goals and resentful of authority. They were said to be "like juvenile delinquents, but that, instead of broken bones, broken laws resulted" (Viney, 1971:917).

This theory of accident proneness was advanced in an attempt to identify potential 'accident' victims before the 'accident' happened, so that these individuals could be protected and placed in low-hazard work areas. However, a study using this methodology showed that when accident prone truck drivers were moved to lower hazard occupations, they continued to spend as much time off work by tending to have more 'accidents' at home (Haddon, Suchman & Klein, 1964).

Although the theory of accident proneness per sé has been disputed by many researchers (Froggatt, 1961; Froggatt & Smiley, 1964; Gheselli & Brown, 1955), it is clear that some individuals are more at risk of injury than others and that human behaviour is an important aspect in injury causation (Haddon & Baker, 1981).

We now know that accident proneness is not a permanent but rather a transient phenomenon (Ferguson 1975, cited in Wigglesworth, 1977) and therefore to place emphasis on this concept would be wrong since it is "... both irrelevant and fruitless" (Wigglesworth, 1977:250).

Despite much debate about its relevance, accident proneness continues to be cited in the literature (D. Klein, 1980) and this has, to some degree, retarded the development of injury epidemiology as a multivariate phenomenon.

2.3.2 THE EPIDEMIOLOGICAL TRIAD

The idea that epidemiological principles could be adequately applied to the study of injuries arose out of experience in World War II. Trench foot was found to be a major problem among thousands of men and was a cause of disability and loss of personnel power. Initially the cold weather was thought to be the cause - about which little could be done. However, it soon became apparent that there were other factors involved, such as the terrain through which troops walked, the management of troops and foot hygiene. On further investigation of the causes of trench foot it was found that some related to host factors, some to the agent, and some were associated with the environment. Preventative strategies were thus devised by determining the specific factors contributing to the injury (Gordon, 1949).

This example showed that injuries could be described within the framework of the epidemiological triad (host, agent and environment) and that, like most diseases, injuries have definite patterns and non-random characteristics. The causes of injuries may therefore be seen to arise out of these three factors.

The disadvantage of utilising this framework is that there is sometimes a failure to distinguish the mechanism of the injury from the agent, i.e. the mechanism is often incorrectly labelled as the cause. In reality the mechanism of an injury is the process by which the epidemiological triad interacts in order to produce a result; it is not the cause of the injury.

As a result of the inconsistencies in the epidemiological triad, Haddon (1972) refined the framework and this became known as the 'Haddon Matrix'. This new epidemiological framework is most useful when analysing traffic-related injuries but may be used for other types of injuries as well.

2.3.3 THE 'HADDON MATRIX'

William Haddon, the inaugural head of the Road Safety Agency in the USA, developed the 'Haddon Matrix' (Haddon, 1972), which in its simplest form has two dimensions. The first is related to the chronology of events, the second to the epidemiological triad.

The first dimension is based on the fact that injuries "... are preceded by processes that naturally divide into three stages" (Haddon, 1980:417): the 'pre-event', 'event' and 'postevent' phases. For motor vehicle related collisions these phases are relabelled 'precrash', 'crash' and 'postcrash'.

The precrash phase includes those events which determine whether or not a collision will occur, e.g. an intoxicated pedestrian, a vehicle with deficient brakes, or inadequate road lighting.

The crash phase includes factors which determine whether or not an injury will occur during the crash, and, if it does, how severe these injuries will be, e.g. a very old pedestrian with osteoporosis, a heavy speeding vehicle, or a patient striking a barrier as he falls.

The postcrash phase determines the consequences of the injury, e.g. the delayed control of haemorrhage after the collision or delayed transportation to an appropriate hospital. This phase also includes rehabilitation.

The second dimension of the matrix is based on the epidemiological triad, i.e. 'host', 'agent' and 'environment'. For motor vehicle related collisions these were relabelled 'host', 'vehicle' and 'environment'. The latter, i.e the environment, is sometimes subdivided into 'physical' and 'sociocultural'.

The combination of these two dimensions results a nine-cell matrix (Table 2.I).

Table 2.1 : The 'Haddon Matrix'

Phases	**Factors**		
	Human	**Vehicle**	**Environment**
Precrash	Alcohol intoxication Fatigue Experience & judgement Driver vision Distance travelled	Brakes, tyres Centre of gravity Jack-knife tendency Ease of control Load weight Speed capability	Laws related to alcohol and driving Visibility of hazards Road curvature, gradient & surface Intersections, access control Speed limits
Crash	Seat belt use Age Sex Osteoporosis	Speed at impact Vehicle size Restraints (airbag) Hardness & sharpness of contact surfaces Load containment	Speed limits Recovery area Guard rails Median barriers Roadside embankments
Postcrash	Age Physical condition	Fuel system integrity	Emergency communication & transport systems Distance to & quality of medical services Rehabilitation programmes

Adapted from Table 16.1 (Baker, O'Neill, Ginsburg et al. 1992:213)

This matrix provides a means to identify the following factors, cell by cell:

- previous and future resource allocation and the efficacy of each,
- available and required research, and
- prevention strategies and priorities in terms of their costs and effects on injury outcome (Haddon, 1980).

Following the development of the 'Haddon Matrix', Haddon went on to develop a logical sequence of ten strategies for reducing human and economic losses resulting from injuries or "from energy which is transferred in such ways and amounts, and at such rapid rates, that inanimate or animate structures are damaged" (Haddon, 1973). These strategies were first published in a paper entitled "On the Escape of Tigers" (Haddon, 1970) and are summarised in Table 2.2.

Table 2.2 : Energy damage and ten counter-measure strategies

1. To prevent the creation of the hazard in the first place.
2. To reduce the amount of hazard brought into being.
3. To prevent the release of the hazard that already exists.
4. To modify the rate or spatial distribution of release of the hazard from its source.
5. To separate, in time or space, the hazard and that which is to be protected.
6. To separate the hazard and that which is to be protected by interposition of a material barrier.
7. To modify relevant basic qualities of the hazard.
8. To make what is to be protected more resistant to damage from the hazard.
9. To begin to counter the damage already done by the environmental hazard.
10. To stabilise, repair, and rehabilitate the object of the damage.

Adapted from Haddon, 1980:418

These ten strategies, together with the 'Haddon Matrix', are guidelines to aid in the identification and selection of methods which may be implemented in order to reduce a given phenomenon.

Pedestrian collisions, the ensuing injuries and how they may be prevented can be described in terms of the 'Haddon Matrix'. It is within this framework that this thesis is based.

For many years, all preventative interventions in traffic trauma were focused on the precrash phase and particularly on efforts to change behaviours, e.g. drinking and driving. Although this intervention cannot be overlooked, many studies have indicated that behaviour modification is usually only transient (Robertson, 1992; Wigglesworth, 1977). A more balanced approach would therefore be to aim at changing events in the precrash, crash and postcrash phases and not to focus only on behaviours.

Using this framework, pedestrian injuries may be addressed by Educating drivers and pedestrians in an attempt to change faulty behaviours, Enforcing road laws and improving or changing Environmental factors - the three Es. Passive prevention, or interventions which reduce damage irrespective of any voluntary action on the part of the human, also "... show greater promise of reducing highway losses" (Wigglesworth, 1977:249).

2.4 CHAPTER SUMMARY

This chapter describes the historical development of an appropriate epidemiological framework for injury description, with particular reference to traffic related incidents. It discusses the concepts of accident proneness, the epidemiological triad and the 'Haddon Matrix'. It also briefly addresses the controversial usage of the word 'accident' which has, to some degree, retarded injury prevention and control strategies in the past. Data illustrating these epidemiological concepts, from both international and local studies, will be discussed in the following two chapters.

CHAPTER THREE

TRAFFIC TRAUMA WORLDWIDE

"Whenever alcohol and transportation meet there is conflict"
(Borkenstein, Trubitt & Lease, 1963 cited in L.S. Smith, 1979a).

3.1 INTRODUCTION

In most countries in the world motor vehicle crashes are endemic and are the leading cause of non-natural deaths, particularly in people younger than 65 years. Each year more than half a million people die in motor vehicle crashes and about 15 million people are injured (Chorba, 1991). Pedestrian injuries and deaths in developing countries appear to be disproportionately high, probably due to rapid motorisation and urbanisation. This was highlighted in the World Bank's report of 1993 which emphasised the importance of traffic-related morbidity and mortality in developing countries: 74% of all traffic deaths occur in such countries (World Bank, 1993).

3.2 THE MAGNITUDE OF VEHICULAR TRAUMA GLOBALLY

In the USA motor vehicle collisions cause more deaths in people aged 1 - 75 years than any other injury-producing event and they are the leading cause of death for people aged 1 - 34 years. In the age group 5 - 19 years, more than one-fifth of deaths from all causes are caused by motor vehicle collisions (Baker et al., 1992). Of the 6.5 million motor vehicle collisions reported in the USA in 1990, 28% resulted in minor or moderate injuries and 6% in severe or fatal injuries. In the USA "at current mortality rates, a baby born today has roughly 1 chance in 70 of ultimately dying in a traffic crash" (Graham, 1993:515).

In the UK, while motor vehicle collisions are the fourth leading cause of death, they are the leading cause of premature death and account for the greatest number of potential years of life lost (Glucksman, 1994).

In Australia the importance of road crashes, both fatal and non-fatal, have been well documented. Over 60% of all unintentional deaths in Victoria in 1991 were traffic related, of which 21% were pedestrians (Henderson, 1992). Furthermore, studies in Adelaide and Sydney have shown that pedestrian traffic collisions are the most common cause of traumatic death in children (Hill, West, Abraham et al., 1993).

In Canada, injuries rank third (after circulatory disease and cancer) as a cause of overall mortality, and are the primary cause of potential years of life lost. They are the main cause of death before the age of 40 years. Motor vehicle collisions injure or kill approximately 280 000 Canadians every year. The number of deaths from motor vehicle collisions in Canada "is tantamount to the decimation of an entire population of a large village by an epidemic that could have been foreseen and, to a great extent, prevented. This sad reality, despite the horror it entails, hardly raises an eyebrow" (Chapdelaine & Rochette, 1990:91).

Although data is readily available for developed countries, obtaining reliable motor vehicle collision data from developing countries[1] is problematic (Odero & Zwi, 1996). The incomplete databases are probably the result of a lack of funding and organisation as well as the fact that "the data-capture systems of many

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1 Defined by the World Bank as "... those countries with an annual per capita gross national product of less than US$ 2,500, based on 1986 figures..." (cited in G.S. Smith & Barss, 1991:230).

developing countries are inadequate" (Hutchinson, 1987:9). Data on road death rates worldwide (Table 3.1) seem to indicate that most developing countries have more of a problem than developed countries.

Table 3.1 : Overall road death rates per 100 million km travelled

COUNTRY	RATE per 100 million km travelled
Korea	45.0
Kenya	39.0
Morocco	20.0
Iraq	13.6
South Africa	**11.7**
Brazil	11.0
Spain	6.8
Portugal	6.6
Hong Kong	4.0
Italy	2.0
Japan	1.9
Britain	1.7
Denmark	1.7
Finland	1.6
USA	1.3
Ethiopia	0.4*

* Ethiopia has a very low rate because they have very few vehicles on their roads.

Adapted from the International Road Federation, 1991

According to Balogun & Abereoje (1992) the incidence of road traffic collisions in most developing countries is becoming a 'social scourge', although the exact magnitude of the problem in these countries is not known. Siddique & Abengowe (1979) suggest, however, that it is safe to speculate that road traffic collisions in developing countries are a major cause of both mortality and morbidity.

In Saudi Arabia, for example, there have been "massive strides in road construction and a subsequent increase in the number of motor vehicles and road traffic accidents" (Shanks, Ansari & Al-Kalai, 1994). In the early 1970s there were only about 150 000 registered vehicles in this country, today there are more than 5 million. Consequently the number of road traffic collisions has risen from

17 743 collisions and 2 871 deaths in 1979 to 35 799 collisions and 23 697 deaths in 1989 (Arab News, cited in Shanks et al., 1994). There has thus been an increase in the proportion of road traffic deaths from 16.2% in 1979 to 66.2% in 1989.

3.3 THE GLOBAL MAGNITUDE OF PEDESTRIAN TRAUMA

The previous section has indicated that motor vehicle collisions in general remain a problem in both developing and developed countries. The proportion of pedestrians involved in these motor vehicle collisions does, however, differ from country to country depending of the level of motorisation and urbanisation (Shanks et al., 1994). Despite this it has been said that worldwide "three per cent of adults will be involved as pedestrians in a road traffic accident (RTA) at some point in their life and almost one-third will report a 'near-miss'" (Todd & Walker, quoted in Bradbury, 1991:132).

The proportion of traffic trauma cases who are injured as pedestrians in developed and developing countries ranges from 11% in the Netherlands to 91% in Ethiopia (Table 3.2).

Table 3.2 : Pedestrians as a proportion of road traffic deaths

COUNTRY	YEAR	% PEDESTRIANS	AUTHOR
Developing countries			
Bangladesh (Dhaka)	1987	60	Hutchinson, 1987
Ethiopia	1987	91	Dessie & Larson, 1991
Hong Kong	1984	61	Hutchinson, 1987
India (Delhi)	1995	42	Mohan, 1992
Indonesia	1980	23	Mohan, 1992
Israel	1984	45	Hutchinson, 1987
Kenya	1990	42	Odero, 1995
Kuwait	1987	58	Jadaan & Bener, 1993
Libya (Tripoli)	1987	66	Mohan, 1992
Malawi	1977	40	Hutchinson, 1987
Nigeria	1992	28	Balogun & Abereoje, 1992
Saudi Arabia (Jeddah)	1985	44	Jadaan & Bener, 1993
South Africa	1993	45	Directorate of Traffic Safety, 1993a
Taiwan	1987	30	S.Lee, Lui, Chang et al. 1990
Thailand	1987	47	Mohan, 1992
Zambia	1977	40	Hutchinson, 1987
Developed countries			
Australia	1990	18	Holubowycz, 1995
Canada (Quebec)	1990	19	Chapdelaine & Rochette, 1992
France	1991	13	Pearce, 1992
Greece	1991	24	Pearce, 1992
Japan	1984	28	Hutchinson, 1987
Netherlands	1991	11	Pearce, 1992
New Zealand	1984	18	Hutchinson, 1987
United Kingdom	1991	33	Pearce, 1992
USA	1987	14	Center for Disease Control, 1993
West Germany	1991	18	Pearce, 1992

According to Baker et al. (1992) pedestrian deaths are the second largest category of vehicle deaths in the USA and include almost half of all deaths for ages three to nine years and more than a quarter for ages 75 and older. In 1988 almost 7 000 people died as a result of pedestrian collisions in the USA, representing about one-seventh of all traffic-related deaths. Non-fatal pedestrian collisions account for 3% of all traffic related trauma in the USA (Centers for Disease Control, 1993).

In most developing African nations there appears to be a large proportion of financial resources being diverted to the importation of vehicles and the construction of new roads. However, the health impact of these transitions has not been well documented and "... motor vehicle injuries have not figured prominently in the past as a priority public health problem" (Dessie & Larson, 1991). However, it is anticipated that, as the number of vehicles in African countries increases, motor vehicle injuries will become an important public health problem requiring preventive interventions structured on baseline knowledge of their occurrence, distribution and causative factors. In a study done in Addis Ababa, Ethiopia, Dessie & Larson (1991) found disturbingly high motor vehicle injury rates despite the low number of registered vehicles. When they adjusted for the number of registered vehicles, the road collision fatality rate was 10 to 20 times higher than rates reported in developed countries, but similar to those reported in other African countries.

In Saudi Arabia, from 1974 to 1985, there was a 2.5 fold increase in pedestrian collisions and they have become a serious public health problem (Jadaan & Bener, 1993:157). In the whole of Saudi Arabia, in both urban and rural areas, pedestrians constitute 17.4% of all motor vehicle collisions but in Jeddah they account for 34.2%, reflecting the increased impact of pedestrian collisions in urban areas. In Kuwait pedestrians accounted for 57.9% of all fatal road traffic collisions in 1987 (ibid).

3.4 THE ROLE OF ALCOHOL IN PEDESTRIAN COLLISIONS

Alcohol appears to play a significant role in the precrash, crash and postcrash phases of pedestrian collisions. As early as 1907 an editorial in the Lancet called attention to the problem of alcohol and road traffic collisions (cited in Glucksman, 1994:77). Since then, alcohol has become one of the most important single causes of road traffic collisions which result in injury or death because "as the BAC rises, the chances of any form of accident also rise" (Lowenfels & Miller, 1984:1056).

Alcohol-related collisions tend to be more serious than collisions in which alcohol is not involved (Glucksman, 1994; Raffle, 1989). Alcohol has been found to be contributory in 10% of collisions which result in slight injuries, approximately 25% of collisions which result in serious injury and nearly 50% of fatal crashes (Glucksman, 1994). Furthermore, about 65% of single vehicle fatal crashes, such as pedestrian collisions, are alcohol-related. In fact, according to Irwin et al. (1983), pedestrians who have been drinking are three to four times more likely to be involved in a collision than their sober counterparts.

There appears to be a downward trend in alcohol-related collisions in the USA, viz. from 51% in 1979 to 41% in 1990 (Zobeck, Grant, Stinson et al., 1994) but this does not appear to be the case in most developing countries.

Various studies on the relationship between alcohol intoxication and pedestrian mortality and morbidity have indicated an alarmingly high association in this category of road-user (Table 3.3).

Table 3.3 : Pedestrian alcohol-relatedness studies

CITY, COUNTRY	% BAC +	AUTHOR
Morbidity studies		
Baltimore, USA	24	Soderstrom, Trifillis, Shankar et al., 1988
Belfast, Ireland	36	Irwin et al., 1983
California, USA	57	Kliger & Sporty, 1993
Edinburgh, Scotland	16	Bradbury, 1991
Glasgow, Scotland	43	Galloway & Patel, 1988
Harborview, USA	32	Rivara, Jurkovich, Gurney et al., 1993a
Lausanne, Switzerland	42	Wyss, Rivier, Gujer et al., 1990
Pittsburgh, USA	30	Jehle & Cottington, 1988
Taipei, Taiwan	19	Wu, Yang, Chou et al., 1991
Tuscon, USA	65	Brainard, Slauterbeck, Benjamin et al., 1989
Vancouver, Canada	30	Vestrup & Reid, 1989
Mortality studies		
Dade county, USA	22	Copeland, 1991
Jerusalem, Israel	13	Richter, Meltzer, Bloch et al., 1986
Lusaka, Zambia	32	Patel & Bhagwatt, 1977
Manhattan, USA	74	Haddon, Valien, McCarroll et al., 1961
New Mexico, USA	91	Gallaher, Fleming, Berger et al., 1992
Ontario, Canada	12	Lane, McClafferty & Nowak, 1994
Port Moresby, Papua New Guinea	90	Sinhu, Sengupta & Purohit, 1981
Vermont, USA	40	J.A. Waller, 1972
Warrington, UK	21	Teanby, Gorman & Boot, 1993a
Combination studies		
Oxford, UK	9	Atkins, Turner, Duthie et al., 1988

Although there are large differences between the designs, and hence biases, a meta-analysis of the morbidity studies cited in Table 3.3 indicated an average alcohol incidence of 35.8%, while that of the mortality studies indicated an average alcohol incidence of 43.9%. The only outlier in the studies cited was a combination mortality and morbidity study conducted in Oxford, UK, which indicated an apparent absence of alcohol use. The authors conceded, however, that this may have been due to "the inexact and incomplete methods that we used to assess alcohol consumption" (Atkins et al., 1988).

Although it has been found that adult pedestrians with more than 0.10 g/100ml of alcohol in their blood are usually accountable for their own injuries while their sober counterparts are usually the innocent victims of traffic trauma initiated by the motorist (Kliger & Sporty, 1993; J.A. Waller, 1972), the pedestrian may not be the only person intoxicated at the time of the collision. In most instances both parties involved in pedestrian collisions are not routinely tested for alcohol. If this were to be done, the contribution of alcohol to pedestrian fatalities would undoubtedly be even greater (Baker, Robertson & O'Neill, 1974a) but no two-party studies could be found in the literature to validate this hypothesis.

Emergency room studies have indicated that between 9% and 39% of all trauma patients are intoxicated at the time of iinjury and that alcohol has an "important impact on the medical care these people require" (Adams, Magruder-Habib, Trued et al., 1992).

Alcohol complicates the management of trauma patients because many misconceptions still linger, such as: alcohol protects people from serious injury; there are good legal reasons for not doing the blood alcohol concentration in a patient; most people injured after consuming alcohol are social drinkers; and the most appropriate way to avoid the delirium tremens in an alcoholic who has been hospitalised with trauma is to provide them with alcohol (J.A. Waller, 1990).

3.5 WHERE PEDESTRIAN COLLISIONS OCCUR

In the USA one-fifth of all collisions that kill adult pedestrians occur at intersections, compared with less than one-tenth in the case of children under the age of five years. Pedestrian collisions also appear to be predominantly an urban problem since "six out of seven injuries and three out of four deaths occur in urban areas" (Baker et al., 1992:272).

In the United Kingdom most pedestrian collisions occur in built up areas (68%) on single carriageway roads with speed limits of 48 kph (Atkins et al., 1988).

A different pattern is evident in developing countries. In Saudi Arabia more than 70% of pedestrian fatalities occur while pedestrians are crossing roads at points other than formal road-crossings (Jadaan & Bener, 1993). Similarly, in Nigeria, such "impromptu pedestrian crossing of the highway" is the most frequent cause of pedestrian collisions (Balogun & Abereoje, 1992).

In Addis Ababa, Ethiopia, although only 52% of the roads are paved, nearly all (99.3%) the pedestrian collisions occur on these roads. Furthermore, 86.6% of collisions occur while pedestrians are crossing these tarred roads (Dessie & Larson, 1991). As with many large African urban communities, Addis Ababa shares the characteristics of overcrowding, inadequate road construction and a poorly educated population with regard to basic road safety. These factors, compounded by the lack of pedestrian sidewalks and other engineering advancements tend to force large numbers of pedestrians onto the roads and thereby greatly increase their collision risk.

3.6 WHEN PEDESTRIAN COLLISIONS OCCUR

Although most studies have shown that pedestrian collisions tend to be spaced reasonably evenly throughout the week (Atkins et al., 1988; Haddon et al., 1961; Teanby et al., 1993a), one study in the UK indicated a clustering of pedestrian collisions over the weekend, with substantial proportions occurring at night (Galloway & Patel, 1988). The highest incidence of fatal pedestrian collisions in the USA appears to be about an hour after sunset (Baker et al., 1992).

Many studies have indicated an increased occurrence of non-fatal pedestrian collisions correlating with high traffic volumes in the late afternoons and early evenings (Atkins et al., 1988; Teanby et al., 1993a; Vestrup & Reid, 1989; Wyss et al., 1990). Haddon et al. (1961), however, found that 73% of fatal injuries occurred in the 12 hour period from 15h00 to 03h00 and that 51% of these occurred in the six hours preceding midnight. He found a low incidence between 06h00 and 09h00, suggesting that exposure to large volumes of traffic is not necessarily a determinant of the occurrence of these collisions.

Many of the studies reviewed showed a clustering of collisions after dark (Brainard et al., 1989; Fisher, 1967; Galloway & Patel, 1988; Hall & Fisher, 1972; Kliger & Sporty, 1993), particularly where alcohol was related. Richter et al. (1986:273) found that 59% of all pedestrians admitted to a hospital in Israel between 22h00 and 05h00 had BAC levels over 0.05 g/100ml and that during this time frame "the risk for BAC > 0.05 was 5.8 fold greater that for the rest of the day".

Bradbury (1991) confirmed this trend by indicating that those patients who were BAC positive were more likely to be admitted in the 'social' hours of the late evening or early morning. Jehle & Cottington (1988) found that not only were 93%

of collisions alcohol-related if they occurred between 18h00 and 06h00, but that 64.4% of collisions which occurred over the weekend were also alcohol related.

Not surprisingly in developed countries, it appears as though pedestrians who are injured during the daylight hours tend more often than not to be women (Galloway & Patel, 1988), elderly (Atkins et al., 1988) or sober (Kliger & Sporty, 1993).

In Addis Ababa most motor vehicle injuries (77%) are sustained during the daytime, with 49.7% occurring between 06h01 and 12h00 and 31.3% between 12h01 and 18h00. A possible explanation for this clustering of collisions during the day is that there are more students and workers on the roads at these times of the day and that there was a curfew in effect from 24h00 to 05h00 for the duration of the study (Dessie & Larson, 1991).

The weather appears to play little or no role in the causation of pedestrian collisions, both fatal and non-fatal (Atkins et al., 1988; Haddon et al., 1961; Teanby et al., 1993a; Vestrup & Reid, 1989). However, there may well be fewer pedestrians walking on the roadside in inclement weather, so that the risk per unit of exposure may well be higher in the rain, but this would be difficult to prove.

3.7 VEHICLES INVOLVED IN PEDESTRIAN COLLISIONS

Motor cars, since they are the most frequent type of vehicle on the roads, are consistently found to be implicated in the majority of pedestrian collisions (Atkins et al., 1988; Galloway & Patel, 1988; Teanby et al., 1993a; Vestrup & Reid, 1989).

Vehicle size and design are major factors in pedestrian collisions. "The dynamics of the collision depend on many factors, including the vehicle's shape, speed at impact, braking action, contact point, and the height of the pedestrian relative to the bumper and the front of the hood" (Baker et al., 1992:276). A pedestrian may be 'run over' especially if a child, but the more serious injuries arise as a result of the pedestrian being 'run under' and being thrown onto the hood or top of the car (MacKay, 1994).

The speed of vehicles involved in pedestrian impacts is a major determinant of the severity and outcome of injury (Lerer & Volpe, 1992a). This is reflected in the much higher ratio of deaths to injuries in areas where the speed limits are higher (Baker et al., 1992). A study performed by Zivot & Di Maio (1993) indicated that the amputation of a limb, transection of the torso or atlanto-occipital dislocation is associated with pedestrian collisions in which the vehicle involved was travelling at more than 55 miles per hour at the time of the impact.

A study conducted by Hall & Fisher (1972) in Sydney found that the pedestrian fatality rate increased 18-fold when the outcome at an impact speed of 20 mph was compared with that of an impact speed of 60 mph.

A recent study conducted by McLean, Anderson, Farmer et al. (1996) has shown that a reduction of 5 km/hr in vehicle travelling speed could be expected to result in a 30% reduction in fatal pedestrian collisions because the distance it takes to stop is proportional to the square of the initial speed.

3.8 AGE AND GENDER

The majority of studies indicate that injured pedestrians are mostly males (Kingma, 1994). In fact, males were between two to three times more likely to be involved in pedestrian collisions than females. This male preponderance was also found to be exaggerated in BAC positive patients (Bradbury, 1991; Jehle & Cottington, 1988). Only one study, conducted in Canada, differed considerably. Here pedestrians involved in collisions were found to be predominantly female (54.0%) and these females were generally older than the males, viz. 56.3 years versus 43 years, respectively (Vestrup & Reid, 1989).

In the USA, the highest pedestrian death rates are seen in the elderly, with lower peaks for children and teenagers (Baker et al., 1992). This biphasic trend has also been reported by Lane et al. (1994) and Hall & Fisher (1972). Other studies, particularly those in Australia, have found a very high rate of pedestrian collisions in adults over the age of 50 years (Hill et al., 1993; Hossack, 1975; Teanby et al., 1993a) with less significant peaks for children and teenagers.

A triphasic age distribution showing a large peak at 15 - 20 years, with smaller peaks at 0 - 5 years and 70 - 75 years, was identified by Atkins et al. (1988) in the UK. This is in contrast to the classic J-shaped distribution most often seen in fatal pedestrian collisions in the USA, where preschool children have the highest incidence, 15 - 34 year olds have the lowest incidence and then there is a large, progressive increase in subsequent decades (Haddon et al., 1961).

Developing countries tend to show a different pattern. In Nigeria, the highest proportion of deaths were among males aged between 22 and 31 years. Males also had a three times higher risk of traffic collisions than female pedestrians (Siddique & Abengowe, 1979). Similarly, in Addis Ababa, the incidence rates for both genders was found to be highest in the 20 to 29 and 50 to 64 year age groups (Dessie & Larson, 1991). Only one study in a developed country showed a similar pattern. Young adults, aged 20 to 29 years, intoxicated and almost exclusively male, were found to be a particular high-risk group by Bradbury (1991).

Furthermore, in developing countries, motor vehicle collisions injuring males in the economically active age group are considered to be the third most important cause of death after tuberculosis and AIDS (Söderlund & Zwi, 1995).

It is generally accepted that, as the age of the pedestrian increases, so too does the risk of collision involvement (Haddon et al., 1961; Hill et al., 1993) and mortality (Brainard et al., 1989; Hall & Fisher, 1972; Lane et al., 1994) as well as the need for long-term specialised care (Brainard et al., 1989; Vestrup & Reid, 1989).

3.9 POPULATION GROUP

There appears to be little consensus in the literature with regard to race and pedestrian collisions. One study indicated that there was a higher incidence of pedestrian fatalities in minority populations in the USA (Centers for Disease Control, 1991). It was suggested that this was possibly due to the large proportion of Afro-American people living in rural areas, having limited access to emergency transportation and being exposed to roadways which do not have designated pedestrian areas. In addition, pedestrians who were injured in rural locations were often struck by cars travelling at higher speeds, thus increasing the likelihood of death (Mueller, Rivara & Bergman, 1988).

However, another study, conducted in the USA, showed that non-fatal pedestrian collisions were more frequent in rural blacks while fatal pedestrian collisions were more common in whites living in urban areas (Capan, Miller & Turndorf, 1990).

An Israeli study found that Christians had the highest risk for fatal pedestrian injuries, followed by Moslems, and that Jews (12.6%) had the lowest risk (Richter et al., 1986).

Kliger & Sporty (1993) found virtually no difference between Caucasians (49%) and Hispanics (45%), other than the fact that the latter were more likely to be intoxicated at the time of the collision. A study in New Mexico has, however, indicated that there was a high incidence of pedestrian fatalities among the native American population (Gallaher et al., 1992).

3.10 SOCIO-ECONOMIC STATUS

The socio-economic status of a patient is probably more of a risk factor for pedestrian collisions than population group. In the USA it is well documented that residents of low-income areas, both black and white, have higher overall injury rates (Baker, 1987). In fact, for motor vehicle occupants, the death rate is 2.7 times higher for residents of low-income areas than for those in higher income areas (ibid) and pedestrian collisions follow a similar pattern.

Poor urban communities, in particular, tend to show higher rates of non-fatal pedestrian injuries, probably because of the higher traffic densities, greater population densities, fewer alternatives for street play and poorer traffic education (Graham, 1993). On the other hand, fatal pedestrian collisions tend to occur more frequently in rural communities. Mueller et al. (1988) suggest that there are proportionally more pedestrian deaths in rural areas because rural victims do not receive emergency care as rapidly as those injured in urban areas.

It therefore appears that there is a clear correlation in the time that elapses between the collision and the commencement of medical treatment and the outcome. Pedestrians, wherever they are injured, therefore need to be transported to hospital as quickly as possible since "the shorter the rescue time the better the results" (Shanks et al., 1994:31).

3.11 INJURIES SUSTAINED BY PEDESTRIANS

Pedestrians are particularly vulnerable to severe injury because of the inherent physical disparity between them and motor vehicles and because of their relative lack of adequate protection. Pedestrians are usually more severely injured than any other category of road-user as a result of these disparities (Wyss et al., 1990) and there is a direct correlation between the severity of injuries sustained and the weight of the vehicle concerned (Atkins et al., 1988).

In general "... pedestrian motor vehicle accident victims place a significant demand on hospital and health care resources. Pedestrian victims represent a ... lethal category of motor vehicle trauma. They are characterized by multi-system injury with concomitant high ISS and mortality rates, particularly in the periaccident period" (Brainard et al., 1989:137).

On average, it has been found that pedestrians sustain at least two injuries (Hall & Fisher, 1972; Hill et al., 1993; Wyss et al., 1990). These injuries are most likely to be to the limbs, particularly the lower limbs (Burgess, Poka, Brumback et al.,

1987) and the head (Atkins et al., 1988; Hall & Fisher, 1972; Hill et al., 1993; Vestrup & Reid, 1989) - head injuries usually being caused by a secondary impact. Hossack (1975) found that nearly all fatally injured pedestrians had a lower extremity fracture from the primary impact and 70% had a major head injury, the result of the secondary impact.

In 1965, Farley described a triad of skull, pelvis and extremity fractures in pedestrians injured in vehicular collisions. The only subsequent confirmation of this triad has been by Waddell & Drucker (1971) who found that pedestrians were initially stuck by the leading edge of a vehicle, usually the bumper, which produced a knee injury, followed by a hip/pelvis injury caused by the hood of the vehicle and then a head injury as a result of the pedestrian's head hitting either the ground or the hood of the vehicle.

Fractures, particularly to the lower limbs or pelvis, appear to be very common among pedestrians although many also sustain visceral lesions (Balogun & Abereoje, 1992; Brainard et al., 1989; Brainard, Slauterbeck & Benjamin, 1992; Wyss et al., 1990). The commonest sites for fractures appear to be tibia-fibula, pelvis and femur (Brainard et al., 1989; Burgess et al., 1987). Furthermore, there is evidence of an ipsilateral dyad (same side fracture to both lower and upper limb) in some studies Brainard et al. (1992).

Multiple injuries, or polytrauma, appear to be common (Dessie & Larson, 1991). In a study conducted by Hill et al. (1993), 20% of injured pedestrians requiring hospitalisation had an ISS greater than 15. Furthermore, 40% of injured pedestrians in this study had at least two injuries - 28% had three or more injuries. A common pattern among the multiple injured patients appeared to be the triad of head, chest and lower limb injury.

3.12 THE MANAGEMENT OF INJURED PEDESTRIANS

Not only do pedestrians generally have a higher risk of severe injury or death than an occupant of a motor car, but they are also more likely to be admitted to a hospital ward (Atkins et al., 1988). Generally, "... pedestrians place proportionally greater immediate and lasting demands on the health resources in that they are more frequently fatally or seriously injured, are transported to hospital with greater urgency, and more often require diagnostic radiology and inpatient care" (Galloway & Patel, 1988:297).

In a study in Lausanne, Switzerland, 63% of pedestrians required hospital admission in comparison to 36% of drivers. The average length of stay for all motor vehicle collision patients was 23 days, while for pedestrians specifically it was 30.3 days (Wyss et al., 1990). Hill et al. (1993) found that the median hospital stay for pedestrians with ISS >15 was 21 days (range 11 - 75 days), including a median of three days in an Intensive Care Unit (ICU) (range 0-26 days).

In another study, 85.2% of injured pedestrians required hospitalisation, of whom 69% were sent to an ICU and of these 47% required ventilatory support. Among patients who required hospitalisation the average length of hospital stay was 11 days (Brainard et al., 1989).

Alcohol consumption appears to complicate the management of pedestrians involved in traffic trauma in more than one way. Studies have shown that the intoxicated pedestrian is more likely to suffer severe injuries (Bradbury, 1991; Jehle & Cottington, 1988) and subsequently require longer hospitalisation (Jehle & Cottington, 1988). Acute intoxication has also been shown to alter the patient's initial assessment since "alcohol and head injury commonly co-exist in pedestrian victims ..." (Vestrup & Reid, 1988:744). This often results in more, sometimes unnecessary, invasive diagnostic and therapeutic procedures being performed (Jurkovich et al., 1992).

3.13 THE OUTCOME FROM PEDESTRIAN COLLISIONS

According to Morris, MacKenzie & Edelstein (1990) the outcome following a traffic-related injury is related to four variables: host factors, the injury severity, the time delay to definitive treatment, and the quality of care received.

If outcome is measured by admission rates and death ratios, injured pedestrians have a higher overall risk of adverse outcome than any other category of road-user (Barancik, Chatterjee, Greene-Cradden et al., 1986).

Due to the nature and severity of injuries, many pedestrians require post-acute management. Vestrup & Reid (1988) found that 12.5% of surviving pedestrians required placement in long-term care facilities. The mean age of the patients requiring long term care was 68.4 years and their mean ISS was 16.1.

Many pedestrians appear to be left with some degree of disability. In Nigeria, of the 353 hospitalised patients, 12.2% died in the wards while the remaining 87.8% had some functional disability for which they received treatment such as physiotherapy before being discharged (Balogun & Abereoje, 1992). In Saudi Arabia, 24% of motor vehicle collision patients still had some degree of disability at six months and 23% of patients had still not returned to work at one year (Shanks et al., 1994).

The cause of death in injured pedestrians appears to be predominantly due to severe head or cardiothoracic injuries (Atkins et al., 1988; Brainard et al., 1989; Sevitt, 1973). Mortality rates for injured pedestrians range from 5% (Atkins et al., 1988) to 22% (Brainard et al., 1992).

No consensus regarding the effect of alcohol intoxication on the outcome of motor vehicle trauma could be found in the literature. In a study by Soderstrom & Eastham (1987a) alcohol use prior to trauma was found to have no effect on survival, while in another study alcohol intoxication appeared to be associated with an increased chance of survival (Ward, Flynn, Miller et al., 1982). On the other hand, P.F. Waller, Stewart, Hansen et al. (1986) found that the intoxicated driver was more likely to die from his injuries. Probably the most comprehensive study on alcohol and outcome was conducted by Jurkovich et al. (1993). This study demonstrated that patients with evidence of chronic alcohol abuse were at a substantially higher risk of complications, particularly infection, but that there was no effect on mortality, either at the scene of the collision or after hospital admission.

3.14 THE COST OF VEHICULAR TRAUMA

There has been considerable focus in recent years on the costs associated with disease and injury. Consistent throughout all the work is the finding that injuries rank among the costliest of all conditions (MacKenzie, Shapiro & Siegel, 1988).

In the USA the annual cost of motor vehicle-related injuries is estimated to be approximately $333 billion (Miller, 1993a), approximately half of which results from indirect costs (such as pain and suffering, lost work, etc), while the other half respresents the direct cost of crashes (Miller, Luchter & Brinkman, 1989).

Alcohol-related collisions in the USA account for "... over one-third of all motor vehicle crash costs" (Miller & Blincoe, 1994:591).

In Canada the total cost resulting from motor vehicle collisions in Quebec alone amounted to nearly $2 million in 1990 (Chapdelaine & Rochette, 1990). In the United Kingdom the total costs to society of road traffic collisions in 1989 was estimated to be £6360 million, £5040 million of which was due to collisions in which injuries had occurred and the rest to collisions with vehicle damage only (Raffle, 1991).

As a result of the severity of pedestrian injuries, the length of hospitalisation and the management required by these patients, they place a greater demand on hospital and health care resources than other categories of injured road-users and consequently put a significant economic burden on the State (Brainard et al., 1989). An Australian study found that the mean hospital costs for pedestrians were significantly higher than for any other road-user category (Hendrie & Rosman, 1994).

One USA study on injured pedestrians indicated that the average treatment costs were $16 900 per patient (Brainard et al., 1989). But treatment costs are only the tip of the iceberg. Other major cost factors include emergency services, property or vehicle damage, lost productivity (Miller, Pindus & Douglass, 1993b) and other hidden costs which cannot be adequately transcribed into fiscal amounts, such as pain and suffering, post traumatic stress, anxiety and rehabilitation, as well as the emotional burden suffered by the family. Generally speaking "the socio-economic effects are therefore enormous" (Shanks et al., 1994:32).

3.15 CHAPTER SUMMARY

This chapter quantifies the worldwide extent of vehicular trauma, and pedestrian trauma in particular. A profile of the adult pedestrian in both developing and developed countries is presented. The role which alcohol plays in these collisions is discussed with regard to incidence, injury severity, management and outcome.

The following chapter will review the South African vehicular and pedestrian statistics and present some results from the available data sources for pedestrian collisions in Cape Town and discuss their limitations.

CHAPTER FOUR

TRAFFIC TRAUMA IN CAPE TOWN

"*The undue carnage on our roads is well known*" (Van der Spuy & De Wet, 1991b:61).

4.1 INTRODUCTION

South Africa is undergoing major demographic transition as it slowly moves from a developing to a developed country, bringing with it a slow, but progressive, reduction in infant mortality rate, an increased life expectancy, better access to health care and the control of tuberculosis, malnutrition, infections and parasitic conditions. But unfortunately, as technological advances and urbanisation occur, there is a concomitant increase in the trauma rates per capita, which precipitates a disproportionate demand for trauma services and "... indications are that only AIDS will compete with it as the potential No. 1 community health hazard over the next few decades" (Van der Spuy & De Wet, 1991b:61).

Non-natural causes of death in South Africa represent just over 16% of all deaths (Bradshaw et al., 1987) - three times the global average of 5.2% (World Health Organisation, 1987). When compared with the USA, where injuries rank fourth as a cause of overall mortality (Baker et al., 1992), non-natural causes of death in South Africa rank second to circulatory disease such as cardiac conditions, vascular diseases and strokes (Bradshaw et al., 1987). Furthermore, childhood injury mortality rates are between 1.5 and 3.8 times higher in South Africa than the USA, depending on the age and population group (Kibel et al., 1990a).

The most devastating effect of trauma in South Africa is, however, that it selectively kills young, economically active adults, predominantly males, whose fatalities outnumber those of females 3:1.

In 1984 it was estimated that premature deaths accounted for the loss of some 2.43 million potential years of life (Bradshaw et al., 1987) and that non-natural causes of death (36%) were the single largest category, followed by parasitic and infective diseases (15.9%) and circulatory diseases (Table 4.1).

Table 4.1 : Deaths in SA, 1984 - Lost potential years of life

CAUSE OF DEATH	PERCENTAGE
Non-natural	36.0
Parasitic/infective	15.9
Circulatory	9.4
Respiratory	8.8
Tumours	6.0

Adapted from Bradshaw et al., 1987

But mortality data represent only one side of the spectrum. Disability due to trauma, temporary or permanent, results in vast additional person-power losses to the country (Van der Spuy & De Wet, 1991b).

4.2 ALCOHOL MISUSE IN SOUTH AFRICA

It is well known that South Africa has one of the highest per capita alcohol consumptions in the world (Cooper, Schwär & Smith, 1979) and that ".. drinking of alcoholic beverages is fast becoming one of South Africa's most serious problems... with a high number of alcohol-related deaths and injuries being reported" (Parry, Tibbs, Cummins et al., 1994a:43).

Alcohol misuse appears to be particularly problematic in males, black South Africans, migrant workers, road users, patients with tuberculosis and the youth (McCabe,1982; Parry, 1994b). A meta-analysis of studies assessing problem drinking among urban black South Africans has revealed a consistent pattern of high risk drinking in 29% to 37% of males and 25% of females (Parry et al., 1994a). Alcohol misuse appears to be particularly problematic in 'informal settlement' areas and townships (Rocha-Silva, 1994). In some such areas "research shows that there is one shebeen[1] to every five homes..." (Gumede, 1986:19). Many of the residents in 'informal settlements' see alcohol as a means of income generation and as a way to help them cope with the problems of daily living (Parry, 1994c).

Alcohol misuse, and binge drinking in particular, has also been identified as problematic in adolescents and young adults in Cape Town. A study conducted on 7 340 high school students in the Cape Peninsula found that 27% of boys and 15% of girls had had five or more alcoholic drinks on one or more occasion in the two weeks preceding the study (Flisher, Ziervogel, Chalton et al., 1993a). Nkhoma & Maforah (1994) found that 74.7% of students living in a University of Cape Town (UCT) residence were alcohol drinkers and only 25.4% were non-drinkers. Furthermore, 50% of the males in their sample were identified as 'moderate' to 'heavy' alcohol drinkers (Nkhoma & Maforah, 1994:57).

Alcohol misuse has been indentified in both the national health plan for South Africa, drawn up by the African National Congress (ANC), and the Reconstruction and Development Programme (RDP) as a priority issue and both recognise the need for the development of prevention programmes. The ANC document states that "the use and abuse of tobacco and alcohol products causes a major disease burden on all South Africans, more especially lower income groups, and therefore imposes considerable health care costs" (African National Congress, 1994).

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1 A shebeen is an unlicenced bar often found in informal settlements in South Africa.

The cost of alcohol misuse imposes a heavy burden on the South African economy. The costs are borne "... not only by misusing individuals, but by their families, the community, industry, and ultimately society as a whole" (Tibbs, Parry, Goosen et al., 1994:2). It was estimated, in 1986, that the total cost of alcohol misuse in South Africa amounted to R1,178 billion a year (Langley, 1986). A press report from the South African National Council on Alcoholism and Drug Dependence (SANCA) in June 1994 estimated that the economic burden had risen to R5 billion a year (Cape Times, 1994). This estimate has, however, been severely criticised as being based on speculation. Medical care is the single largest contributor to the core costs of alcohol misuse in most countries (National Institute on Alcohol Abuse and Alcoholism, 1991).

But the relationship between alcohol and trauma in South Africa is a disturbing one.

The Cape Metropolitan Study found that 60.7% of fatally injured trauma victims in the Cape Town metropolitan area had BAC levels at or over 0.08 g/100ml (Van der Spuy, Peden & Strydom, 1995).

A consecutive sample of 80 patients admitted to the trauma unit of Baragwanath Hospital on a Saturday night in 1990 showed 48.8% to be intoxicated on blood alcohol analysis. The authors stressed that, since levels were only done on Saturday nights, this proportion was probably not representative (Butchart, Nell, Yach et al., 1991).

In a recent study conducted by the MRC's Urbanisation and Health Programme it was found that experienced pathologists and trauma surgeons in South Africa estimate that over half of all trauma-related injuries and deaths from motor vehicle collisions and interpersonal violence, for persons 14-60 years of age, are directly attributable to alcohol use and misuse (Parry, Tibbs, Van der Spuy et al., 1996a).

A study by La Grange (1991) in the Pretoria area confirmed that alcohol was a significant factor in trauma epidemiology and that there was an increase in its incidence with urbanisation.

A number of studies on sub-categories of trauma have also been conducted.

In 1964 a study showed that 36% of fatal vehicular collision victims were alcohol positive, with 50.5% of those 18 years and older being BAC positive (Le Roux & Smith, 1964).

Lerer (1992b) assessed 216 female homicide victims admitted to the Salt River State Mortuary in Cape Town between January 1990 and July 1991. He found that 56% had BACs of 0.1 g/100ml or higher.

A retrospective analysis of 948 medico-legal postmortems over a 5 year period found that 52.5% of cases tested positive for alcohol. The BACs ranged between 0.008 - 0.48 g/100ml with a mean of 0.142 g/100ml. This study further showed that 41.3% of 293 cases of vehicular deaths were alcohol-related, with a mean BAC of 0.147 g/100ml (Loftus & Dada, 1992).

A study conducted at Tygerberg Hospital by Müller & Van Rensburg (1986), indicated that 77% of assault and vehicular injuries were associated with alcohol misuse. This is a particularly high percentage, which suggests that the methodology may have been biased towards finding alcohol positive results.

A study by Davis & Smith (1982), conducted between 1979 and 1981, found that 50% of 223 victims of drowning over the age of 15 years had BACs of 0.1 g/100ml or higher.

These studies highlight the concern that "... alcohol misuse may well come to be recognised as one of the most significant public health concerns facing the New South Africa over the next few years" (Parry, 1994c:2).

4.3 VEHICULAR TRAUMA IN SOUTH AFRICA

4.3.1 INTRODUCTION

"South African roads are a major disaster area, and the annual mortality and morbidity figures are a national disgrace" (N.C. Lee 1990:1). Although the reasons for this state of affairs are multifactorial, and may include the poor enforcement of existing traffic laws due to staff shortages in the traffic departments or the lack of adequate training programmes for drivers, one of the major factors appears to be alcohol abuse.

4.3.2 THE MAGNITUDE OF THE PROBLEM

As was mentioned on page 2, the road traffic death rate in South Africa is 11.7 per 100 million kilometres travelled (International Road Federation, 1991). Although this rate is substantially higher than in most developed countries, it is not dissimilar to that in many developing countries, such as Morocco, Kenya and Brazil (see Table 3.1, p23).

Although there appeared to be a downward trend in fatal road traffic collisions in South Africa in the early years of this decade, viz. an 8.7% decrease from 1991 to 1992, and a 6.5% decrease from 1992 to 1993, the 1993 to 1994 figures indicate a relapse (an increase of 4.9%). Road traffic collisions still account for approximately 28 deaths per day.

In 1993 nearly half a million collisions occurred in South Africa. More than 9 000 people were killed, more than 33 000 seriously injured and nearly 85 000 slightly injured (Directorate of Traffic Safety, 1994a) (Table 4.2).

Table 4.2 : Collisions and injuries per province (1993)

	COLLISIONS	CASUALTIES			
PROVINCE	**TOTAL**	**Deaths**	**Serious Injuries**	**Slight Injuries**	**TOTAL**
Western Cape	73 569	1 262	3 365	15 903	20 530
Eastern Cape	26 357	660	2 076	6 573	9 309
Northern Cape	6 266	266	806	1 952	3 024
Free State	23 380	899	2 548	6 126	9 573
KwaZulu/Natal	77 033	1 984	6 200	15 798	23 982
North-West	13 274	577	1 500	3 021	5 098
Gauteng	180 454	2 151	11 423	27 109	40 683
Eastern Transvaal	18 418	994	2 814	4 847	8 655
Northern Transvaal	13 977	652	2 652	3 490	6 794
TOTAL	**432 728**	**9 445**	**33 384**	**84 819**	**127 648**

Adapted from the Directorate of Traffic Safety, 1994a

4.3.3 THE ROLE OF ALCOHOL

As shown in Section 4.2 alcohol plays a significant role in most trauma in South Africa. However, the role which it plays in motor vehicle trauma is particularly disturbing and it is an area where much preventative action could be directed.

4.3.3.1 Uninjured road-users

Multicentric, random surveys have been done annually for the Directorate of Traffic Safety (DTS) since 1975. These surveys are conducted between the hours of 17h30 and 19h00 on pedestrians and between 20h00 and 24h00 on drivers. Since 1980 these surveys have consistently shown that approximately 13% of adult pedestrians (uninjured, walking on the side of the road) and 7% of drivers (uninjured, stopped at road blocks) have BACs of 0.08 g/100ml or more (De Jager, 1986; 1988). The figures for 1995 were 16% for pedestrians and 7% for drivers (personal communication, J. Van der Spuy, NTRP, 28 December 1996).

4.3.3.2 Fatally injured road-users

A study was conducted in 1983 on 1 679 fatally injured drivers and pedestrians, 16 years and older, of whom 60.1% were pedestrians and 39.9% were drivers. Blood alcohol testing was performed on only 793 (<50%) of the cases. Almost two-thirds (62.9%) of those tested were found to have positive BAC levels and 56.9% had BAC levels $\geq$ 0.08 g/100ml. Of those with positive BACs, 33.9% had levels $\geq$ 0.26 g/100ml. When drivers and pedestrians were assessed separately, 52.2% of drivers and 60.4% of pedestrians had BAC levels $\geq$ 0.08 g/100ml. This study also showed that 64.7% of collisions occurred in urban areas, mainly at night, and that 59.9% of collisions occurred during the weekends. Although there was a significant alcohol-relatedness in fatal motor vehicle collisions, there was selection bias in this study because not all cases were tested for alcohol. It was clear, however, that the greatest number of persons involved in fatal collisions and who have positive alcohol levels were black pedestrians and that their BAC levels were substantially higher than the legal limit for drivers (Pieterse, 1984).

Another, somewhat limited, study was done on 2 434 fatally injured drivers and pedestrians who had medico-legal post mortems performed in Johannesburg, Cape Town, Pretoria, Durban and Bloemfontein in 1987. In 28.7% of cases BAC levels were not documented and in a further 42.4% of cases it was not possible to ascertain whether the person had been driving or was a pedestrian. With these limitations taken into account, 50.6% of the 316 drivers and 64.4% of the 946 pedestrians who were tested had BAC levels which were over the legal limit for drivers. Furthermore, approximately 31.4% of all cases tested had BAC levels at or above 0.26 g/100ml (Pieterse, 1988).

4.3.3.3 Non-fatally injured road-users

A study conducted at the Johannesburg General Hospital in 1977 on 115 patients admitted to hospital after a motor vehicle collision found that 37% of the drivers were alcohol positive, 31% having BAC levels of 0.08 g/100ml or more (Myers, Taljaard & Penman, 1977).

In a similar study conducted at Groote Schuur Hospital (GSH) over a 6-month period in 1987 on 285 injured drivers, 107 (37.5%) were found to be alcohol positive and 83 (29.1%) had BACs of 0.08 g/100ml or higher (Van Kralingen et al., 1991). Of these 84 drivers, formal blood sampling was requested by the investigating officers in only 6 instances (7%). This represents a 93% undercall for BAC sampling in drivers subsequently proven to have illegal BAC levels.

Although the above two prospective studies were done ten years apart and in different cities they showed similar results, i.e. approximately 30% of drivers injured in motor vehicle collisions and arriving alive at a hospital had BAC levels of 0.08 g/100ml or higher.

The National Accident Pilot Study was conducted by the DTS between July 1981 and December 1985 on 1 667 people injured in motor vehicle collisions in order to identify the contributing factors involved in these collisions (Pienaar & Upton, 1986). The methodology employed in this study was, however, severely flawed since only 45.7% of cases were interviewed at the site of the collision. The others were interviewed some days after the collision. As a result of these limitations it is not suprising that only 3.2% of collisions were attributed to alcohol (Table 4.3). Furthermore, alcohol was only documented as attributable if all the other human factors had been eliminated. With such gross methodological errors it is not suprising that the authors cautioned that the results should only be seen in the context of the study and could not be used for any other practical purpose.

Table 4.3 : Contributing factors identified in 1 584 collisions (1981-1986)

Contributing Factor	
Inattentiveness/thoughtlessness	30.5%
High speed	16.5%
Reckless/negligent driving	18.0%
Incompetent driving	6.5%
Alcohol or drug intoxication	3.2%
Weather	3.0%
Road surface	2.9%
Vehicle factors	2.4%

Adapted from Pienaar & Upton, 1986

A recent study was conducted by Hedden & Wannenburg (1994) on all patients (drivers, passengers and pedestrians) involved in a motor vehicle collision and who presented to Addington Hospital, Durban, between 7 February and 16 September 1992. This prospective study assessed 530 patients for alcohol intoxication and marijuana use at the time of presentation to the hospital. The results indicated that 51.7% of all the patients had BAC levels $\geq$0.08 g/100ml, 35.1% had traces of marijuana in their urine and 18.5% were positive for both substances.

In overview it can therefore be said that the majority of the studies conducted in South Africa on the role of alcohol in traffic trauma have been retrospective, based on mortality data or flawed by selection bias and therefore cast doubt on the reliability of the data. Nevertheless, it is clear that alcohol plays a significant role in vehicular trauma in South Africa.

4.4 PEDESTRIAN TRAFFIC TRAUMA IN SOUTH AFRICA

4.4.1 INTRODUCTION

According to Van der Spuy (1983:2) "The hallmark of South Africa's disturbingly high traffic injury and mortality rates is the high pedestrian component". Unfortunately this viewpoint is not shared by most people, possibly because "Pedestrian deaths and injuries have become a normal occurrence in the South African way of life - something we hear about every day, but believe we have little or no control over!" (Directorate of Traffic Safety, 1992:8). But solutions can be found. The first step, however, is to accurately quantify the problem and describe its epidemiology.

4.4.2 THE MAGNITUDE OF THE PROBLEM

Pedestrians account for approximately 45% of the overall number of traffic fatalities in South Africa (Directorate of Traffic Safety, 1990b). That means that every year approximately 4 500 pedestrians are killed and a further 26 000 are injured on South African roads - about 12 pedestrians killed and 71 injured per day (Table 4.4).

Table 4.4 : National statistics for pedestrians (1989-1993)

YEAR	DEATHS	SERIOUS INJURIES*	LIGHT INJURIES**	TOTAL
1989	5 118	9 374	19 124	**33 616**
1990	4 985	9 374	19 967	**34 326**
1991	4 897	10 249	19 636	**34 782**
1992	4 437	9 079	18 684	**32 200**
1993#	4 115	9 555	19 479	**33 149**

* Serious injuries = requiring hospital admission
** Light injuries = treated on an out-patient basis (no admission required)
Adapted from the Directorate of Traffic Safety, 1993a
Personal communication, Mrs Van Vuuren, Directorate of Traffic Safety, 29 March 1995

In South Africa, road traffic injuries are the single most important cause of morbidity and mortality in children over the age of four years. Pedestrians collisions account for 46% of all these traffic-related injuries and results in 25% of the potential years of life lost (Bass et al., 1995).

Most pedestrian deaths in South Africa occur in the urban rather than rural areas (66.1% versus 33.9%). Black males aged between 20 and 34 years and living in urban areas appear to be the most at-risk group (Ribbens, 1989) and this situation does not appear to be improving. In the last two decades the proportion of the national pedestrian death toll occurring among black people has risen from 38.4% to 45.2%, while for white people it has dropped from 3.8% to 1.1% (Directorate of Traffic Safety, 1990b).

Only about one-third of the total number of fatal pedestrian collisions occur in the rural areas of South Africa but the injuries sustained by these pedestrians are appreciably worse (Ribbens, 1986). This is possibly related to the fact that many rural pedestrians are injured on open roads where cars travel at high speeds ($\geq$120 km/hr) and the lighting is poor. This latter problem was reconfirmed by Ribbens in 1989 when he again found that although 80% of all pedestrian collisions occur between midday and midnight, significantly more fatal collisions occur after dark.

One of the earliest studies to profile some aspects of pedestrian traffic trauma in South Africa was conducted by Odendaal (1969). This study showed that black South Africans accounted for two-thirds of all pedestrian collisions and that there was an over-representation of young people in the sample, i.e. 70% of all pedestrians injured were under the age of 30 years and more than 50% were less than 20 years of age.

Most pedestrians were injured while crossing a road and in 26% of such collisions there was a pedestrian crossing within 30.5 m of the crash scene. Furthermore, in 48% of the collsions pedestrians were in a hurry to get to their destination and therfore crossed the road at a convenient rather than a safe place. This latter finding was corroborated by Ribbens (1985).

Odendaal (1969) found that pedestrians were to blame for the collision in many cases. Most pedestrains had minimal education and displayed inadequate knowledge of road safety principles. Futhermore, human factors such as poor visual acuity (13%), distractions (35%), preoccupation (26%), alcohol (13%), poor reflexes (35%) and limited road experience (30%) were found to be predisposing factors.

A recent study on the risk-taking behaviours of 7 340 Cape Peninsula high school students indicated that 7.4% had been injured in a pedestrian collision in the year prior to the study (Flisher, Ziervogel, Chalton et al., 1993b). These results are considerably higher than that reported by Todd & Waller (cited in Bradbury, 1991), who estimated that 3% of adults worldwide would be involved in a pedestrian collision some time in their life.

4.4.3 THE ROLE OF ALCOHOL

No national data is available on the relationship between alcohol intoxication and pedestrian collisions but sentinel mortality studies suggest that the incidence is very high.

4.5 VEHICULAR TRAUMA IN CAPE TOWN

4.5.1 INTRODUCTION

With the launching of the RDP for the new South Africa it has been recommended that "provincial governments... play a much bigger role in promoting traffic safety by establishing a structure which accommodates all functional areas to coordinate and integrate activities" (Directorate of Traffic Safety, 1994a:1). Within the Western Cape our first necessity was to define the magnitude of the problem and then to define appropriate prevention strategies.

4.5.2 THE MAGNITUDE OF THE PROBLEM

In 1993, in the Western Cape, there were 1 262 people fatally injured, 3 365 seriously injured and 15 903 slightly injured in motor vehicle collisions. There were a further 73 569 collisions which did not result in any human injuries (Directorate of Traffic Safety, 1994a).

The Cape Metropolitan Study, conducted by the MRC's National Trauma Research Programme in 1990, found that traffic collisions in Cape Town accounted for 10.4% of all non-fatal injuries and 38.4% of all fatal injuries (Van der Spuy et al., 1995).

According the City of Cape Town, Traffic Department (1992), 299 people died as a result of traffic collisions in the Cape Town municipal area during 1992. Of these 299 cases, 50 (16.7%) were drivers, 32 (10.7%) were passengers, 206 (68.8%) were pedestrians and 11 (3.8%) were pedal cyclists (City of Cape Town, Traffic Department, 1992). Data for 1993 on 284 fatally injured traffic cases, indicates that the proportions in the different traffic-users categories remain fairly constant (Figure 4.1) (City of Cape Town, Traffic Department, 1993).

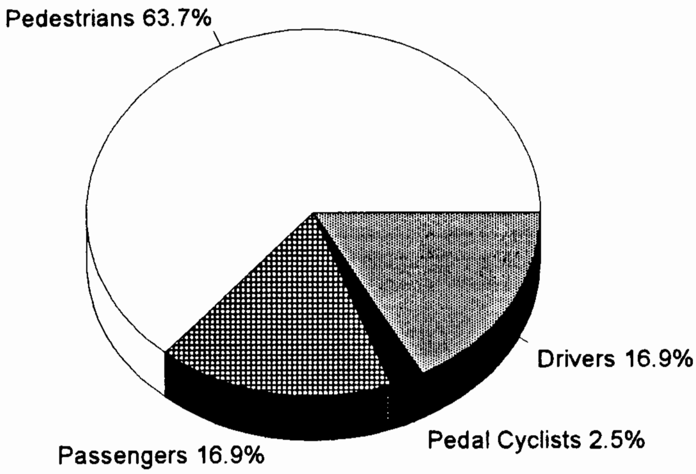


Figure 4.1 : Traffic fatalities in the City of Cape Town municipal area (1993)

4.5.3 THE ROLE OF ALCOHOL

In South Africa BAC levels are routinely performed by the State mortuary on all cases over the age of 15 who require a medico-legal postmortem (this includes all cases killed in motor vehicle collisions) and who died within six hours of their collision (personal communication, H. Scholtz, Department of Forensic Medicine, UCT, 20 January 1995). As a result, the incidence of alcohol intoxication among fatally injured road-users is fairly well documented.

In the City of Cape Town municipal area there were 284 people killed in traffic collisions in 1993. Blood alcohol levels were available on 210 of these 284 cases. Just over half of these cases (51.2%) had BAC levels $\geq$ 0.08 g/100ml. Further analysis (Figure 4.2) showed that just over one-third of drivers and passengers, nearly two-thirds of pedestrians and a quarter of pedal cyclists had BAC levels $\geq$ 0.08 g/100ml at the time of their death (City of Cape Town, Traffic Department, 1993).

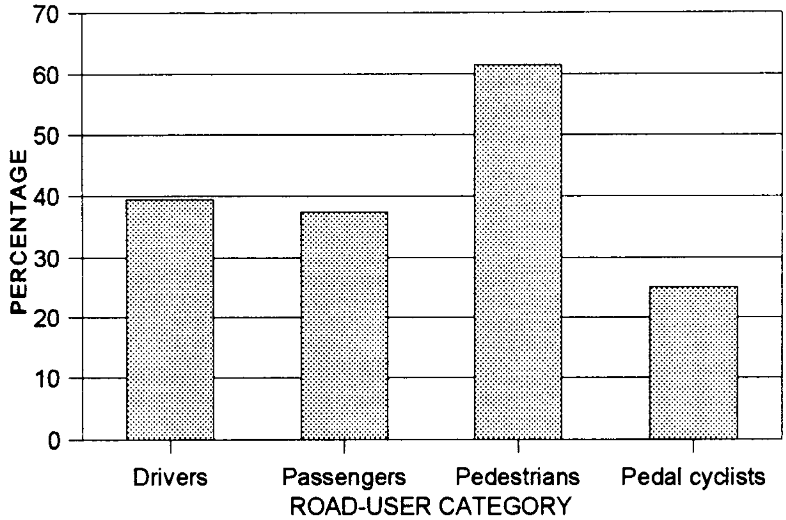


Figure 4.2 : Proportion of fatally injured road-users with BAC levels ≥0.08 g/100ml (City of Cape Town municpal area, 1993)

The incidence of alcohol intoxication in non-fatal motor vehicle collisions is less well documented. A prospective study conducted at GSH trauma unit in 1987 indicated that 29.1% of 285 injured drivers had BAC levels of 0.08 g/100ml or above. The mean BAC for these patients was 0.19 g/100ml (Van Kralingen et al., 1991). Black drivers had the highest incidence of intoxication at the time of their collision, i.e. 37.1% had levels of ≥ 0.08 g/100ml (Table 4.5).

Table 4.5 : Distribution of BAC levels according to population group of the driver

RACE	BAC in g/100ml			TOTAL	Proportion (%) with BACs ≥0.08 g/100ml
	Zero	0.01-0.07	0.08+		
Asian	5	0	0	5	0
Black	19	3	13	35	37.1
Coloured	105	11	44	160	27.5
White	49	10	26	85	30.6
TOTAL	178	24	83	285	29.1

Adapted from Van Kralingen et al., 1991

Müller & Van Rensburg (1986) reported that 77% of patients injured in traffic collisions or assaults, who presented to Tygerberg Hospital trauma unit, had positive BAC levels with a mean BAC of 0.212 g/100ml (range 0.01-0.492). However, only 27% of this sample were traffic-related injures - the other 73% were assault victims. The authors did not indicate what proportion of the traffic-related injuries were BAC positive; however, they did record an alarmingly high mean alcohol level (0.196 g/100ml) for young pedestrians.

Results from the Cape Metropolitan Study showed that 24.5% of all traffic-related injuries in Cape Town in 1990 were alcohol-related (Van der Spuy et al., 1995). These results were, however, a conservative estimate since no objective measures were used, i.e. alcohol-relatedness was based on clinical judgement only. Of the traffic deaths, more than 50% of cases had BAC levels of $\geq$ 0.08 g/100ml.

4.6 PEDESTRIAN TRAFFIC TRAUMA IN CAPE TOWN

4.6.1 INTRODUCTION

In the Cape Town metropolitan area there appears to be a disproportionately high number of pedestrians killed in comparison to the national average, viz. 64%-69% versus 45%, respectively.

A substantial number of these pedestrian collisions in Cape Town involve children under the age of 15 years. De Villiers, Jacobs, Parry et al. (1984) found that more than half of all non-natural deaths in children younger than 15 years were transport related, while Kibel (1990b) found that 31% of all childhood deaths were the results of traffic collisions. The majority of children involved in traffic collisions are pedestrians (Bass et al., 1992; 1995; De Villiers et al., 1984; Fowler, 1991).

This paediatric pedestrian problem in Cape Town appears to have been fairly well addressed. Fowler (1991) wrote a doctoral thesis on the topic and both she and Bass et al. (1992; 1995) have offered some suggestions for prevention and control of the problem.

The adult non-fatal pedestrian problem in Cape Town has, until now, not been researched in detail. Although it has been hypothesised that the reasons for the high incidence of adult pedestrian collisions in Cape Town may be linked to the high rates of alcohol abuse in the city, no accurate prospective data are available.

4.6.2 AVAILABLE DATA SOURCES

4.6.2.1 City of Cape Town, Traffic Department Data

The only data which are routinely collected on pedestrian collisions in Cape Town are on the 'Accident Form' which is completed by the Traffic or Police Officer at the scene of the collision. This information is, however, often incomplete because of the circumstances of the collisions or the severity of the patient's injuries. Furthermore, collisions where there is minimal damage to the vehicle and/or little or no injuries to the pedestrian are often not reported and thus 'Accident Forms' are not completed. Despite these limitations, this data is the only available which gives an indication of the pedestrian problem in the City of Cape Town municipal area on a yearly basis.

As previously indicated in Section 4.5.2 for 1992 and 1993, approximately 65% of all traffic fatalities in Cape Town were pedestrians.

In 1993 there were 2 781 pedestrians involved in collisions, of whom 6.6% were killed, 10.2% were seriously injured, 67.9% were slightly injured and 15.3% were not injured, although there was damage to the motor vehicle (City of Cape Town, Traffic Department, 1993).

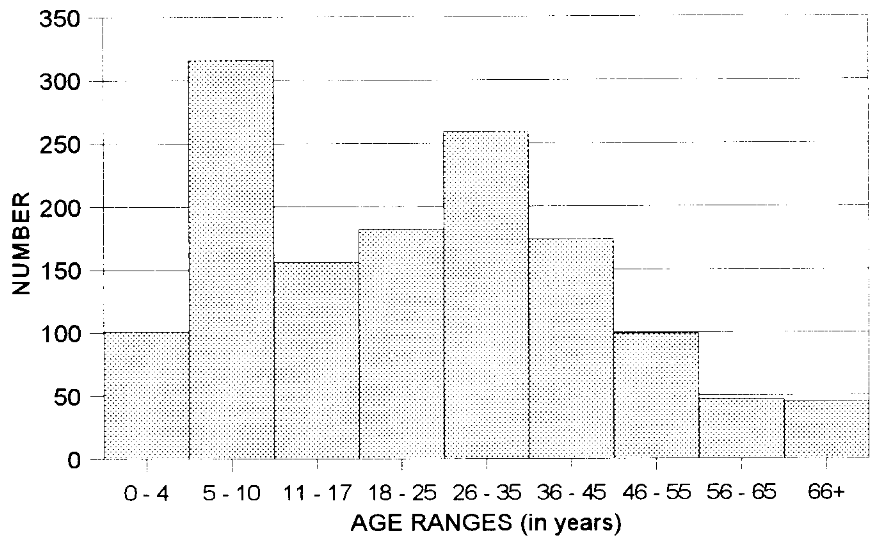


Figure 4.3 : Pedestrian collisions in Cape Town by age group (1993)

Although a lot of children younger than 18 years are involved in pedestrian collisions (Figure 4.3), there are also substantial numbers of adults, particularly between the ages of 18 and 45 years, involved in these collisions.

When one looks at absolute numbers of pedestrians injured in Cape Town, the majority are male and coloured (Table 4.6). However, when these figures are expressed as rates for the population of Cape Town[2], black pedestrians are the most at risk group.

2 According to the 1991 Population Census, the population profile of Cape Town was: 47.9% coloured, 27.9% black, 24.2% white and 0.01% Asian.

Table 4.6 : Pedestrian fatalities in Cape Town by population group (1991-1993)

RACE	1991	1992	1993
White	14 (7.0%)	13 (6.3%)	9 (4.9%)
Coloured	104 (51.7%)	93 (45.4%)	109 (59.6%)
Asian	1 (0.5%)	1 (0.5%)	0 (0.0%)
Black	63 (31.3%)	78 (38.0%)	52 (28.4%)
Unknown	19 (9.5%)	20 (9.8%)	13 (7.1%)

Adapted from the City of Cape Town, Traffic Department, 1992; 1993

The largest group of pedestrians were injured or killed crossing the road 'elsewhere', i.e. not at an intersection or pedestrian crossing (Table 4.7). Walking on the roadway and not on the sidewalk also appears to be problematic although there are less pedestrians injured walking with their back to the traffic than was expected.

Table 4.7 : Pedestrian actions involved in traffic trauma in Cape Town (1991-1993)

ACTION	1991	1992	1993
Crossing street			
At crossing	232	228	252
At pedestrian crossing	84	84	85
Elsewhere	1538	1338	1145
Walking in roadway			
Facing traffic	230	214	285
Back to traffic	116	155	179
Stand/play in roadway	129	160	170
Stand/play on sidewalk	172	167	208
Unknown	154	312	457
TOTAL	**2 655**	**2 658**	**2 781**

Adapted from the City of Cape Town, Traffic Department, 1992; 1993

In addition, alcohol intoxication appears to play a significant role in the causation of fatal pedestrian collisions in Cape Town. In 1992, of the 206 pedestrians killed, 120 were tested for alcohol; of these 88 (73.3%) had BACs >0.08 g/100ml and 32 (26.7%) had levels of 0.08 g/100ml or less (Table 4.8). Of the 86 cases in which BAC levels were not documented, 37 were children. The others were probably not tested because they had died more than six hours after their collision (City of Cape Town, Traffic Department, 1992).

Similarly in 1993, 114 of the 181 pedestrians killed were tested for alcohol. Seventy cases (61.4%) had BACs >0.08 g/100ml and 44 (38.6%) had levels of 0.08 g/100ml or less (Table 4.8). Of the 67 cases not tested, 41 were children (City of Cape Town, Traffic Department, 1993). For both 1992 and 1993 the proportion of pedestrians with BAC levels >0.20 g/100ml was disturbingly high.

Table 4.8 : BAC levels in fatally injured pedestrians, Cape Town (1992-1993)

	BLOOD ALCOHOL CONCENTRATION (g/100ml)				
YEAR	**0.00-0.08***	**0.09-0.20**	**0.21-0.30**	**0.31+**	**TOTAL**
1992	32 (26.7%)	14 (11.7%)	26 (21.7%)	48 (40.0%)	120
1993	44 (38.6%)	21 (18.4%)	29 (25.4%)	20 (17.5%)	114

* Unfortunately the traffic department data does not indicate how many cases had zero BAC levels. Also the conventional cut-off point, i.e. 0.07 g/100ml is not used.

Adapted from the City of Cape Town, Traffic Department, 1992; 1993

4.6.2.2 The Cape Metropolitan Study Data

The 1990 Cape Metropolitan Study was a comprehensive, predominantly prospective, survey of trauma in the Cape Town Metropolitan area (National Trauma Research Programme, 1990). It covered all facilities (primary, secondary and tertiary) treating trauma in both the private and State sectors in the greater Cape Town. Both fatal and non-fatal injuries were included. Data were collected on 8 493 first-time attenders. These raw data were extrapolated to an annual case-load of 248 843 trauma cases for the Cape Town Metropolitan area.

There were 26 804 (extrapolated) traffic-related injuries, which made up 10.8% of the total annual case load. This equates to an annual traffic injury rate for the metropole of 1 072/100 000 over an estimated 2.5 million population, or 73.4 traffic-related injuries per day. Of these patients, 32.2% were pedestrians, 34.6% were passengers and 31.4% were drivers/riders. In 1.7% the road-user category was undetermined (ibid).

Alcohol was clinically assessed to be present in 23.5% of all non-fatally injured road-users. In fatally injured road users, 59.7% had positive BAC levels, with 35.7% having levels of ≥0.2 g/100ml (ibid).

Out of the total of 26 804 road-users injured or killed on Cape Town roads in 1990, 8 673 were pedestrians. Of these 54.9% were coloured, 37.9% black and 7.2% white. Males formed 68% of the case load. The age distribution showed a bi-phasic trend, i.e. a peak at 5 - 9 years and again at 20 -29 years (ibid).

More than half (56.8%) of the pedestrians were injured at night (18h00 - 24h00) and a further 8.3% between midnight and 8h00. Sixty percent of collisions occurred on Fridays, Saturdays or Sundays, with Saturdays (24.1%) being the most frequent day of occurrence. The vast majority of pedestrians were injured by motor cars (82.4%) but 7.8% were struck by minibus taxis , 5.3% by bicycles and a further 2.8% by trains (ibid).

Alcohol was clinically assessed to be present in 33.2% of non-fatally injured pedestrians. In fatally injured pedestrians 67% had positive BAC levels with nearly half (47.7%) having levels of ≥0.2 g/100ml. The mean BAC level for all fatally injured pedestrians was 0.16 g/100ml; for those with positive BAC levels the mean was 0.24 g/100ml (range 0.01-0.4 g/100ml) (ibid).

Lesions to the lower limbs and head injuries were the most common injuries sustained by pedestrians. Generally, injuries were more severe than those seen in general trauma patients, i.e. 22% of pedestrians had an Injury Severity Score (ISS) of ≥ 10. Just less than half (47.6%) of injured pedestrians required in-patient admission to hospital for the management of their injuries - 5.1% required admission to an ICU. The overall mortality rate for pedestrians in this study was 8.8% (ibid).

4.6.3 LIMITATIONS OF AVAILABLE DATA

The data from the City of Cape Town, Traffic Department and the Cape Metropolitan Study are limited for a number of reasons, predominantly related to methodology or the measures used to assess alcohol intoxication.

Data from the City of Cape Town, Traffic Department are valuable in that they indicate a trend. However:

- they only represent data for the City of Cape Town municipal area;
- they do not document **all** pedestrian collisions but this under-reporting of traffic collisions is an international problem (Raffle, 1991; Teanby, 1992);
- the 'Accident Form' is not designed to capture salient data on injuries, injury severity and management;
- the 'Accident Form' is often poorly completed; and
- alcohol relatedness is not indicated in non-fatally injured pedestrians although the BAC level of fatal cases is subsequently determined and documented.

Data obtained from the CMS is probably the most comprehensive information on pedestrian collisions available for the Cape Town area. Unfortunately no objective measures were used to assess alcohol intoxication in non-fatally injured pedestrians nor were **all** the injuries sustained by pedestrians or their management documented. These therefore could not be accurately related to the level of alcohol intoxication, i.e. a correlation between injury severity and the level of alcohol intoxication could not be computed for non-fatally injured patients.

The most methodologically sound study design would be to sample all facilities in the Cape Metropole prospectively and do breath alcohol levels on all injured pedestrians and then combine this with the retrospective analysis of all cases admitted to the two mortuaries in Cape Town during the same time period. Ideally all drivers involved in the collisions should also be sampled in order to obtain a true reflection of alcohol relatedness. This type of study, although feasible, would be both lengthy and costly.

4.7 THE COST OF PEDESTRIAN TRAFFIC TRAUMA

According to Fouracre & Jacobs (1976) traffic collisions in less developed countries are estimated to cost the country between 1% and 2% of the gross domestic product annually.

An estimate of the unit cost of road traffic collisions in South Africa for 1991 was calculated by De Haan (1992). A gross output methodology was used to assess the sum of real resource costs which occur as a result of road traffic collisions, together with the victims' loss of future earnings. The composite costs included (1) the value of lost output, (2) property damage, (3) pain, suffering and loss of amenities of life, (4) medical costs, (5) administrative costs, (6) legal costs and (7) miscellaneous costs, including the value of lost time and towing costs.

The values obtained for the unit cost of each road traffic collision (in 1991 rands) were: R184 604 for each collision resulting in a fatal injury, R48 455 for each collision resulting in a serious injury, R13 796 for each collision resulting in a slight injury and R9 754 for each collision where there was damage to the vehicle only. Taking the inflation rate for 1992 (at 13.9%) and 1993 (at 9.7%) into account (South African Reserve Bank, 1995) and the cost of the total number of vehicular collisions for 1993 (Directorate of Traffic Safety, 1993a) was approximately R30 million per day.

The composite costs for pedestrian collisions only in 1993 amounted to nearly R2.3 million per day. If these unit costs are utilised for the pedestrian collisions in the Cape Town city municipal area, pedestrian collisions cost approximately R100 000 a day in 1993, or R36.5 million for that year (Table 4.9).

Table 4.9 : Composite costs for pedestrian collisions in the City of Cape Town municipal area (1993)

TYPE	UNIT COST (in rands)	NUMBER#	PER YEAR (R millions)	PER DAY (R thousands)
Fatal	102 498	183	18.757	51.254
Serious Injury	32 757	283	9.270	25.380
Light injury	4 257	1 889	8.042	22.016
No injuries, vehicle damage only	922	426	0.393	1.076
TOTAL		**2 781**	**36.462**	**99.726**

After De Haan, 1992
City of Cape Town, Traffic Department, 1993

Although the immediate and medium term costs of motor vehicle collisions can be disastrous to the victims and their families, many of whom come from lower socio-economic groups (Kibel et al., 1990a), the majority of these costs are borne by the State and the taxpayer (Directorate of Traffic Safety, 1992).

A study conducted by the National Trauma Research Programme in 1990 on 120 patients who required ward or ICU admission at GSH for traffic-related orthopaedic injuries (49.1% of whom were pedestrians) found that only 5.5% of the medical costs were recovered from the patients. "This results in a great financial shortfall for Groote Schuur Hospital" (Abrahams, 1993:4).

Although there is a Multilateral Motor Vehicle Accident Fund in South Africa from which patients injured in motor vehicle collisions can claim for the costs incurred by them, the public awareness of this third party claim procedure is poor (Grobbelaar, Albertyn & Bass, 1992). To further compound this problem, until the Medical Scheme Act was amended recently, medical aid societies were not liable for the medical costs incurred in a motor vehicle collision until the claim had been rejected by the third-party insurer (N.C. Lee, 1986).

According to Mr Eric Wise, former Director of the Directorate of Traffic Safety in South Africa, the money spent on vehicular trauma "... could have been spent on essential services such as medical and educational services" (Directorate of Traffic Safety, 1993b:7). He added that it was time for the community at large to decide whether these vehicular collisions and costs were a realistic price to pay for the privilege of optimal mobility or, if not, to initiate an appropriate action plan " ... to create a safety conscious culture" (ibid).

4.8 CONCLUDING REMARKS

It is quite clear from the data presented that "There are three elements to the equation of pedestrian traffic trauma: the motorist and the vehicle, the road and road conditions and then the pedestrian [and that] our problem will not be solved by concentrating on the first component, giving some attention to the second and ignoring the third" (Van der Spuy, 1993:2).

Pedestrian safety in South Africa will require a multidisciplinary approach if the objective of reducing the number of fatal and non-fatal collisions is to be achieved. It will be essential to address simultaneously the inadequate road environment, the human failures and the inadequate law enforcement (Directorate of Traffic Safety, 1994b).

4.9 CHAPTER SUMMARY

This chapter has presented South African and Cape Town data on traffic trauma and, in particular, pedestrian traffic trauma. Some previous research on the alcohol-relatedness of traffic trauma is presented and the limitations of those studies outlined. The chapter concludes with a brief discussion on the estimated cost of pedestrian traffic trauma in South Africa.

The following chapter will present the methodology used in the prospective study on the relationship between alcohol intoxication and adult pedestrian traffic trauma in Cape Town.

CHAPTER FIVE

METHODOLOGY

"the medical examiners have custody of one of the keys, the hospitals have the other - and the answers will not fall into place until both keys are put to use" (Baker, 1971:892).

5.1 INTRODUCTION

This prospective study was designed in order to address the limitations of the Cape Metropolitan Study with regard to the objective measurement of alcohol intoxication in injured pedestrians. Although there are inherent limitations in the methodology chosen, to the author's knowledge it is the first prospective study of its kind in sub-Saharan Africa and therefore gives objective baseline data where previously there was a deficit.

5.2 STUDY DESIGN

The study was essentially a prospective, descriptive survey of adult pedestrians who arrived alive at Trauma Unit, Groote Schuur Hospital, over a nine week period in 1993 (hereafter referred to as Hospital Pedestrians). In addition, data on 'dead on arrival' pedestrians was extracted from the records kept by the Department of Forensic Medicine at Salt River Mortuary, for the same time frame as the prospective study (hereafter referred to as Mortuary Pedestrians). These Mortuary pedestrians were matched with the Hospital pedestrians in the prospective section of the study in order to prevent an over-representation of the former (see 5.3.1). Mortality data was included since it forms an essential component in the epidemiological description of adult pedestrian injuries (Baker, 1971).

The study was a collaborate effort between the Department of Forensic Medicine at the University of Cape Town, the National Trauma Research Programme of the Medical Research Council, and the Trauma Unit at Groote Schuur Hospital.

The study did not attempt to quantify the total incidence of adult pedestrian traffic trauma in Cape Town (since this had already been achieved by the Cape Metropolitan Study), but rather to describe the extent of the problem as identified by a large tertiary hospital and State pathology department, with particular reference to the incidence of alcohol intoxication.

The study design was chosen because it was simple, valid, easy to repeat and was performed on a very low budget, hence making it possible to be repeated in a number of centres, particularly in developing countries.

5.3 CRITERIA FOR PATIENT SELECTION

All injured pedestrians who arrived alive at hospital were entered into the study as they presented to the Trauma Unit over a nine week period in 1993. Certain inclusion and exclusion criteria were applied, which are outlined below.

5.3.1 INCLUSION CRITERIA

The following inclusion criteria were applied for Hospital pedestrians.

- Patients had to be at least thirteen years old.

  Children younger than thirteen years of age are seen at a nearby paediatric hospital. Furthermore, a substantial amount of research has already been done on paediatric pedestrian collisions (Bass et al., 1992; Fowler 1991).

- The injury-to-presentation time was limited to six hours.

  Alcohol is generally metabolised by the body within six hours of ingestion (Cooper et al., 1979), although it can take up to 24 hours. It is questionable whether traces of alcohol consumed many hours before a pedestrian collision can be said to be causative.
- Collisions must have occurred in the GSH drainage area (see map on p76). No patients referred from hospitals outside the GSH area or from rural towns near Cape Town were included.
- Informed consent was required from all patients who were entered into the study. Consent was obtained from the legal guardian in the case of a child under the age of eighteen years. Patients who were unable to give consent, e.g. unconscious patients, were only included if blood was required for other diagnostic purposes (see 5.10).

The following inclusion criteria were applied to Mortuary pedestrians.

- Cases had to be at least thirteen years old.
- Each Mortuary pedestrian had to be matched with at least one hospital patient with regard to the place of injury since Salt River Mortuary receives cases from outside the Groote Schuur Hospital drainage area. In order to prevent or minimise an overcount of fatally injured pedestrians this matching strategy was employed.
- Only pedestrians who died at the site of their collision or in the pre-hospital phase were included as Mortuary pedestrians. Patients who died while in GSH were included as Hospital pedestrians.
- Only pedestrians injured fatally during the identical time frame as the prospective section of the study were included.
- All cases required documentation of BAC. Alcohol sampling is not performed in cases where six or more hours has elapsed between their collision and death since these BAC levels would not reflect their alcohol

state at the time of the injury. These cases, as well as those for whom BAC results were not available, were excluded.

5.3.2 EXCLUSION CRITERIA

The same exclusion criteria were applied to both Hospital and Mortuary pedestrians, i.e. injuries sustained by collisions with trains or bicycles. These types of pedestrian collisions were excluded because their epidemiology, injury profiles and preventive strategies are different to those involving motor vehicles.

5.4 SAMPLING PROCEDURES

All injured adult pedestrians who arrived alive at the Trauma Unit during a nine week period in 1993 and who fulfilled the inclusion criteria were included (see 5.6). All 'dead on arrival' pedestrians who fulfilled the inclusion criteria were identified from the register at the Salt River Mortuary.

5.5 SAMPLE SIZE

A pilot study performed over a weekend in March 1993 indicated that approximately 200 patients would be obtained in a two month period.

A total of 201 Hospital pedestrians were prospectively identified in the main study but five patients did not meet the inclusion criteria. Therefore 196 injured patients were included in the prospective section of the study.

On retrospective analysis of Trauma Unit's patient register, 205 pedestrians had presented to the hospital. It transpired that four patients had been inadvertently omitted from the study due to either clerical errors, e.g. the patient was incorrectly identified as a passenger, or because the mechanism of injury was not known at the time of presentation, e.g. an unknown, unconscious patient who was found injured on the side of the road.

The Hospital pedestrians included in this study therefore represent 95.6% of the total number of adult pedestrians seen at the Trauma Unit during the nine week study period.

Thirty-five Mortuary pedestrians were identified from the records at Salt River Mortuary. However, four cases did not have BAC levels documented and were thus excluded from the study (see 5.4).

The total sample size was 227, i.e. 196 Hospital and 31 Mortuary pedestrians.

5.6 TIME FRAME OF THE STUDY

Data was captured during a total of nine weeks: from 7h00 on 2 May 1993 to 6h59 on 16 May 1993 and from 7h00 on 30 May 1993 to 6h59 to 18 July 1993. It was necessary to split the nine week data capture period into two periods due to an unforeseen illness in the researcher and the unavailability of field workers.

5.7 THE SETTING

Prospective data was captured in the Trauma Unit, GSH, the main teaching hospital of the University of Cape Town. It has a capacity of approximately 1420 beds. It is one of two teaching hospitals for adults in the Cape Metropolitan area (the other being Tygerberg Hospital) which together serve a population of more than 2.5 million. Figure 5.1 attempts to delineate the drainage area for GSH, although this is not absolutely accurate because there tends to be 'cross transportation' and cross attendance of patients between the areas of the two teaching hospitals.

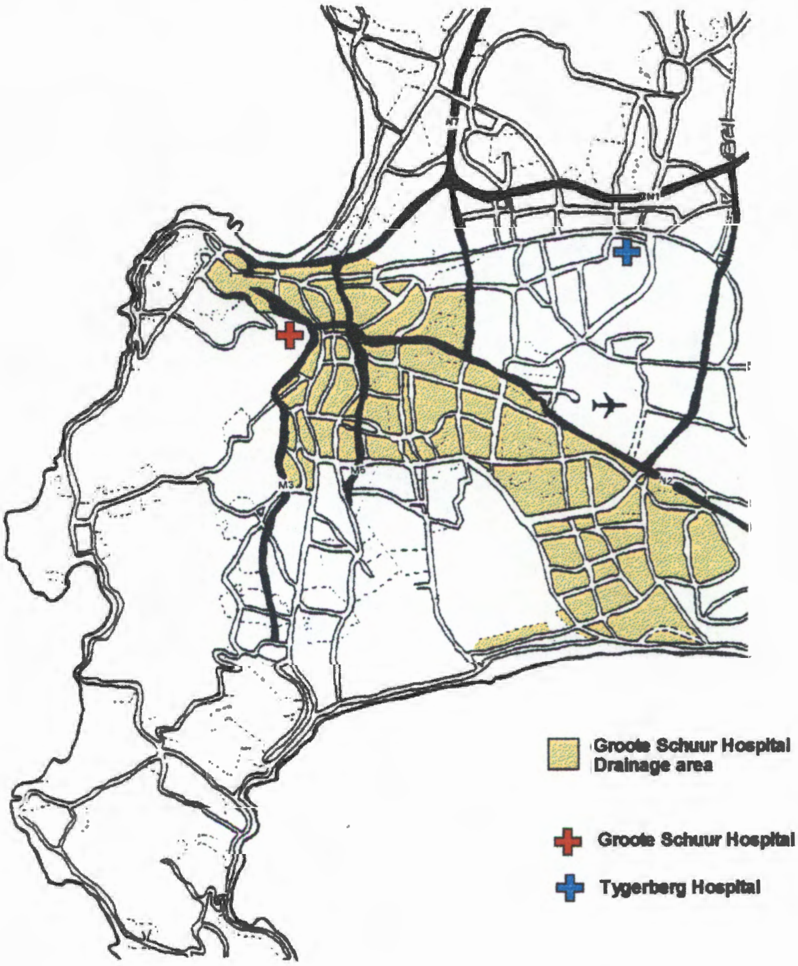


Figure 5.1 : Drainage area for Groote Schuur Hospital

The Trauma Unit at GSH sees about 30 000 patients annually, of whom approximately 17% have been involved in a traffic collision. Pedestrians on average account for 40% of all traffic-related injuries and therefore represent about 7% of the total number of patients seen in this unit (personal communication, J.D. Knottenbelt, Head: Trauma Unit, GSH, November 1994). The study sample may therefore not fully reflect the profiles of all pedestrians injured in the metropole.

Retrospective data was gathered from the State Pathology facility situated in Salt River, Cape Town. This mortuary handles cases requiring medico-legal postmortem examinations from all State and private facilities in the southern part of the Cape metropole. The Tygerberg mortuary deals with cases from the northern suburbs.

5.8 COLLECTION OF DATA

A number of research instruments were used to collect data in order to measure the key variables in the study. The instruments were:

- two research questionnaires;
- injury severity scoring; and
- four methods of alcohol assessment, viz. self-evaluation, clinical assessment, breath alcohol analysis and blood alcohol analysis.

Each of these instruments, the procedures involved and why they were chosen for the study are briefly described in the following sub-sections.

5.8.1 THE RESEARCH QUESTIONNAIRES

The research questionnaires were constructed by the researcher based on questionnaires used for similar international studies, but adjusted for the South African context. Advice concerning the acceptability, accuracy and reliability of the questionnaire was sought from an epidemiologist and a statistician at the Medical Research Council.

Two separate questionnaires were designed, i.e. one for Hospital pedestrians (Appendix A) and one for Mortuary pedestrians (Appendix B).

The questionnaires were separately piloted during March 1993, whereafter the necessary adjustments were made. Field workers were included in the piloting of these questionnaires and inter-researcher validity and reliability was assessed and ensured.

The data obtained by means of the questionnaires included the following:

- patient demographics, i.e. 'who'
- collision demographics, i.e. 'where', 'when', 'how'
- alcohol assessment
    - self-evaluation
    - clinical assessment
    - breath alcohol
    - blood alcohol
- physiological response to injury
- anatomical nature and severity of injuries
- progress and outcome
- crude cost analysis

5.8.2 INJURY SEVERITY SCORING

Several well known and reliable scoring methods were employed in order to code injuries, assess the severity of injuries and document the physiological response to the injuries sustained.

5.8.2.1 The Abbreviated Injury Score

The Abbreviated Injury Score (AIS) codes the severity of anatomical injuries (see Ch 7, p122). The 1990 version of the AIS was used and a maximum of six injuries were coded for patients with multiple injuries (both Hospital and Mortuary Pedestrians).

This scoring system was chosen in preference to the International Classification of Disease (ICD) codes because the AIS was designed specifically for blunt injuries (such as those sustained in motor vehicle collisions) and it is the scoring system most frequently used by trauma researchers. This system would therefore facilitate the comparison of results obtained in this study with those of international studies and it is the system already in use at GSH.

5.8.2.2 The New Injury Severity Score

The Injury Severity Score (ISS) was initially used to calculate the overall injury severity in pedestrians with multiple injuries. This score is attained by adding together the squares of the three highest AIS scores in three different body regions.

The New Injury Severity Score (NISS) was, however, developed in late 1995. This score is attained by adding together the squares of the three highest AIS scores, irrespective of body region, and has been found to be superior to the ISS (Osler, Baker & Long, 1996).

Both scoring systems were used and a comparison made (see Ch 8).

5.8.2.3 The Revised Trauma Score

The Revised Trauma Score (RTS) provides an estimate of the physiological derangement incurred by patients as a result of their injuries. The score is obtained by assessing respiratory rate, systolic blood pressure and the level of consciousness (see Ch 7, p132).

In this study, patients who were intubated and ventilated at the time of their assessment were given a respiratory rate code of 1. Although another method of scoring ventilated patients has been suggested, i.e. substituting the motor component of the Glasgow Coma Scale (Offner, Jurkovich, Gurney et al., 1992), it was felt that the standard method was probably as accurate as, and definitely less complicated than, the latter. Furthermore, the suggested alternative has yet to be validated on large cohorts.

5.8.2.4 TRISS Methodology

TRISS methodology provides an estimate of the probability of survival as a result of the injury incurred (see Ch 7, p136). TRISS was therefore calculated for Hospital pedestrians only.

TRISS was used since it can identify 'unexpected' survivors and 'unexpected' deaths in a study cohort and can thus serve as a trauma audit.

5.8.3 ALCOHOL ASSESSMENT

5.8.3.1 Self-evaluation

Each Hospital pedestrian was questioned regarding his/her intake of alcohol, including the quantity and type of alcohol consumed. Patients unable to talk were excluded from this assessment.

5.8.3.2 Clinical Assessment

The clinical assessment of patients was divided into two, viz. a rapid assessment and a detailed assessment.

The rapid assessment included the following parameters:

- the smell of alcohol;
- slurring of speech; and
- inappropriate behaviour.

The detailed clinical assessment involved the following parameters which have been found to be useful in the evaluation of alcohol intoxication:

- nystagmus on lateral gaze;
- pupil size; and
- pupil reaction to light.

These three parameters were chosen since they were quick and easy to conduct and required the least possible effort on the part of the patient.

5.8.3.3 Breath Alcohol Analysis

The Lion Alcolmeter S-D2 (Lion Laboratories Ltd), a pocket size, portable and easy to use device containing its own fuel cell, was used for breath alcohol (BrAC) analysis. This device measures the amount of alcohol in a 1.5 ml sample of exhaled air by means of a process of electrochemical oxidation. It displays a digital reading in g/100ml which indicates the probable BAC.

The Lion Alcolmeter S-D2 was modified by means of a cup device into which end-expiratory breath was trapped (Figure 5.2).

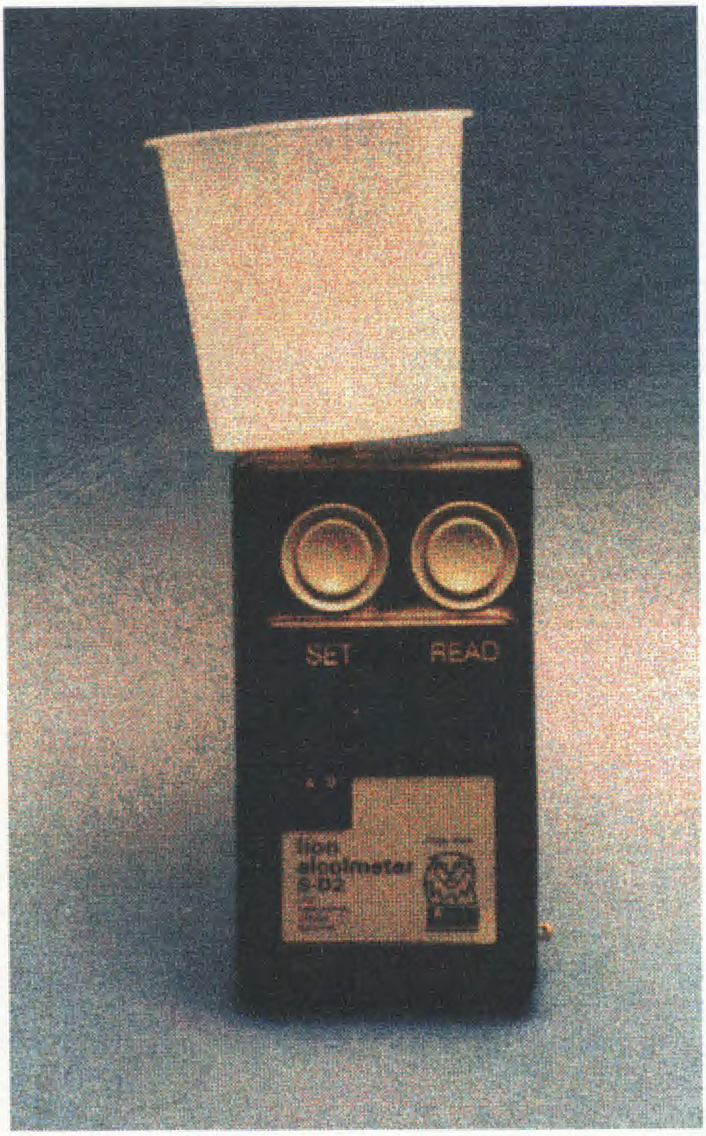


Figure 5.2 : The modified Lion Alcolmeter S-D2

The Alcolmeter was modified in order to facilitate breath alcohol analysis in unco-operative, unconscious and ventilated patients. The modification was made by means of attaching a small plastic specimen container directly onto the Alcolmeter. The addition was made at minimal cost and had the advantage of being quick and easy to clean, as well as cheap to replace.

Conscious patients were asked to exhale into the cup for the stipulated period of time. In unconscious patients, the nostrils were pinched closed and the patient was allowed to exhale into the cup until a fine mist developed on its inside, indicating the capture of alveolar air. In ventilated patients, air was captured from the expiratory valve of the ventilator in order not to compromise the patient's oxygenation.

The Alcolmeter S-D2 was calibrated fortnightly, using known concentrations of alcohol vapour (NALCO), as recommended and supplied by the manufacturer Lion Laboratories Ltd. According to the manufacturers, this Alcolmeter has been officially approved and is in regular police use in many countries around the world. In the United States of America it complies with the Department of Transport's requirements for evidential breath testing devices.

Two such Lion Alcolmeters are presently on loan to the Trauma Unit by the manufacturers. One Alcolmeter was used regularly for the purpose of the study while the other one was kept as a backup.

5.8.3.4 Blood Alcohol Analysis

For the purpose of BAC analysis approximately 5 ml of venous blood was taken from each patient immediately after breath analysis. As a precaution alcohol swabs were not used to clean the skin before venipuncture.

Specimens were labelled with the patient's study number only, in order to maintain the patient's confidentially, i.e. the analyst was 'blinded' to the true identity of the patient and the patient was therefore assured that the results could not be used in litigation. Litigation would also be impossible as the specimens were not statutorily sealed and accepted by a policeman and transported to the laboratory.

Blood was collected in specimen containers, identical to those used for legal BAC specimens in South Africa, which were supplied by the State Chemical Laboratory. Blood was analysed by means of standard headspace gas chromatography, as in most studies of this nature, by a qualified analyst at the State Chemical Laboratory, i.e exactly the same procedure as for formal legal BAC analysis.

5.9 FIELD WORKERS

The author was the primary data capturer and was on twenty-four hour call for the duration of the study. Assistance in the form of five Intensive Nursing Science (Trauma) students was obtained from Carinus Nursing College. The collection of data by these students formed part of their obligatory involvement in a research project, as set out in their curriculum. Students were credited accordingly for their involvement.

Prior to data capture these students attended an afternoon seminar explaining *inter alia* the aims and objectives of the study and the data capture methods. Each student was issued with guidelines on data capture (Appendix C) and advised to consult the primary researcher if they had any queries.

Since these students were only available for data collection during office hours, they captured less than 10% of the total sample. Spot checks on each student were done by the primary researcher while they were capturing data. The students' data capture was found to be methodical and precise, probably because their progress was being monitored, as well as the fact that the primary researcher was a past ICU Tutor at Carinus Nursing College.

During the retrospective collection of data on fatally injured pedestrians, assistance was obtained from Dr H.J. Scholtz, Registrar in the Department of Forensic Medicine, UCT.

5.10 ETHICAL CONSIDERATIONS

Prior to the commencement of this study permission and ethical approval was obtained from the Ethics Committee of the University of Cape Town (Appendix D).

Verbal, informed consent (although controversial in intoxicated patients) was taken from each patient prior to their inclusion in the study. Those patients who refused consent were excluded from the study. Verbal consent was obtained from an adult guardian in the case of children less than eighteen years old. Unconscious patients were included in the study only if venipuncture for other diagnostic purposes was required during resuscitation efforts, i.e. blood was not specifically drawn for the purpose of BAC analysis. Breath alcohol analysis in unconscious patients is done routinely in Trauma Unit in order to facilitate the initial assessment and management of these patients.

Each patient was given a brief description of the study. It was felt that an elaborate explanation of the study would lead to some bias in their responses, particularly those pertaining to alcohol consumption.

The primary researcher and two of the Carinus Nursing Students were sufficiently fluent in Xhosa to eliminate the need for an interpreter in order to gain consent.

Blood alcohol samples were labelled with the patient's study number only. Only the primary researcher had access to the identity of patients (for follow-up purposes) and this information was kept in strictest confidence. The blood taken was used for the purpose of BAC analysis only. Patients were assured that the BAC results could not be used in litigation procedures.

5.11 THE PILOT STUDY

A pilot study was conducted over a busy weekend in March 1993 in order to test the accuracy and reliability of the questionnaire and the Lion Alcolmeter S-D2. The logistics of the study, resources, equipment and staff co-operation were also assessed and found to be acceptable. All field workers were involved in the pilot study in order to acquaint them with completion of the questionnaire.

The results obtained from the pilot study indicated that the questionnaire required modification because some questions were misinterpreted by the patients, particularly those relating to the amount of alcohol which they had consumed. Two questions were found to be redundant and were therefore removed.

5.12 DATA PROCESSING AND ANALYSIS

The number of patients included in the study was checked against the Trauma Unit register. Data included in the questionnaire was rechecked against patient records. It was then coded and encoded by the primary researcher, using Quattro Pro version 4 (Borland International, Inc.,1993).

Checking and cleaning of the data were performed prior to its transfer into the Statistical Analysis Support System (SAS) version 6 (SAS Institute Inc., Cary, NC, USA, 1990) on the mainframe at the Medical Research Council. A biostatistician from the CERSA at the MRC, was consulted for advice and assistance where necessary.

For the purpose of data presentation and analysis the results were divided into two separate data sets. For the purpose of baseline epidemiological data, the following data set was used, viz. Hospital pedestrians (n=196) and Mortuary pedestrians (n=31). For comparative purposes, patients with BAC levels of $\geq$ 0.01 g/100ml were classified as BAC positive (BAC+ve) while patients with zero BAC levels were classified as BAC negative (BAC-ve). There were 141 patients in the BAC+ve group and 86 patients in the BAC-ve group.

Chi squared analysis was used in order to test for statistical significance between the sub-groups on most variables. The corresponding P values and odds ratios were calculated. Where measures of central tendency were used, the standard deviation was computed while the 95% Confidence Intervals were calculated for measures of effect. Inter-quartile ranges were calculated when the median was used for non-parametric data. The level of significance was set at $\propto$ = 0.05, unless otherwise stated.

Pearson's and Spearman's correlations were employed in order to assess the association between breath alcohol and BAC as well as between BAC and injury severity. Agreement was tested by means of the Bland and Altman (1986) technique.

Where indicated, some variables such as NISS and RTS were analysed by means of non-parametric statistical procedures.

Graphical presentation of data was generated using Harvard Graphics version 3.0 (Software Publishing Corporation, 1991) and Presentations (Corel Corporation Limited, 1996).

5.13 CHAPTER SUMMARY

This chapter describes the research design and methodology used in this study, including the criteria adopted for patient selection, sampling procedures and data collection methods. Despite the limitations inherent in the research design and methodology, the study was conducted as objectively as was possible in order to obtain valid, reliable and repeatable data.

The methodology was chosen for its simplicity and suitability for use in developing countries as well as its repeatability and low cost.

CHAPTER SIX

A DEMOGRAPHIC PROFILE OF INJURED PEDESTRIANS IN CAPE TOWN

"I keep six honest serving-men. They taught me all I knew; Their names are What and Why and When, And How, Where and Who" (Rudyard Kipling, Just-So Stories)

6.1 INTRODUCTION

The results of the present study will be broadly presented within the framework of the 'Haddon Matrix', i.e. precrash, crash and postcrash factors. This chapter will look at the precrash factors such as alcohol as well as when and where the collision occurred. Crash factors, such as the injuries sustained, and some postcrash factors, such as the outcome and the cost of treating these pedestrians, will be presented in separate chapters.

Although alcohol is discussed as a precrash factor it also plays a significant role in the crash and postcrash phases and so the role which it plays will be discussed in all the result chapters. Similarly, age and gender are discussed as precrash factors but also have significant implications in the crash and postcrash phases.

The four methods used to assess alcohol intoxication in this study will be presented in detail in a separate chapter of results (see Ch 11) with an emphasis on the comparison between breath and blood alcohol.

6.1.1 PRESENTATION OF DATA

For baseline epidemiological data pedestrians were analysed according to injury category, i.e. whether they arrived alive at the hospital (Hospital Pedestrians) or whether they were DOA (Mortuary Pedestrians). Two hundred and twenty-seven pedestrians were included (196 Hospital Pedestrians and 31 Mortuary Pedestrians).

All pedestrians were also classified according to their BAC level. There were 141 pedestrians who had BAC levels $\geq$0.01 g/100ml and they were classified as BAC positive (BAC+ve). The 86 patients who had zero BAC levels, were classified as BAC negative (BAC-ve).

6.2 ALCOHOL INTOXICATION

Blood Alcohol Concentration was assessed in all 227 pedestrians. Of these, 141 patients (62.1%) were BAC+ve. Only 2.6% had BAC levels between 0.01 and 0.07 g/100ml, while 59.5% were at or above the legal limit for drivers ($\geq$0.08 g/100ml). Forty-one percent of pedestrians had BAC levels at least twice the legal limit for drivers (Figure 6.1).

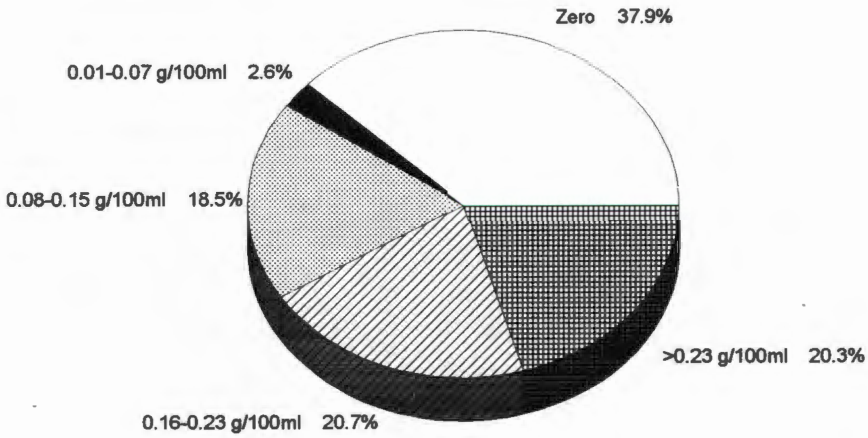


Figure 6.1 : BAC levels for all pedestrians (N=227)

Overall, there was not a statistically significant difference between the two injury categories in terms of the proportion of patients who were BAC+ve, viz. 67.7% of Mortuary Pedestrians versus 61.2% of Hospital Pedestrians (z=0.69, P>0.05). However, within BAC groups there were more Mortuary Pedestrians who had BAC levels over 0.23 g/100ml, viz. 32.2% versus 18.4% (Table 6.1). This result was, however, not statistically significant, probably because of the small sample of Mortuary Pedestrians, but it has clinical significance.

Table 6.1 : BAC levels by injury category (N=227)

BAC levels (g/100ml)	Hospital Pedestrians* n (%)	Mortuary Pedestrians# n (%)
0	76 (38.8)	10 (32.3)
0.01 - 0.07	5 (2.5)	1 (3.2)
0.08 - 0.15	36 (18.4)	6 (19.4)
0.16 - 0.23	43 (18.9)	4 (12.9)
0.24+	36 (18.4)	10 (32.2)

$X^2 = 0.25$ P = 0.62

* 10 of the Hospital Pedestrians died while in Trauma Unit or the Wards

\# the 31 Mortuary Pedestrians all represent prehospital deaths.
Altogether there were 41 deaths

The mean BAC for all 227 patients tested was 0.12 g/100ml (±0.11), with a range of 0-0.39 g/100ml. For BAC+ve pedestrians only (n=141), the mean BAC was 0.19 g/100ml (±0.08), with a range of 0.03-0.39 g/100ml. There was no significant difference in mean BAC for the two injury categories (Table 6.2).

Table 6.2 : Mean BAC results by injury category (N=227)

BAC (g/100ml)	Hospital Pedestrians	Mortuary Pedestrians
Mean	0.12	0.15
Median	0.11	0.14
Range	0 - 0.36	0 - 0.39
Standard deviation	±0.11	±0.13

6.3 GENDER

Males accounted for exactly 70% of all the pedestrians injured. This 2.3:1 male to female ratio is marginally, but not significantly, higher than the usual two-third male majority seen in other types of trauma.

This male preponderance was slightly higher in Mortuary Pedestrians (74.2%) than Hospital pedestrians (69.4%), but this difference did not reach statistical significance.

Males were twice as likely to be BAC+ve than females ($P<0.05$) (Table 6.3). It was interesting to note that exactly half of the females included in the study were BAC+ve, which is a higher proportion than is usually reported in the literature.

Table 6.3 : Gender by BAC (N=227)

Gender	BAC+ve Pedestrians n (%)	BAC-ve Pedestrians n (%)
Males	107 (67.3)	52 (32.7)
Females	34 (50.0)	34 (50.0)

$X^2 = 5.34$ P = 0.02 Odds Ratio = 2.06 95%CI = 1.1 and 3.8

Overall, males had significantly higher mean BAC levels than females, viz. 0.13 g/100ml (±0.11) versus 0.10 g/100ml (±0.11), respectively (T=1.9, P=0.05). However, in BAC+ve pedestrians only, females and males had almost the same mean BAC levels. In fact, females had slightly higher levels, viz. 0.20 g/100ml versus 0.19 g/100ml, respectively.

6.4 AGE

The youngest pedestrian included in the study was 13 years old, while the oldest was 77 years (Figure 6.2). The mean age for all patients was 35.9 years (±13.4), however, the median age of 33 years is probably a more reliable measure since the distribution is markedly skewed because children under the age of 13 years where excluded from the study (see 5.3.1, p72).

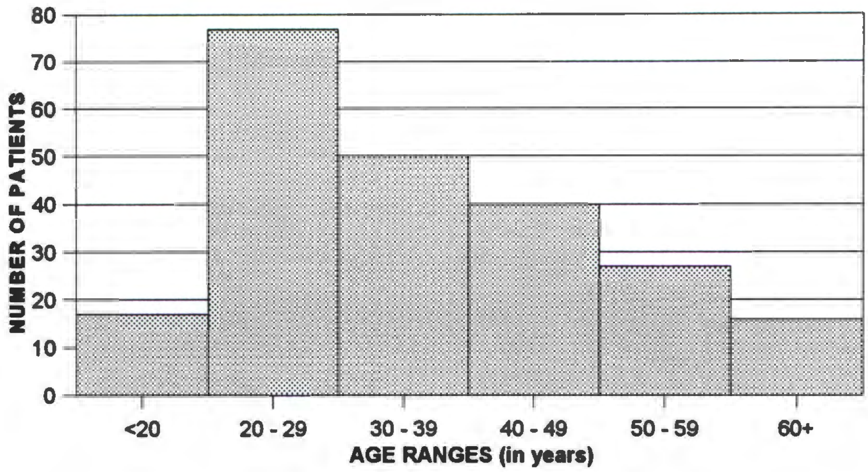


Figure 6.2 : Age distribution of all pedestrians (N=227)

Young adults, aged 20 - 29, appeared to be most at risk for pedestrian collisions since they accounted for almost one-third of all pedestrian injuries. There were no statistically significant differences in age ranges for Hospital and Mortuary pedestrians but almost one-third of geriatric patients (≥60 years) died in the pre-hospital phase (Table 6.4).

Table 6.4 : Age by injury category (N=227)

Age (in years)	Hospital Pedestrians n (%)	Mortuary Pedestrians n (%)
< 20	16 (94.1)	1 (5.9)
20 - 29	68 (89.6)	9 (10.4)
30 - 39	46 (92.0)	4 (8.0)
40 - 49	35 (87.5)	5 (12.5)
50 - 59	20 (74.1)	7 (25.9)
60+	11 (64.7)	5 (31.3)

$X^2 = 10.2$ $P = 0.07$

Overall, Mortuary pedestrians were slightly older than Hospital pedestrians, viz. 41.8 (±15.8) versus 35.0 (±12.8) years, respectively, but this did not reach statistical significance (P=0.08).

The youngest BAC+ve patient was 16 years old, while the oldest was 77 years old. Overall, just over one-third of BAC+ve pedestrians were in the 20-29 year age group and two-thirds of all the pedestrians aged between 20 and 49 years were BAC+ve. More than three-quarters of pedestrians aged between 30 and 39 years were BAC positive. There was a statistically significant trend, i.e. younger pedestrians were more likely to be BAC positive.

Table 6.5 : Age by BAC (N=227)

Age (in years)	BAC+ve Pedestrians n (%)	BAC-ve Pedestrians n (%)
< 20	5 (29.4)	12 (70.6)
20 - 29	52 (67.5)	25 (32.5)
30 - 39	38 (76.0)	12 (24.0)
40 - 49	25 (62.5)	15 (37.5)
50 - 59	12 (70.6)	15 (29.4)
60+	9 (56.3)	7 (43.7)

$\chi 2 = 16.6$ P = 0.005

There were significant differences in mean BAC levels for the six age ranges (F=3.93, P=0.002) (Table 6.6). Thirty to thirty-nine year olds had the highest mean BAC while pedestrians less than 20 years of age had the lowest mean BAC.

Table 6.6 : Age by mean BAC (N=227)

Age (in years)	Mean BAC (g/100ml)	Range (g/100ml)
< 20	0.04	0 - 0.20
20 - 29	0.13	0 - 0.33
30 - 39	0.15	0 - 0.39
40 - 49	0.15	0 - 0.39
50 - 59	0.07	0 - 0.26
60+	0.11	0 - 0.36

F = 3.93 P = 0.002

There was no statistically significant difference in age for gender, i.e. females were an average of 35.0 (±12.0) years old, while males were an average of 36.3 (±14.0) years. However, almost two-thirds of the patients in each of the age ranges were males, except for the geriatric group (60+ years) where 94% were males (Table 6.7). This last result is surprising since, according to the 1991 Census data, the majority of the geriatric population in Cape Town are female.

Table 6.7 : Age by gender (N=227)

Age (in years)	Males n (%)	Females n (%)
< 20	13 (76.5)	4 (23.5)
20 - 29	52 (67.5)	25 (32.5)
30 - 39	35 (70.0)	15 (30.0)
40 - 49	28 (70.0)	12 (30.0)
50 - 59	16 (59.3)	11 (40.7)
60+	15 (93.8)	1 (6.2)

$\chi 2$ = 6.3 P = 0.27

6.5 POPULATION GROUP

The population distribution of patients included in this study was blacks (46.7%), coloureds (50.7%) and whites (2.6%). However, the population profile for Cape Town (according to the 1991 Population Census) is 47.9% coloured, 27.9% black, 24.2% white and less than 0.01% Asian. There was thus an over-representation of black pedestrians and an under-representation of whites in the study. This could be due to the fact that GSH drains predominantly black areas like Khayelitsha, Langa and Guguletu, that many white pedestrians attend private facilities or have less exposure to vehicle traffic as pedestrians. It is also possible that the census data was inaccurate, particularly for the black population in Cape Town, since there is a heavy urbanisation influx. However, other studies conducted in South Africa have also found that black people are more at risk for pedestrian collisions, so the results obtained in this study could be a true reflection.

White pedestrians in this study were, however, more likely to die in the pre-hospital phase ($P<0.05$) than either of the other two groups (Table 6.8).

Table 6.8 : Population group by injury category (N=227)

Population group	Hospital Pedestrians n (%)	Mortuary Pedestrians n (%)
Black	90 (45.9)	16 (51.6)
Coloured	103 (52.6)	12 (38.7)
White	3 (1.5)	3 (9.7)

$X^2 = 7.92$ $P = 0.02$

Sixty-six percent of coloured pedestrians and just less than 60% of black pedestrians were BAC+ve at the time of their collision but this difference was not statistically significant. There were also no statistically significant differences in mean BAC for the three population groups.

Most of the black and coloured pedestrians were between the ages of 20 and 39 years, i.e. the economically active age groups (Table 6.9).

Table 6.9 : Population group by age (N=227)

Age (in years)	Black n (%)	Coloured n (%)	White n (%)
13 - 19	9 (8.5)	8 (6.9)	-
20 - 29	30 (28.3)	46 (40.0)	1 (16.7)
30 - 39	24 (22.6)	26 (22.6)	-
40 - 49	21 (19.8)	18 (15.7)	1 (16.7)
50 - 59	14 (13.2)	13 (11.3)	-
60+	8 (7.6)	4 (3.5)	4 (66.6)

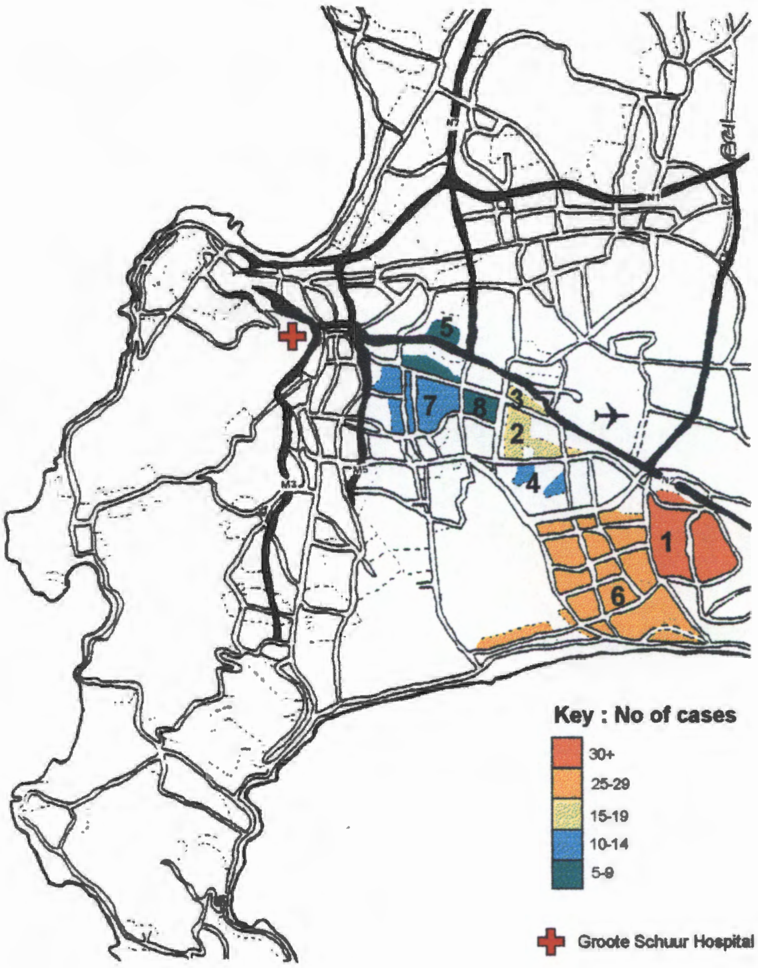
6.6 SOCIO-ECONOMIC STATUS

In assessing socio-economic status the place of residence, occupation and income of patients were used as a proxy. More sophisticated methods are available but due to the severity of injuries many pedestrians were unable to supply adequate information. Understandably, the socio-economic status of Mortuary pedestrians was largely unobtainable.

6.6.1 PLACE OF RESIDENCE

The place of residence for the injured pedestrians included in the study was scattered throughout the Cape metropolitan area (Figure 6.3) and was not confined to the GSH drainage area (see map on p76). A small proportion of injured pedestrians lived in areas outside the Cape Metropolitan area, e.g. Stellenbosch or Paarl. These latter patients were taken to GSH because they were injured in Cape Town.

As can be seen from Figure 6.3, almost half of the pedestrians included in the study lived in 'informal settlements', viz. Khayelitsha (15.4%), Nyanga/Crossroads (8.1%), Guguletu (7.9%), Philippi/Brown's Farm (5.3%) and Langa (3.5%). A further 1.7% had no fixed abode. There were also significant numbers of pedestrians who lived in suburbs such as Mitchells Plain (12.3%), Athlone (4.4%), Hanover Park (4.0%) and Bonteheuwel (3.5%).



Key: Suburbs

1	Khayelitsha	2	Nyanga/Crossroad s	3	Guguletu
4	Philippi	5	Langa	6	Mitchells Plain
7	Athlone	8	Hanover Park		

Figure 6.3 : Map indicating place of residence of pedestrians

6.6.2 OCCUPATION

Only 34% of injured pedestrians were unemployed at the time of their collision. Forty-three percent were employed, while scholars and pensioners made up another 10%. The occupational status was not known in a number of patients since it is not routinely documented at post-mortem (Figure 6.4). How long patients had been unemployed or the differentiation between 'never worked' and 'temporarily unemployed' was not included in the database, nor was the exact type of occupation.

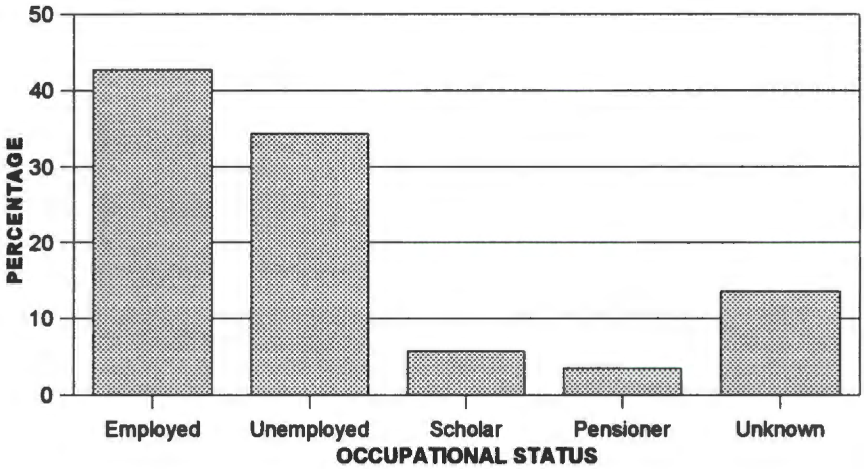


Figure 6.4 : Occupational status of all pedestrians (N=227)

Hospital pedestrians were no more likely to be employed than Mortuary pedestrians, viz. 43.3% versus 38.7%, respectively (Table 6.10). Although there were only eight pensioners included in the sample, more than one-third died in the pre-hospital phase. This latter result was not statistically significant but it has significant clinical implications.

Table 6.10 : Occupational status by injury category (N=227)

Occupational Status	Hospital Pedestrians n (%)	Mortuary Pedestrians n (%)
Employed	85 (87.6)	12 (12.4)
Unemployed	69 (88.5)	9 (11.5)
Pensioner	5 (62.5)	3 (37.5)
Scholar	11 (84.6)	2 (15.4)
Unknown	26 (83.9)	5 (16.1)

There was no significant difference between the proportion of employed and unemployed pedestrians who were BAC +ve at the time of their collision (Table 6.11). But it was disturbing to note that more than one-quarter of scholars injured in pedestrian traffic trauma were intoxicated at the time of their injury.

Table 6.11 : Occupational status by BAC (N=227)

Occupational Status	BAC+ve Pedestrians n (%)	BAC-ve Pedestrians n (%)
Employed	57 (58.8)	40 (41.2)
Unemployed	52 (66.7)	26 (33.3)
Pensioner	4 (50.0)	4 (50.0)
Scholar	4 (30.8)	9 (69.2)
Unknown	24 (77.4)	7 (22.6)

6.6.3 INCOME

Information regarding income was only obtained from 88 of the employed pedestrians who arrived alive at hospital. The mean income for these employed pedestrians was R745 per month (±R1028). The range was R100 to R8 000, but the distribution was markedly skewed - the median of R510 is therefore probably more representative of employed patients. It should be noted that for the majority of pedestrians data regarding income was not gathered directly from the patient but from their hospital folders. This data may consequently have been out-dated or not particularly reliable. No reliable data on income could be obtained from the mortuary records for those pedestrians who had died before reaching hospital.

6.7 WHERE PEDESTRIAN COLLISIONS OCCURRED

6.7.1 TYPE OF ROAD WHERE COLLISION OCCURRED

Large numbers of pedestrians were injured or killed on busy roads or highways (where speed limits were $\geq$80 km/hr), usually while crossing the road at an undesignated point, i.e. jaywalking. Thirty-five pedestrians were injured at an intersection while 138 were injured while crossing the road 'elsewhere'. A further 28 injuries took place in 'informal settlements' where there are no formal roads. There was no significant difference between Hospital and Mortuary patients with regard to where they were injured (Table 6.12). However, proportionally more pedestrians were killed instantly while crossing the road 'elsewhere' than were injured non-fatally (71% versus 62.4%, respectively) but this was also not statistically significant.

Table 6.12 : Place of injury by injury category (n=217)

Place of Injury	Hospital Pedestrians* n (%)	Mortuary Pedestrians n (%)
At an intersection	29 (15.6)	6 (19.4)
Crossing road, not at intersection	116 (62.4)	22 (71.0)
Suburb known, but road unknown	15 (8.1)	1 (3.2)
'Informal settlement', no formal roads	26 (13.9)	2 (6.4)

* Unknown in 10 patients

There was no relationship between the type of road where pedestrians were injured and whether they were BAC positive or not.

6.7.2 ROAD WHERE COLLISION OCCURRED

The actual road where the collision took place was only known in 76.2% of cases. Table 6.13 indicates the roads where many pedestrian collisions occurred. It was notable that more than 60% of all collisions occurred on these 16 roads in Cape Town. The highest number of collisions occurred on Lansdowne Road (18), followed by the N2 highway (15). The three major highways, i.e. the N2, the N1 and Vanguard Drive accounted for 24 collisions or 13.9% of all collisions. Koeberg Road had a very high instant mortality rate, i.e. two out of three pedestrians died before reaching hospital. Main Road (from Cape Town to Muizenberg) and Lansdowne Road also had very high mortality rates, but both these roads are very long and traverse many suburbs.

Table 6.13 : Roads on which many pedestrian collisions occurred

Road Where Collision Occurred	Hospital Pedestrians n	Mortuary Pedestrians n
Lansdowne Rd	12	6
The N2	12	3
The N1	1	0
Klipfontein Rd	10	2
Main Rd (Cape Town to Muizenberg)	5	3
Duinefontein Rd	10	0
Vanguard Dr	8	0
Morgenster Rd	4	1
NY1	5	0
NY3A	5	0
Voortrekker Rd	3	0
Terminus Rd	3	0
NY108	3	0
Koeberg Rd	1	2
Durban Rd	3	0
Station Rd (Observatory)	3	1

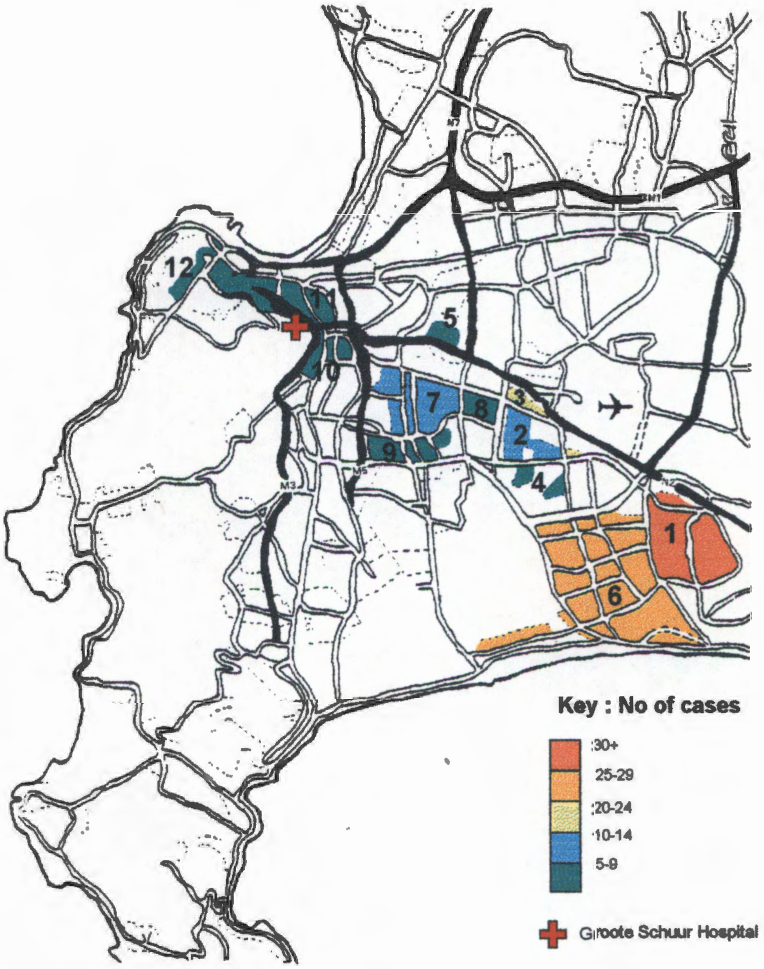
Many of the roads indicated in Table 6.13 have speed limits of ≥80 km/hr, while on those that have speed limits of 60 km/hr, speeding often occurs. All the roads indicated in the table carry high volumes of traffic.

More than one-third of the pedestrians injured or killed on the above 'high flow' roads were between 20 and 29 years old. Two-thirds were male and there were equal numbers of coloured and black pedestrians.

Pedestrians who were injured on these 'high flow' roads were no more likely to be BAC positive than those injured on other roads. In fact, quite the opposite was found, viz. pedestrians involved in collisions on 'light flow' roads were twice as likely to be alcohol positive (χ^2=7.6, P=0.006, OR 2.2, 95% CI 1.2 to 4.0).

6.7.3 SUBURB WHERE COLLISION OCCURRED

A definite pattern emerged when the suburbs in which the collisions took place were analysed. Figure 6.5 indicates that the highest number of collisions occurred in Khayelitsha (30), followed by Mitchells Plain (27) and Guguletu (24). The frequency of pedestrian collisions in 'informal settlements' is particularly striking. This map also shows the long distances that patients were transported from the site of their collision to GSH.



Key: Suburbs

1	Khayelitsha	2	Nyanga/Crossroads	3	Guguletu
4	Philippi	5	Langa	6	Mitchells Plain
7	Athlone	8	Hanover Park	9	Landsdowne
10	Mowbray, Observatory	11	Woodstock, Salt River	12	City Bowl
1 + 2 + 4 + 5 = 'informal settlements'					

Figure 6.5: Map indicating the suburbs where numerous pedestrian collisions occurred.

Patients who were injured in 'informal settlements' were no more likely to be BAC positive than those who were injured elsewhere. Furthermore, they did not have higher mean BAC levels. It was significant that 73% of these pedestrians were male and that 95.1% were black ($P<0.05$).

There were less pedestrian collisions in 'informal settlements' during the dark than in other places (57.9% versus 70.0%, respectively) but this did not reach statistical significance. However, pedestrians were twice as likely to be injured in an 'informal settlement' on a Saturday night than pedestrians in other areas (χ^2=5.2, P=0.023, OR=2.0, 95%CI = 1.1 to 3.8).

6.8 WHEN PEDESTRIAN COLLISIONS TOOK PLACE

6.8.1 TIME OF COLLISION

The majority (65.5%) of pedestrians were injured between sunset and sunrise. However, almost half of these pedestrians were injured between 18h00 and 24h00. The well known transient increase in collisions an hour after sunset[1] (when pedestrian conspicuity is poor and the road lighting insufficient) was apparent in this study (Figure 6.6). Another small peak is evident at approximately 10h00 in the morning.

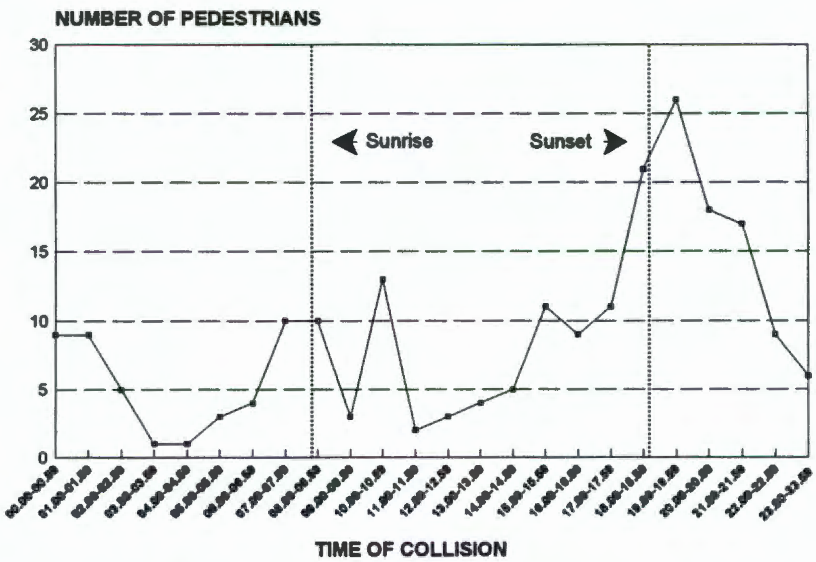


Figure 6.6 : Time of collision for all pedestrians (n=206)

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1 According to the DF Malan Weather Office the average time of sunset, for the nine weeks in 1993 during which this study was conducted, was 18h01 and sunrise was 07h40 (personal communication, P. Mulder, 8 November 1994).

From Table 6.14 it is apparent that proportionally more Mortuary pedestrians compared to Hospital pedestrians were injured in the dark (74% versus 65%, respectively). Although this result was not statistically significant it is important in terms of service planning.

Table 6.14: Time of collision by injury category (n=206)

Time*	Hospital Pedestrians n (%)	Mortuary Pedestrians n (%)
Dark (18h00-07h59)	113 (64.6)	26 (74.3)
Light (08h00-16h59)	62 (35.4)	9 (25.7)

$\chi 2 = 0.24$ $P = 0.36$ * Time not known for 21 patients

When looking at alcohol levels, significantly more BAC+ve pedestrians were involved in collisions in the dark (Table 6.15). Furthermore, the mean BAC of patients injured in the dark was significantly higher than those injured during the daylight hours, i.e. 0.15 g/100ml versus 0.06 g/100ml, respectively (T=6.5, P=0.0001).

Table 6.15: Time of collision by BAC (n=206)

Time*	BAC+ve Pedestrians n (%)	BAC-ve Pedestrians n (%)
Dark (18h00-07h59)	104 (82.5)	31 (38.8)
Light (08h00-16h59)	22 (17.5)	49 (61.2)

$\chi 2 = 39.6$ $P < 0.0001$ * Time not known for 21 patients

6.8.2 DAY OF COLLISION

Nearly 50% of all collisions took place on a Saturday or Sunday (Figure 6.7), but Saturdays had a particularly high incidence. A slight and unexpected peak was also found on Wednesdays.

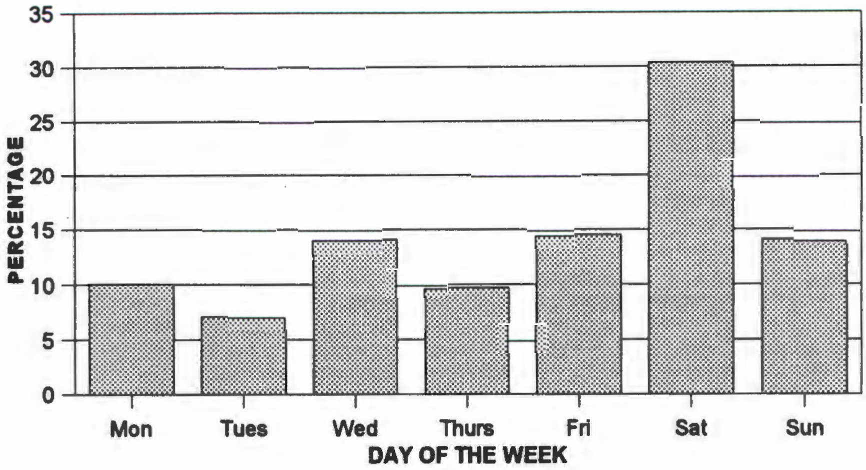

Figure 6.7 : Day of collision for all pedestrians (N=227)

Injured pedestrians had a proportionally higher risk of sustaining fatal injuries if injured on Saturdays than if they were injured on any other day of the week, viz. 38.7% of the pedestrians injured on Saturdays died of their injuries in the pre-hospital phase. Although these results are not statistically significant, they remain important with regard to service planning.

A clinically not unexpected, but highly significant trend ($\chi 2=41.7$, $P<0.0001$), was noted between BAC and day of the week (Table 6.16). Further analysis of this data revealed that pedestrians injured over the weekend[2] were nearly six times as likely to be BAC +ve than those pedestrians whose collisions took place during the rest of the week ($\chi 2=34.3$, OR=5.7, 95%CI=3.03 to 10.8,$P<0.0001$).

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2 Weekend refers to 17h00 on a Friday afternoon until 07h59 on a Monday morning.

Table 6.16: Day of collision by BAC (N=227)

Day	BAC+ve Pedestrians n (%)	BAC-ve Pedestrians n (%)
Monday	11 (47.8)	12 (52.2)
Tuesday	10 (62.5)	6 (37.5)
Wednesday	9 (28.1)	23 (71.9)
Thursday	12 (54.6)	10 (45.4)
Friday	16 (48.5)	17 (51.5)
Saturday	61 (88.4)	8 (11.6)
Sunday	22 (68.8)	10 (31.2)

$\chi 2 = 41.7$ $P < 0.0001$

With regard to the day of the week and time of the collision, it was found that a Saturday night was the worst time for pedestrian collisions. Strikingly also, 92% of pedestrians injured on Saturday nights were BAC positive (Table 6.17). Although all the patients injured on Tuesday nights were BAC positive, this was not significant because of the small numbers involved.

Table 6.17: Day and time* of collision by BAC (n=206)

Day	DARK (18h00-07h59)		LIGHT (08h00-17h59)	
	BAC+ve Peds n (%)	BAC-ve Peds n(%)	BAC+ve Peds n(%)	BAC-ve Peds n(%)
Monday	7 (53.8)	6 (46.2)	6 (54.5)	5 (45.5)
Tuesday	8 (100.0)	0	4(44.4)	5 (55.6)
Wednesday	6 (46.2)	7 (53.8)	1 (16.7)	5 (83.3)
Thursday	9 (69.2)	4 (30.8)	2 (11.8)	15 (88.2)
Friday	14 (73.7)	5 (26.3)	0	6 (100.0)
Saturday	46 (92.0)	4 (8.0)	2 (16.7)	10 (83.3)
Sunday	14 (73.7)	5 (26.3)	3 (30.0)	7 (70.0)

* Time of collision not known for 21 pedestrians

6.8.3 WEATHER CONDITIONS

Although the study was conducted in winter, a notoriously wet season in Cape Town, the weather did not appear to play a role in whether pedestrians lived or died as a result of their injury. In fact, the data indicates that pedestrians were five times more likely to die in the pre-hospital phase when they were injured when the weather was fine (Table 6.18).

Table 6.18: Weather conditions by injury category (N=227)

Weather	Hospital Pedestrians n (%)	Mortuary Pedestrians n (%)
Fine	126 (64.3)	28 (90.3)
Wet	70 (35.7)	3 (9.7)

$\chi 2 = 7.2$ P = 0.007 OR = 5.2 95%CI = 1.4 and 17.3

There was no statistically significant association between the weather condition and alcohol intoxication.

6.9 TYPE OF VEHICLE INVOLVED IN COLLISIONS

Motor cars were most commonly involved (60.4%) in these pedestrian-vehicle collisions (Figure 6.8). Since motor cars are the most frequent vehicle on Cape Town roads, this was to be expected. However, the second largest vehicle group involved in these collisions were minibus taxis (11%) and many of these pedestrians were injured while getting onto or off these taxis.

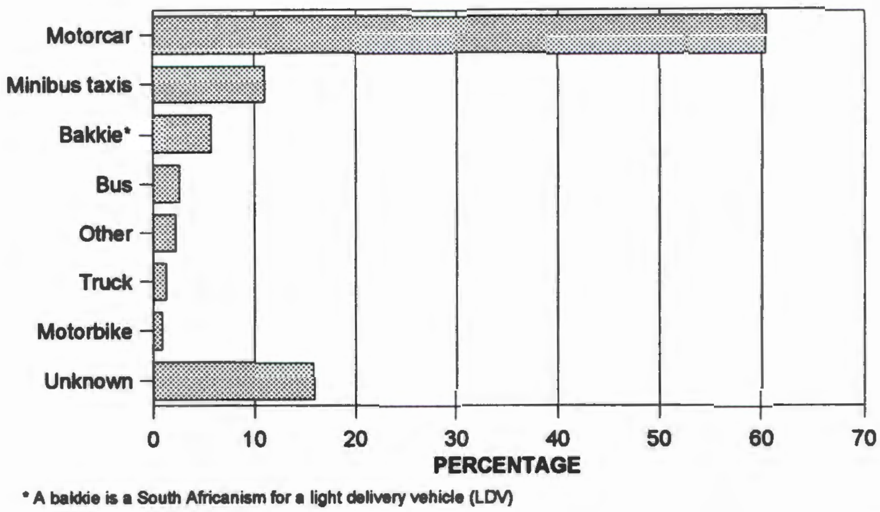

Figure 6.8 : Type of vehicle involved in collision (N=227)

There was no association between the type of vehicle involved in the collision and whether the patient lived or died. There were also no associations between the type of vehicle and the weather conditions, time of the day or day of the week. Unfortunately the speed of the vehicle involved in the collision was not ascertained in this study.

There was no statistical association between alcohol intoxication and the type of vehicle involved in the collision, except that less pedestrians (40%) who were injured by taxis were BAC positive.

6.10 DISCUSSION

A very high proportion of the 227 pedestrians in this study were found to be BAC positive and more than 40% had BAC levels at least twice that of the legal limit for drivers. This is considerably higher than the results obtained in most developed countries (see Ch 3, p 28) but is thought to be similar to other African countries although reliable comparative data is not readily available.

There was no significant difference between the mean BAC for Hospital and Mortuary pedestrians but considerably more pedestrians who died before reaching hospital had BAC levels at or over 0.24 g/100ml. This confirms the findings of Dischinger, Soderstrom, Shankar et al. (1988) and P.F. Waller et al. (1986) indicating that traffic crash victims who were severely intoxicated were more likely to die at the scene of the injury.

6.10.1 PRECRASH HOST FACTORS

6.10.1.1 Gender

Two-thirds of the injured pedestrians in this study were males, which is no different from what was found in most of the studies reviewed. Similarly, males in this study were at least twice as likely as females to be BAC positive at the time of their collision as is the case elsewhere (Bradbury, 1991; Jehle & Cottington, 1988). What, to the author's knowledge, has not previously been described in the literature was that, although there were considerably fewer women who were BAC positive at the time of their collision, those who were intoxicated had BAC levels slightly higher than their BAC positive male counterparts.

The consistent pattern of pedestrian injuries to young males from country to country cannot be explained by alcohol consumption alone. It strongly suggests that there is a biological (Honkanen, Koivumaa-Honkanen & Smith, 1990) or behavioural factor involved which needs further exploration .

6.10.1.2 Age

This study only showed one significant peak in age distribution, viz. between 20 and 29 years. This is similar to the results obtained in other African countries such as Nigeria (Siddique & Abengowe, 1979) and Ethiopia (Dessie & Larson, 1991). The biphasic age distribution in adults, viz. peaks at 20 years and 50-60 years which has been described in many studies (Haddon et al., 1961; Hall & Fisher, 1972; Lane et al., 1994) was not found in this study. In fact, there were surprisingly few elderly pedestrians.

What was interesting about the group of pedestrians ≥60 years old in this study was that they were predominantly male despite the preponderance of females in the geriatric population of Cape Town. Although many international studies have found females to be more commonly involved in pedestrian collisions in this age group (Teanby, Gorman & Boot, 1993b; Vestrup & Reid, 1989), Hill, Delaney & Duflou (1996) also recorded elderly males to be at greater risk.

Geriatric pedestrians in this study were more likely to die in the pre-hospital phase, concurring with the literature which states that the risk of mortality increases with age (Brainard et al., 1989; Hall & Fisher, 1972; Lane et al., 1994). What was different from other studies was that the geriatric pedestrians were just as likely as younger ones to be intoxicated at the time of their collision - this possibly relates to the higher incidence of males in this sub-group which is unusual in other studies.

The high incidence of pedestrian collisions in the 20 to 29 year age group was not associated with higher BAC levels, as was found by Bradbury (1991). In this study, 30 to 39 year old pedestrians were the most likely to be BAC positive at the time of their collision and they also had the highest mean BAC levels.

6.10.1.3 Population group

There were slightly more coloured pedestrians than black pedestrians in this study but when one takes into consideration the population proportions in Cape Town it was evident that there was an over-representation of black people in the sample. This could be because GSH drains many of the primarily black areas in Cape Town or it may confirm previous South African literature indicating black people to be at higher risk of pedestrian collisions than any of the other population groups (Directorate of Traffic Safety, 1990b; McCabe, 1982; Ribbens, 1989).

This study allows few inferences to be drawn about white pedestrians as the sample size for this sub-group was too small. This does not mean that white people do not get injured as pedestrians but rather that they attend non-State facilities.

6.10.1.4 Socio-economic status

The majority of pedestrians came from lower socio-economic backgrounds but this must be seen with reference to GSH being a State hospital, i.e. it sees predominantly indigent patients. Other studies have also indicated that trauma in general is more prevalent in low-income areas, regardless of population group or ethnicity (Baker, 1987). More specifically, it has also been found that poor urban communities have higher rates of pedestrian injuries, possibly related to the higher population densities in such areas (Graham, 1993) .

Nearly half of all the pedestrians in this study lived in 'informal settlements' such as Khayelitsha and Langa. These pedestrians were no more likely to be BAC positive at the time of their collisions than those who lived in other areas, despite the finding that alcohol misuse is particularly common in these peri-urban communities (Rocha-Silva, 1994).

It was interesting to note that there were almost equal numbers of unemployed and employed injured pedestrians. Furthermore, the unemployed pedestrians were no more likely to be BAC positive than their employed counterparts, which questions the hypothesis that unemployed people in South Africa tend to drink more.

It was disturbing to note the high proportion of scholars who were BAC positive at the time of their collision. These results confirm those of Flisher et al (1993a) who found that alcohol misuse, and binge drinking in particular, is problematic among high school students in the Cape Peninsula.

6.10.2 PRECRASH AGENT FACTORS

6.10.2.1 Vehicle involved

As is found in most studies, motorcars were most commonly involved in these pedestrian collisions (Atkins et al., 1988; Galloway & Patel, 1988; Teanby et al., 1993; Vestrup & Reid, 1989). There was, however, a notable proportion of pedestrians who were injured by minibus taxis. The minibus taxi is a common form of public commuter transportation in South Africa and a means of income generation for many. Many of these taxis are driven by unlicensed, reckless drivers who pay little attention to the laws of the road (Directorate of Traffic Safety, 1995). According to Mr Bodinnar, Traffic Chief of Victoria, Australia, travelling in a South African minibus taxi was "a scary experience" (Du Plessis, 1996:10).

What was most disturbing to note about taxi-related pedestrian injuries was that many patients were injured while getting onto or off a taxi. A personal observation made by the author, subsequent to the completion of this study, was that many minibus taxis do not come to a complete stop when passengers disembark and some taxi drivers start driving off before all the passengers have boarded properly and the door had been closed. These taxi-related collisions are a growing concern in South Africa and need to be addressed urgently.

Roads with a high volumes of traffic and speed limits greater than 80 km/hr, e.g. the N2 highway, Vanguard Drive, etc. were common sites for pedestrian collisions. These roads had very high mortality rates despite the fact that fewer than average pedestrians were intoxicated at the time of their collision. This highlights speed as a major determinant of the severity and outcome of pedestrian collisions (Lerer, 1992a, Zivot & Di Maio, 1993) and also explains the higher ratio of deaths to injuries on these roads (Baker et al., 1992). Unfortunately, although it is illegal to cross these types of roads in South Africa, jaywalking is not seen as a priority infringement and the law is therefore not enforced.

6.10.2.2 Weather conditions

This study showed that there was no relationship between weather conditions and the risk of pedestrian collision despite the study being conducted in winter. This has also been found in many other pedestrian studies (Atkins et al., 1988; Haddon et al., 1961; Teanby et al., 1993; Vestrup & Reid, 1989), although some authors do suggest that this is because fewer pedestrians walk in inclement weather and therefore the risk of collision is lower.

6.10.3 PRECRASH ENVIRONMENTAL FACTORS

6.10.3.1 Road where collision occurred

The majority of pedestrians were injured while crossing roads at undesignated areas, which is the same pattern as is seen in other developing countries such as Saudi Arabia (Jadaan & Bener, 1993), Nigeria (Balogun & Abereoje, 1992) and Ethiopia (Dessie & Larson, 1991). Unlike in developed countries (Baker et al., 1992) very few pedestrians are injured at intersections or pedestrian crossings.

6.10.3.2 Suburb where collision occurred

A significant proportion of pedestrian collisions occurred in 'informal settlements' where there are no formal road structures. As has been mentioned previously, these pedestrians were no more likely to be intoxicated than those who were injured in other areas, nor were the collisions more likely to occur in the dark. In fact, the majority of such collisions occurred during day light hours. These collisions can thus not be attributed to the lack of lighting nor to a higher incidence of alcohol abuse in these areas. The frequency of such collisions is possibly due to the poor road construction, poor education of the communities with regard to basic road safety and the lack of pedestrian sidewalks which forces people to walk on the roads and thereby greatly increases their collision risk.

6.10.3.3 Time of collision

The majority of all pedestrian collisions occurred at night (or in the dark) and significantly more of these collisions were alcohol-related. Furthermore, a personal observation made by the author was that the majority of these injured pedestrians were also wearing dark clothing at the time of their collision, thereby compounding their poor conspicuity.

The classic transient increase in collisions an hour after sunset was also evident in this study, confirming results found by other researchers and suggesting that pedestrian conspicuity at dusk is particularly critical (Baker et al. 1992). It may, however, also represent the time of maximal pedestrian exposure.

6.10.3.4 Day of collision

A very high proportion of pedestrian collisions occurred on a Saturday or over the weekend. The alcohol-relatedness of these collisions was also higher than for other days of the week - in fact, nearly 90% of pedestrians injured or killed on a Saturday had positive BAC levels. This, however, is probably also be related to the fact that more people drink alcohol at weekends. Most studies conducted in developed countries have found that pedestrian collisions are fairly evenly spaced throughout the week (Atkins et al., 1988; Haddon et al., 1961; Teanby et al., 1993) but these studies had a much lower incidence of alcohol intoxication than the present study.

There was an unexplained peak of collisions which occurred on Wednesdays. These were largely unrelated to alcohol, were evenly spread during the day and were not confined to either the elderly or to women, as has been found in some studies (Atkins et al., 1988; Galloway & Patel, 1988; Kliger & Sporty, 1993).

6.11 CHAPTER SUMMARY

This chapter has outlined the epidemiology of adult pedestrian traffic trauma as identified at one tertiary hospital in Cape Town.

The following chapter introduces the concept of injury severity scoring and discusses in depth the systems used in this thesis.

CHAPTER SEVEN

INJURY SCORING METHODS

"... it is possible to predict the behavior of populations, but individuals remain unpredictable" (Osler, 1993:50S).

7.1 INTRODUCTION

The purpose of this chapter is to introduce several of the injury scoring methods which are currently used in studies on motor vehicle trauma. It explains the advantages and limitations of some of the methods and introduces those which were used in this study to code injuries and quantify injury severity in adults involved in pedestrian collisions.

A number of methods for determining the injury severity of a trauma patient have been developed over the years, including scales, scores, indices and graphs. The methods devised have been based on the type and anatomical distribution of injuries, the physiological responses to injury or both. The last, i.e. those based on both parameters, have been said to be superior to single parameter scores (Boyd, Tolson & Copes, 1987), but this is dependent on what the scoring system is used for. In general, combination scores are essential when measuring outcome but single scores are excellent for triage purposes.

Table 7.1 lists some of the methods which have been used extensively. This list is by no means exhaustive. It rather indicates the historical development of some of the most frequently used scoring systems. Some of these systems will only be briefly discussed or alluded to in the text, while those which were used in this study will be examined more closely. The reasons for selecting these scoring methods for the present study were discussed in the methodology chapter.

Trauma scoring systems which have been adapted for children, such as the Modified Injury Severity Scale (MISS) and the Paediatric Trauma Score (PTS), will not be discussed at all, partly because the present study was conducted only on adults but also to limit this chapter.

Table 7.1 : Some trauma scoring systems in current use

	Year Published	Title
Anatomical Scores	1971	Abbreviated Injury Scale (AIS)*
	1972	Comprehensive Injury Scale (CRIS)
	1974	Injury Severity Score (ISS)*
	1980	Anatomic Index (AI)
	1980	Maximum AIS (MAIS)
	1990	Anatomic Profile
	1995	The new Injury Severity Score (NISS)*
Physiological Scores	1974	Glasgow Coma Scale (GCS)*
	1975	Respiratory Index (RI)
	1976	Clinical Assessment Research and Education (CARE)
	1980	Triage Index
	1981	Trauma Score (TS)
	1981	Global Score
	1981	Acute Physiology & Chronic Health Evaluation II
	1982	CRAMS Scale (CRAMS)
	1989	Revised Trauma Score (RTS)*
Combination Scores	1980	Triage Index
	1981	Trauma Score - Injury Severity Score (TRISS)*
	1983	preliminary Method (PRE)*
	1983	definitive Method (DEF)*
	1990	A Severity Characterization of Trauma (ASCOT)
	1994	The Injury Impairment Scale (IIS)*

* Used in present study

Although there are inherent problems and limitations in most of the trauma scoring methods developed to date, they are useful - not only to quantify the injury, to triage patients (both in the field and in hospital) and to predict outcome, but also to plan trauma services, evaluate trauma services and care, bill patients as well as for epidemiological and research purposes.

Various trauma scoring systems have been devised to address different situations and requirements and as such they should be used for the purpose for which they were devised. For instance, the ISS is an excellent triage tool but will perform poorly as a measure of outcome.

7.2 SCORES BASED ON ANATOMIC SITE

Injury research and the development of accurate and valid scoring methods has been complicated by the enormous number of possible injuries sustainable. Unlike a patient with cancer, who may have only a very limited number or types of cancer at one time, the number of possible injuries that a pedestrian may sustain is large (Osler, 1993).

7.2.1 THE ABBREVIATED INJURY SCALE

Almost 40 years ago De Haven started looking at an objective measurement for human injuries in relation to his research on light aeroplane crashes. This prompted physicians, engineers and researchers in the arena of motor vehicle crashes to start developing an injury description system. Under the joint sponsorships of the American Medical Association, the Association for the Advancement of Automotive Medicine and the Society of Automotive Engineers, the first edition of the Abbreviated Injury Scale (AIS) was published in 1971 (Joint Committee on Injury Scaling, 1990). This first publication of the AIS only included 73 (predominantly blunt) injuries. No comprehensive list of injuries was created at the time, nor was a single scoring method for multiple injuries devised. The first AIS dictionary, listing more than 500 injuries, was published in 1976 (ibid).

The AIS was primarily devised "to provide researchers with a simple numerical method for ranking and comparing injuries by severity, and to standardise the terminology used to describe injuries" (Joint Committee on Injury Scaling, 1990:2). The AIS describes injuries according to body region, type of anatomic structure involved, specific anatomic structure and level of injury, resulting in a six digit code. A seventh digit is assigned to the injury severity, viz. 1 = minor; 2 = moderate; 3 = severe, not life-threatening; 4 = severe, life-threatening, survival probable; 5 = critical, survival uncertain; and 6 = maximum, injury virtually unsurvivable (Copes, Lawnick, Champion et al., 1988a).

Early editions of the AIS did not include 6 as an option - it was only included in the 1976 revision of the AIS. The AIS 6 code was specified for application to injuries which would almost undoubtedly result in death, given the trauma facility (Baker & O'Neill, 1976).

There have been a total of six revisions to the AIS, viz. 1974, 1975, 1976, 1980, 1985, 1990. The 1985 version of the AIS included severity scores for penetrating trauma for the first time (Copes et al., 1988a).

The most recent version of the AIS, viz. AIS-90 has expanded the dictionary of injuries to more than 1300 and 'fine tuned' injury severity scores, particularly with regard to head injuries (Joint Committee on Injury Scaling, 1990).

The AIS has, however, still been found to have the following limitations:

- Not all types of injuries have been included in the dictionary. There are, for instance, 13 different femur fractures listed in the latest edition of the AIS, but no provision has been made for comminuted or open fractures (Osler, 1993).

- The AIS has been found to have great prognostic/outcome variability, depending on the body region injured. For instance, 95% of patients assigned a score of 5 for and injury in the neck region died versus only 29% of patients assigned a 5 for an injury in the abdomen (Osler, 1993).

- The AIS is not an interval scale, i.e. the increase in severity from AIS 1 to 2 is much less than the increase from AIS 3 to 4 or 4 to 5 (Copes, Champion, Sacco et al., 1988b). This aspect is often overlooked by many researchers, resulting in the incorrect calculation of a mean rather than a median as a measure of central tendency.

- Penetrating injuries were first included in the 1985 revision of the AIS. The manual, however, included a caution which read "these [penetrating injury] descriptions are not sufficiently detailed to satisfy sophisticated studies of penetrating injury, but they do offer a uniformity for coding these injuries and a means to acquire some experience using the AIS in these situations" (Joint Committee on Injury Scaling, 1985:2). The AIS-90 appears to have begun to address the problem of penetrating injury terminology but it still remains less than satisfactory in this aspect.

Despite these limitations, the AIS it is the most frequently and internationally used scoring method. It was not intended to address sophisticated studies. Its relative simplicity is its virtue.

In order to further simplify the use of the AIS for injury severity scoring, particularly in busy hospital situations, Civil & Schwab (1988; 1989) produced two small charts (one for blunt and the other for penetrating trauma). These charts, called the Condensed Abbreviated Injury Scaling (CAIS), allow for rapid, early injury scoring and may be included in the patient record.

The only other vocabulary available for the description of trauma is the International Classification of Disease codes (ICD). Although the ICD (9th edition) contains 2 062 trauma descriptions, it is not routinely or extensively used because the codes are based largely on organs rather than injuries. The ICD also does not make provision for injury severity coding and so it has to be used in conjunction with another injury severity index. Attempts have been made to translate the ICD codes into AIS descriptions but it was found that the two classifications are not sufficiently similar.

7.2.2 THE INJURY SEVERITY SCORE

Since most trauma patients sustain more than one anatomical injury it became obvious that a method of combining injury scores into a single score was necessary. Initially the patient's worst AIS severity score was used. This method became known as the maximum AIS (MAIS). This scoring method was, however, too simplistic because it did not take into account the influence of a second or third injury on mortality. It was therefore decided that it would be more accurate "to derive, in each case, a summary of injury severity that would adjust for variations in mortality associated with the number of body areas involved and the severity of trauma in each" (Baker, O'Neill, Haddon et al. 1974b:189-190). The result was the publication of the Injury Severity Score (ISS), which takes the highest AIS in the three most severely injured, but different, body regions, squares them and adds them together. The minimum ISS is 1 and the maximum is 75, i.e. $5^2 + 5^2 + 5^2$. If a patient is assigned a 6 in any region, the ISS automatically becomes 75. This method of describing multiple injuries was first published in 1974 (Baker et al., 1974b).

The ISS appeared to be a considerable improvement over the MAIS. Testing of this new scoring method revealed that the ISS explained 49% of the variance in mortality in comparison to only 25% for the previously used method of utilising the worst AIS or MAIS (Osler, 1993).

However, despite the fact that the ISS is a simple, user-friendly method of triaging patients with multiple trauma, it still has many limitations:

- The ISS only takes into account the worst injury in each body region (Copes, Champion, Sacco et al., 1990) and, as a result, tends to underscore. This is particularly problematic in penetrating trauma where injuries tend to be concentrated in one body region. Various other scores, such as the Penetrating Abdominal Trauma Index, have been devised in an attempt to address this problem. Bull & Dickson (1991) have suggested that an additional score of 1 be added to the highest AIS score if there is more than one injury in the same region in order to compensate for this limitation.

- Another problem is that "diverse injury combinations with distinct survival probabilities have the same or nearly the same ISS value" (Copes et al., 1990:1200). This is particularly problematic in patients with severe head injuries. For example, three moderately severe injuries (AIS3 + AIS3 + AIS3) may result in a higher ISS than a single potentially fatal head injury with an AIS of 5 (Bull & Dickson, 1991; Collopy, Tulloh, Rennie et al., 1992). Thus the ISS does not accommodate the true impact of a single severe head injury. In fact, it does not accommodate the true impact of any single, potentially fatal injury, e.g. a severely ruptured liver.

- The ISS can only be employed accurately once a definitive diagnosis is available, i.e. on discharge from the hospital or at postmortem because the "... calculation of ISS based on the Emergency Department record has been shown to be inaccurate" (Civil & Schwab, 1989; MacKenzie, Shapiro & Eastham, 1985). Despite this limitation, Civil & Schwab (1989:614) suggest that "... early computation of the ISS by the clinical team caring for the patient sets for them a measure of the magnitude of injury and establishes an environment with greater awareness of the complexity of the injuries" .

- Although it is evident that as the ISS increases mortality increases, the effects of age are not taken into account, i.e. older patients tend to die at lower injury severity scores. Bull (1975) examined the problem of the variance of death rates in different age groups and, using the ISS, derived the concept of the Lethal Dose_{50} (LD_{50}), i.e. an injury severity can be predicted that will be fatal for 50% of patients (in different age categories) injured in such a way.

- "... A significant mismatch between the ISS and patient resource requirements" has been identified by Baxt & Upenieks (1990:1400). Therefore "the use of the ISS as the single means by which to define major trauma may need re-evaluation because it does not fully encompass all the patients that trauma centers seek to treat" (ibid).

- ISS assignment appears to be subjective, which results in considerable observer variation (Zoltie & De Dombal, 1993). These authors found that there was up to 50% disagreement between observers, which leads them to suggest that "... severity case mix assessed by the injury severity score may be subject to too much observer variation to be reliable" (ibid:908).

- Furthermore, coding of injuries requires a sound medical knowledge and therefore accurate information can only be obtained by medically trained personnel.

Despite the limitations of the ISS, it is very useful for identifying different patient groups for study. Several researchers have used an ISS of > 16 when selecting patients with 'severe' injury (Civil & Schwab, 1989), but this cut-off point appears to have been arbitrarily selected. Collopy et al. (1992) conducted a study in Australia and suggested the following cut-off points for grouping patients, viz. 6 or less = minor; 6-13 = moderate; 14 -20 = severe; and ≥21 = critical. Copes et al. (1988b) proposed a set of ISS value intervals which reduce heterogeneity between ISS cohorts and which have been extensively used in the literature. These values are 1-8, 9-15, 16-24, 25-40, 41-49, 50-66 and 75 and correspond to combinations of AIS ratings. These groupings will be used throughout the results section of this thesis.

7.2.3 THE ANATOMIC INDEX

The Anatomic Index was developed by Champion in 1980 in an attempt to overcome the inherent limitations of the ISS. It is based on objectively observed probabilities of mortality, meets the requirements of an interval scale and is simple to extract from patient records, even by medical records personnel (Champion, Sacco, Lepper et al., 1980a).

The Anatomic Index uses the ICD-9 codes, or more specifically the Hospital International Classification of Diseases, 8th Revision (HICDA-8) codes, in order to score multiple anatomical injuries. The HICDA-8 codes are used in most American hospitals for billing purposes. According to the authors this method of classification "has been validated, and, as such, represents a substantial improvement in the development of a simple descriptor of injury severity" (Champion et al., 1980a:202). Despite these improvements the Anatomic Index has not been internationally adopted because most researchers prefer to use the AIS to score anatomic injuries rather than the ICD-9 codes.

7.2.4 THE NEW INJURY SEVERITY SCORE

The latest attempt to overcome the limitations of the ISS has been the presentation of a simple modification of it, called the New Injury Severity Score (NISS) (Osler, Baker & Long, 1996). The NISS has been found to outperform the dated ISS as a predictor of mortality.

The NISS is calculated by adding the sum of the squares of the highest AIS ratings *regardless of the body region in which they occur.* The NISS has been validated by the authors on two large trauma studies in the USA. The NISS is easier to calculate than the ISS and is better at separating survivors from non-survivors. The authors therefore suggest that the NISS should replace the ISS as the standard measure of human trauma severity.

7.3 PHYSIOLOGICAL SCORES

The Glasgow Coma Scale was the forerunner of physiological scoring methods. However, overall physiologic trauma scoring began with the Triage Index in 1980 and evolved through the Trauma Score in 1981 to become the Revised Trauma Score in 1989. "The RTS is now the standard of physiologic injury measurement" (Osler, 1993:47S).

7.3.1 THE GLASGOW COMA SCALE

The Glasgow Coma Scale (GCS) was first published in 1974 (Teasdale & Jennett, 1974) and has become the most accepted and internationally used standard for measuring neurological state. It measures the best response on three variables, namely eye, verbal and motor response. The minimum score assigned to each of these three variables is 1, i.e. the lowest total GCS score is 3, while the maximum score is 15.

Coma is defined as "not obeying commands, not uttering words, and not opening eyes" (Jennett & Teasdale, 1981:80). Since 53% of GCS scores equal to 8 and all GCS scores $\leq$ 7 were found to fit this definition, it is generally accepted that coma is a GCS of less than 8 (ibid).

Apart from being used alone to code neurological injury, the GCS is also utilised in many scoring systems such as the Triage Index, TRISS and the RTS because it has been found to be a good prognostic indicator for the recovery of consciousness. However, there are inherent problems with the GCS when used in such scoring systems; for instance, if a patient is intubated or paralysed the verbal and motor components of the GCS cannot be assessed. Although the GCS itself makes allowances for these situations, viz. ventilated patients are scored out of 10 and paralysed or sedated patients are scored out of 9, the exclusion of these parameters is problematic when the GCS is used as a component of other severity scoring systems.

7.3.2 THE TRIAGE INDEX

The Triage Index was proposed by Champion in 1980 as a system for the early, non-invasive assessment of trauma victims in an attempt to match the available resources in a hospital with the patient's injury severity so as to reduce mortality and morbidity (Champion, Sacco, Hannan et al., 1980b). It uses five physiological variables (respiratory expansion, capillary refill, eye opening, verbal response and motor response) which relate to central nervous system, cardiovascular or respiratory dysfunction which are associated with early death after trauma.

The Triage Index is the sum of the scores for each variable, which are dependent on the severity of dysfunction. Although this tool was found to be valid and reliable it was replaced by the Trauma Score in 1981.

7.3.3 THE TRAUMA SCORE

The Trauma Score numerically summarises the functional assessment of the circulatory, respiratory and central nervous systems. It improved on the Triage Index by adding systolic blood pressure (SBP) and respiratory rate (RR) and by using the total GCS score instead of the three individual responses. The resultant five-variable score was published in 1981 (Champion, Sacco, Carnazzo et al., 1981).

The total Trauma Score is derived by adding the score of the five variables. The minimum is 1 and the maximum is 16. A Trauma Score of 12 or below indicates that the patient should be triaged to a sophisticated trauma centre.

The Trauma Score was found to be slightly less powerful than the Triage Index but it was easier to use, particularly by non-medically trained personnel (Champion et al., 1981). It may be used in the field for triaging purposes, or in the hospital: the raw scores are used for triage while the coded values are weighted and summed for outcome evaluation.

The Trauma Score has been found to have the following limitations (Champion, Sacco, Copes et al., 1989):

- Capillary refill and respiratory expansion were difficult to assess at night;
- Retractive respiratory expansion was difficult to observe, particularly by untrained personnel; and
- It underestimated the severity of some head injured patients.

Although the Trauma Score had clinical difficulties it was widely used as a triage instrument and was incorporated, together with ISS and Age, into the TRISS Index which is a measure of the probability of survival. However, concerns regarding its limitations led to the revision of the Trauma Score and the publication in 1989 of the Revised Trauma Score (Champion et al., 1989), which was found to be easier to apply and to reflect the severity of head injuries more accurately.

7.3.4 THE REVISED TRAUMA SCORE

The Revised Trauma Score (RTS) was published by Champion et al. in 1989. It only uses the GCS, SBP and RR (Table 7.2).

Table 7.2 : The Revised Trauma Score

	CODE	WEIGHT VALUE
Respiratory rate (breath/min)		
10 - 29	4	
> 29	3	
6 - 9	2	0.2908
1 - 5	1	
0	0	
Systolic Blood Pressure (mmHg)		
> 89	4	
76 - 89	3	
50 - 75	2	0.7326
1 - 49	1	
0	0	
Glasgow Coma Scale		
13 - 15	4	
9 - 12	3	
6 - 8	2	0.9368
4 - 5	1	
3	0	

The Revised Trauma Score may be used in the field for triage (referred to as the T-RTS) or in hospitals for evaluating injury severity and outcome. Like the Trauma Score the T-RTS uses raw scores, while the RTS is a weighted score (the weights being determined by logistic regression from the Major Trauma Outcome Study [MTOS][1] data base). The GCS is more heavily weighted than the other two variables in an attempt to more accurately reflect the severity of head injuries. The weighted RTS ranges from 0 (worst) to 7.8408 (best).

1 The MTOS data base contains data on patients from institutions throughout the United States of America, Canada, the United Kingdom and Australia. It was established in 1982 in an attempt to develop norms for trauma care and was co-ordinated through the American College of Surgeons' Committee on Trauma. Demographic, aetiologic, injury severity and outcome data from more than 140 hospitals and more than 120 000 patients have been submitted to the MTOS since 1982. Baseline data from this study is utilised in many scoring systems presently in use (Champion, Copes, Sacco et al., 1990a).

For field triage a patient with an T-RTS of 11 or less has approximately a 7 - 10% chance of dying and should be moved to a trauma facility which has 24 hour x-ray facilities, surgical facilities, etc. A patient with an T-RTS of less than 10 should be taken to a Level I trauma facility (usually at a tertiary hospital in South Africa) since their mortality rate is approximately 30%. In a hospital setting, a patient with an unweighted RTS of 11 or less will probably need resuscitation while a patient with a RTS of 10 or less will probably require ICU management (Boffard, 1993).

Although the RTS is almost universally used because its definition is simple and its utility has been proven, it is not without limitations.

- The RTS utilises the GCS in the equation and thus patients who are ventilated or those who are intoxicated with alcohol cannot be assigned a correct GCS. RTS calculation in these patients is therefore not possible and thus they are excluded from the cohort. A recent advance suggests the use of the motor response component of the GCS only in these cases (Offner et al., 1992).

- Similarly, patients who are mechanically ventilated cannot be assigned a true respiratory rate.

- Severely injured patients admitted to trauma units have fluctuating physiological parameters due to their injuries and the rapid management employed, e.g. fluid resuscitation. True and representative values of SBP, GCS and RR are therefore difficult to obtain during resuscitation attempts (Bull & Dickson, 1991; Osler, 1993). It is also often difficult to decide when to assess the RTS. For example, on admission one patient may have a strong adaptive reaction despite severe injuries and collapse much later, while another patient may have a poor RTS initially due to a fainting spell, without necessarily having any severe injuries (Bull & Dickson, 1991).

- RTS and GCS are measured on an ordinal scale and, as such, should be analysed using non-parametric statistical tests. This limitation is often overlooked by researchers (Gaddis & Gaddis, 1994).

7.3.5 ACUTE PHYSIOLOGY & CHRONIC HEALTH EVALUATION II

The Acute Physiology and Chronic Health Evaluation II (APACHEII) score uses 12 physiological parameters to calculate a measure of illness severity in critically ill patients. All 12 parameters must be measured and the lowest scores within 24 hours of admission used in the calculation - this includes the lowest GCS. The patient's age and chronic health status - determined by the presence of any underlying cardiovascular, respiratory, hepatic, renal and immune disease - are also entered into the equation.

The APACHEII score is not particularly helpful in triaging trauma patients, particularly those with head injuries, because of the controversial use of the lowest GCS (E.J. Smith & Ward, 1990). However, serial APACHEII scores, in an Intensive Care situation, are very useful to plot the progress of critically injured trauma patients.

7.4 COMBINATION SCORES

Anatomical injuries and physiological derangement are not the only determinants of outcome. The patient's age and reserve or underlying disease play an important role in survival. The probability of survival or outcome may thus be expressed as Outcome = Anatomic Injury + Physiologic Derangement + Patient Reserve. In many scoring systems 'age' is used as a substitute for patient reserve (Osler, 1993).

7.4.1 TRISS

TRISS is an acronym derived from TRauma score and Injury Severity Score and was first described by Champion (1982) as a predictor of outcome, i.e. mortality versus survival. It incorporates both the degree of physiological (RTS) and anatomical (ISS) derangement as an indication of probability of survival. Since mortality is also affected by age and the method of wounding (penetrating or blunt) these two variables are also included in the computation (Table 7.3). Because of the complexity of the computation of TRISS and the fact that probability of survival (P_s) is "merely a mathematical calculation ... not an absolute measure of mortality ... only of the probability of death" (Yates, 1991:109) TRISS is primarily used by researchers. The co-efficients utilised in TRISS are derived from the MTOS data base.

Table 7.3 : TRISS methodology

$$P_s = \frac{1}{1 - e^{-b}}$$

$$b = b_0 + b_1(RTS) + b_2(ISS) + b_3(\text{Age co-efficient})$$

where P_s is the probability of survival
e is the natural logarithm, i.e. 2.718282
b_0 - b_3 are weighted co-efficients
Age co-efficient = 0 where patient's age < 55 years
Age co-efficient = 1 where patient's age > 54 years

Adapted from Boyd et al., 1987:372

TRISS methodology may also be used to produce a graphic and three additional sets of statistics:

- The PRE chart

  A chart which plots the ISS on the x-axis and the RTS on the y-axis of a scatter graph. Each patient's values are plotted on the graph but survivors are denoted with an 'L' and non-survivors with a 'D'. A sloping line, identified as the P_s 50 isobar, represents the 0.50 probability of survival. Patients whose co-ordinates fall above this line have less than a 50% chance of survival, while those whose co-ordinates fall below the line have more than a 50% chance of survival. At a glance this chart shows 'unexpected survivors' and 'unexpected deaths' in a cohort and can be used to audit patient care in a trauma unit.

- The 'W' value

  This is the difference between the predicted number of survivors and the actual number of survivors in a cohort, divided by the total number of patients, divided by 100 (Hollis, Yates, Woodford et al., 1995). A positive 'W' value indicates that the facility has more survivors than predicted and therefore its performance is above standard.

- The 'Z' value

  Is a measure of the difference between the actual and predicted number of deaths or survivors in a cohort. A 'Z' score of $> +1.96$ indicates a better performance while a 'Z' score of < -1.96 indicates a worse performance (ibid).

- The 'M' statistic

  This statistic 'matches' the range of injury severity in a cohort with that of the MTOS database. The normal range is 0 to 1 but a level of < 0.88 "... has been deemed unacceptable for the purpose of comparison with the U.S. database" (ibid:763).

Overall, therefore, these three statistics assess the standard of care in an institution in comparison to that generally found in the USA.

TRISS methodology, despite the obvious limitation of being complex to calculate, has several other limitations, many of which have been inherited from the RTS and ISS.

- TRISS methodology can only be applied to patients with trauma who are admitted to hospital for more than three days, managed in an Intensive Care Unit, referred for specialist care or who die while in hospital (Yates, 1991).

- There appears to be a problem of observer variation in TRISS methodology. According to Zoltie & De Dombal (1993:908) "for those patients with probabilities of survival of between 0.05 and 0.95 there is a very large potential source of variation depending on the observer who collected the data". This problem can be overcome if a single coder does all the injury severity scoring.

- Although age is included in the TRISS analysis, the single step at the age of 55 years appears arbitrary. As Bull & Dickson (1991) point out, a patient who is injured at the age of 54 would have the same probability of survival had he been 4 or 34 years old, but had he had his 55th birthday his probability of survival would have been considerably less and would have remained at this level even if he had been 94 years old. A new scoring system, ASCOT, has attempted to overcome this limitation by incorporating five age categories (see p142).

- There is significant misinterpretation of what the probability of survival (P_s) in TRISS represents. For instance, if a case has a P_s of 0.4 it is sometimes erroneously suggested that four out of ten of the cases would be expected to die. This is not the case. What a P_s of 0.4 is actually saying is that of 10 such cases, 4 would be expected to live and 6 to die - however, there is "no way of telling statistically whether this particular case is one of the surviving four or the dying six" (Bull & Dickson, 1991:130). TRISS probabilities are thus best used to assess overall performance by comparing expected deaths with observed deaths (or survivals).

- TRISS does not distinguish between gunshot and knife injuries, the former having a much higher morbidity and mortality rate (Demetriades & Sofianos, 1992; Eisenberg, 1993). This limitation is of particular concern in South Africa where much of the penetrating trauma is caused by either guns or knives. Cayten, Stahl, Murphy et al. (1991) have suggested that this limitation could be overcome by developing separate TRISS coefficients for gunshot and stab wound patients.

- Because ISS is problematic with regard to only scoring one injury per body region, TRISS does not take into account multiple injuries if they are clustered in one area. The ASCOT system has attempted to address this problem (see section 7.4.2, p142).

- TRISS methodology does not take into account the effects of drugs, alcohol and pre-hospital treatment (Demetriades & Sofianos, 1992).

- It is not possible to estimate the RTS (and therefore TRISS) in intubated patients. A modification to TRISS, which substitutes "best motor response" for the RTS, has been proposed but requires further testing on larger data bases (Offner et al., 1992).

- TRISS does not make allowances for pre-existing disease, it is costly in terms of funds and time and it also does not measure quality of life (Wardrope, Cross & Fothergill, 1990).

Although there are significant differences between the USA and SA with regard to injury rates and facilities for management and treatment, the MTOS-based co-efficients have been used in TRISS analysis in this country. TRISS methodology has been successfully used in two studies conducted at Baragwanath Hospital (Demetriades & Sofianos, 1992; Eisenberg, 1993). Demetriades & Sofianos found that there was no statistical difference in the number of expected deaths in their sample compared with the MTOS, and that there was a good correlation in injury severity mix between their patients and the American data base. Likewise, Eisenberg (1993) found that TRISS demonstrated that the outcome of patients at Baragwanath could be compared to that of other centres. TRISS has also been successfully used to evaluate patient care in other developing countries such as Yugoslavia despite the fact that it appears as though they see "... more severely injured patients than the USA" (Cvetkovic, 1992:513).

In conclusion, TRISS methodology has been a major advance in the measurement of injury severity and probability of survival. It is particularly useful in the objective evaluation of trauma care and prediction of survival in trauma patients but its limitations should be taken into account when interpreting results.

7.4.2 A SEVERITY CHARACTERIZATION OF TRAUMA

ASCOT is an acronym for 'A Severity Characterization of Trauma' and it combines both anatomical and physiological criteria in order to predict outcome. It is similar to TRISS in that it uses weighted co-efficients drawn from the MTOS. The ASCOT equation includes the RTS, the type of injury (blunt or penetrating), age and all the anatomical injuries (Champion, Copes, Sacco et al., 1990b).

In an attempt to overcome the limitations inherent in ISS and TRISS, ASCOT uses five age categories (<55, 55-59, 60-69, 70-79, 80-84, 85+) and the Anatomic Profile. The latter was first developed as a refinement of the ISS by Copes et al. (1990b). This four-valued profile (A B C and D) describes **all** injuries sustained by the patients as well as an indication of their location (Table 7.4). The body regions were redefined in ASCOT so that those that strongly affect outcome, i.e. head, brain and spinal cord, have higher weighting co-efficients in the equation.

Table 7.4 : Profile components in ASCOT

COMPONENT	INJURY	AIS SEVERITY	ISS BODY REGION
A	Head/brain	3-5	1
	Spinal cord	3-5	1,3,4
B	Thoracic	3-5	3
	Front of neck	3-5	1
C	All other serious injuries	3-5	1-6
D	All other minor injuries	1-2	1-6

Adapted from Table II : Champion et al., 1990b:541

In calculating ASCOT those patients with extremely good and extremely poor prognoses are omitted from the equation. These so-called 'set-asides' are excluded in an attempt to more accurately calculate the probability of survival of the majority of injured patients. Those patients with minor injuries, or category 'D' patients (in Table 7.4 above) are excluded from the equation because they were not found to be "... a significant contributor to mortality predictions" (Champion et al., 1990b:541). These exclusions have been severely criticised by some authors who suggest that "... no scoring system that fails to account for such factors is likely to do well" (Osler, 1993:49S).

ASCOT appears to have made some improvements on what TRISS provided because it more accurately describes a patient's physiologic status and takes into account all injuries as well as their location and severity. However, it remains deficient in that it does not include patients for whom a GCS cannot be assigned or for whom respiratory rate cannot be assessed, e.g. paralysed or intubated patients. The omission of these high risk patients can "... seriously bias institutional results" since, as Champion et al. (1990b:544) concede "... it has been our experience that patients excluded from analyses have a mortality rate approximately twice that of included patients". A valid and reliable scoring system which includes these types of patients has therefore yet to be devised.

A further limitation of ASCOT is that it once again uses death as the only predictor of outcome and ignores a large group of patients who sustain less severe injuries, but who suffer serious potential long-term effects and disability. ASCOT also continues to use 'age' as a surrogate for patient reserve despite studies showing that underlying diseases such as cirrhosis, AIDS or chronic obstructive airways disease play an important role in the outcome of traumatised patients (MacKenzie, Morris & Edelstein, 1989).

It is perhaps because of the "... very modest improvements ..." (Osler, 1993:49S) in ASCOT that there is a general lack of enthusiasm by researchers and doctors to change from TRISS to this method of trauma scoring.

7.5 MEASURING DISABILITY

A number of attempts have been made to quantify disability, loss of function or reduced quality of life as a result of trauma (Kaplan, 1982). There has been the potential years of life lost (Romeder & McWhinnie, 1977), the quality of well-being scale (Holbrook, Hoyt, Anderson et al., 1974), the disability adjusted life year (DALY) (Murray, 1994) and the quality of adjusted life year (QALY) (Schwartz, Richardson & Glasziou, 1993). But none of these system were actually designed to measure the outcome from trauma and have therefore enjoyed limited success.

The Functional Capacity Index (FCI) was developed by the National Highway Traffic Safety Administration (1992) in the USA and is a measure of the consequences of injuries sustained in motor vehicle collisions, based on adjusted life-years. It assesses 10 functions (such as eating, walking, standing, climbing stairs, etc) and assigns a score to each, based on the loss of function and the severity of the particular disability.

All these studies and a few others contributed to the formulation of the Injury Impairment Scale in 1994 (Joint Committee on Injury Scaling, 1994). This six-point scale was constructed akin to the AIS. It has six dimensions, i.e. mobility, cognitive, cosmetic interference with function, sensory, sexual/reproductive and pain.

The 1320 injury descriptions in the AIS 90 have been assigned an IIS score from 0 (normal function, no impairment) to 6 (impairment level precludes any useful function). These scores were based on a committee's consensus of impairment at one year following injury. The IIS therefore represents the committee's consensus on the most frequent impairment but not necessarily the only disability for a particular injury.

An obvious limitation of this scoring method is that it is based on a single injury. Impairment as a result of multiple injuries has yet to be addressed and a method for combining separate IIS ratings suggested. What has been suggested to date is to use the worst IIS score (Massoud & Wallace, 1996) This scale is therefore the most comprehensive and easy-to-use disability scoring method available but it is still undergoing extensive validation.

7.6 CONCLUDING REMARKS

Although numerous scoring systems have been developed it appears as though the 'perfect scoring system' has yet to be developed. This scoring system should allow for the accurate description of injuries in a clinically acceptable vocabulary so that it is used by all practising clinicians. It should furthermore have injury severity indices which are measured, i.e. each injury should have several different severity indices depending on the outcome being measured, e.g. one for survival, one for disability, etc (Osler, 1993). More importantly, this injury scoring system should be simple to use, reliable, valid and universally applicable so that valid comparisons may be made between countries.

It is inevitable, however, that eventually our quest for better and more perfect scoring systems and predictors of outcome will come to a halt as we realise that some individuals will always remain in the 50% survival category and that their "... outcome will remain the toss of a coin" (Osler, 1993:50S) or in the lap of the Gods.

7.7 CHAPTER SUMMARY

This chapter has outlined the three different categories of injury severity scoring, viz. anatomic, physiological and combination scores. The most commonly used scoring systems in each category have been discussed, including their limitations. The justification for using particular scoring systems in this thesis were discussed in the methodology chapter.

The next chapter will outline the injuries sustained by both Hospital and Mortuary pedestrians in this study and their resultant injury severity.

CHAPTER EIGHT

INJURIES SUSTAINED BY PEDESTRIANS

Pedestrians *"... are often among the most seriously injured patients seen in the Emergency Department"* (Waddell and Drucker, 1971:844).

8.1 INTRODUCTION

Many State mortuaries have data available on the injuries sustained by fatally injured pedestrians in South Africa but the lesions sustained by non-fatally injured pedestrians are poorly described.

This section therefore concentrates on the injuries sustained by the Hospital pedestrians (n=196) included in this study, although a short section on the postmortem findings on the 31 pedestrian fatalities is also included.

The objectives of this chapter are thus to describe the anatomical injuries sustained by Hospital and Mortuary pedestrians, as well as the severity of the injuries sustained by both groups.

Lesions sustained by pedestrians were documented and coded by the author, using the 1990 revision of the AIS (Committee on Injury Scaling, 1990). Since some patients had more than one lesion in a body region a maximum of six lesions were coded, rather than just the three worst lesions (in different body regions) as is required to calculate the ISS. It was felt that coding six lesions would give a more comprehensive clinical picture of the injured pedestrian and thus facilitate future management.

8.2 HOSPITAL PEDESTRIANS

8.2.1 INTRODUCTION

The vast majority of Hospital pedestrians were assessed by the author at the time of their presentation to the trauma unit. Definitive diagnoses were verified at the time of discharge or transfer to another institution.

Just over 70% of the pedestrians sustained an injury to the lower limbs[1] followed by 45% with head injuries (Figure 8.1). These results are in keeping with the mechanism of pedestrian collisions. The lower limbs are generally struck by the vehicle's bumper as part of the primary injury. The head may be injured by the impact with the vehicle but some patients strike their head on the road as they fall (the secondary injury).

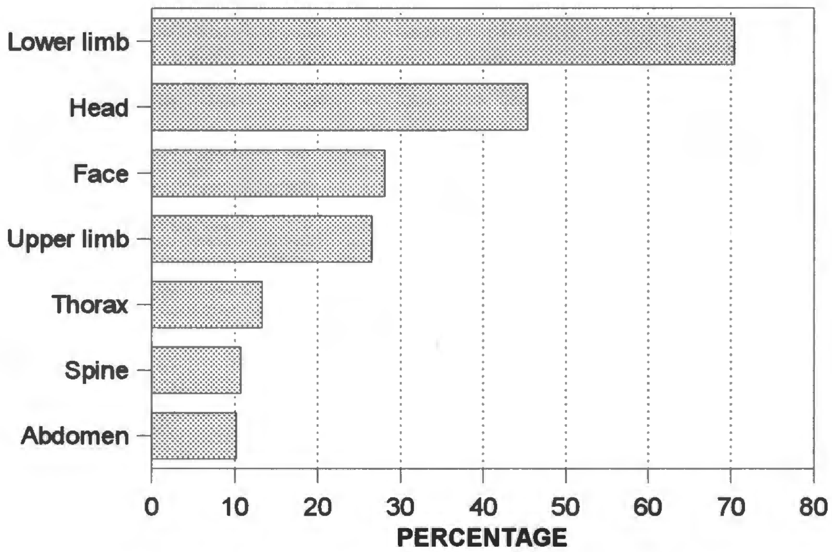

Figure 8.1 : Injuries sustained by Hospital Pedestrians (n=196)

Overall, the hospital pedestrians' injuries were fairly severe, with abdomen, head and thoracic lesions having the highest AIS scores (Table 8.1).

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1 In the 1990 revision of the AIS, the lower limb body region includes injuries to the pelvis.

Table 8.1: Injuries sustained by Hospital Pedestrians by body region

BODY REGION INJURED	Patients with lesions	Median AIS	Mean AIS (±SD)
Head	89	2	2.99 (±1.3)
Face	55	2	1.78 (±0.6)
Spine	21	1	1.90 (±1.3)
Thorax	26	3	2.93 (±1.4)
Abdomen	20	3	3.04 (±0.9)
Upper Limb	52	2	2.00 (±0.6)
Lower Limb	138	2	2.31 (±0.8)

8.2.2 THE NUMBER OF LESIONS SUSTAINED

On average hospital pedestrians (n=196) had two lesions each but nearly half of these cases (45.6%) had polytrauma [2].

8.2.2.1 Pedestrians with polytrauma

Twelve of the 90 patients with polytrauma (13.3%) had a combination of head injury and lower limb injury. Although this combination was by far the most common, other combinations which have significant clinical implications were:

- lower limb and upper limb injuries (7.8%);
- head and facial injuries (6.7%);
- head and upper limb injuries (6.7%);
- head, face and lower limb injuries (6.7%).

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[2] Polytrauma is defined as significant injuries to more than one body region and is synonymous with multiple injuries.

Seventy of the 90 polytrauma pedestrians (77.8%) were males and 51.1% were black. The average age of these polytrauma patients was 36.1 years (±12.7). They generally presented to trauma unit after office-hours or over the weekend[3].

It was interesting to note that polytrauma patients were no more likely to be injured on roads which carry high volumes of traffic (and have speed limits ≥80 km/hr) than patients with single system injuries, nor were they more likely to be struck by heavier vehicles. They were, however, more than twice as likely to be BAC positive at the time of their injury (OR=2.2, P=0.01). They also had significantly higher mean BAC levels than patients with single system injuries (0.13 g/100ml vs 0.10 g/100ml, T=2.14, P=0.03).

8.2.2.2 Pedestrians with single region trauma

There were 106 pedestrians who had single region trauma, the majority of whom (60.4%) had an injury to the lower limbs (Figure 8.2). These lower limb injuries tended to be mild in nature with a median AIS of 2. There were also 24 patients (22.6%) who had an isolated head injury. Although some of these patients had a moderate head injury, the majority were minor.

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3 The weekend refers to 17h00 on a Friday afternoon until 07h59 on a Monday morning.

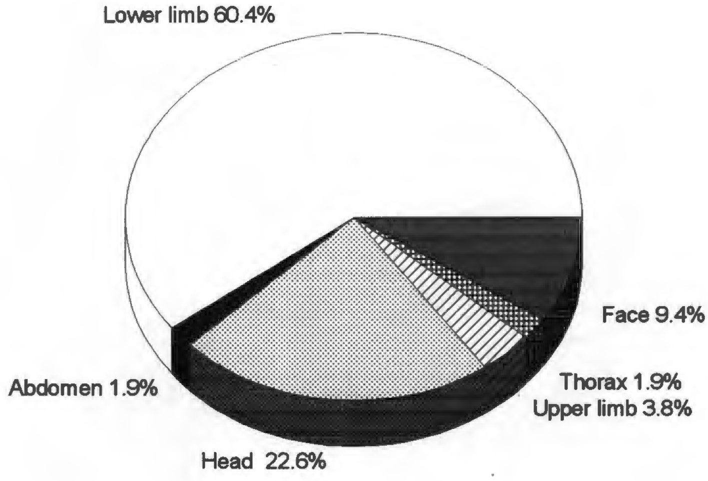

Figure 8.2 : Body regions injured in single system trauma (n=106)

Pedestrians with single region injuries were predominantly male (62.3%) and coloured (57.5%). They were an average of 34 years old (±12.9). Although more than half of all collisions occurred over the weekend it was interesting to note that nearly a quarter (21.7%) of pedestrians with single region injuries were injured on a Wednesday.

There was no statistically significant relationship between alcohol and single region injuries.

8.2.3 TYPE OF INJURY BY BODY REGION

The following sections describe the type of lesions in the different body regions sustained by the hospital pedestrians (n=196).

8.2.3.1 Head Injuries [4]

Eighty-nine pedestrians (45.4%) sustained an injury to the head. These 89 pedestrians had 118 separate head lesions, almost half of which were minor in nature (Table 8.2).

Half of the pedestrians who sustained head injuries were injured on roads where the speed limits were ≥80 km/hr and 18% were hit by heavy vehicles such as buses, trucks or bakkies/LDVs.

Table 8.2 : Head lesions sustained by Hospital Pedestrians

TYPE OF LESION	NUMBER (n=118)	%
Crush (massive destruction of skull and brain)	4	3.4
Cerebral contusion	11	9.3
Intracranial haematomas	7	5.9
Diffuse brain injury	1	0.8
Cerebral oedema	1	0.8
Fractures		
Base of Skull	10	8.5
Vault	6	5.1
Closed head injury (nil further specified) AIS 1-2	35	29.7
Closed head injury (nil further specified) AIS 3-5	21	17.8
Scalp Injury (AIS 1 - 2)	22	18.6

As a result of the considerable number of minor head lesions (Figure 8.3), the median AIS for all head injuries was only 2 (mean AIS=2.99).

4 In the context of this thesis the term head injury encompasses all injuries to the scalp, skull and brain, but not to the face.

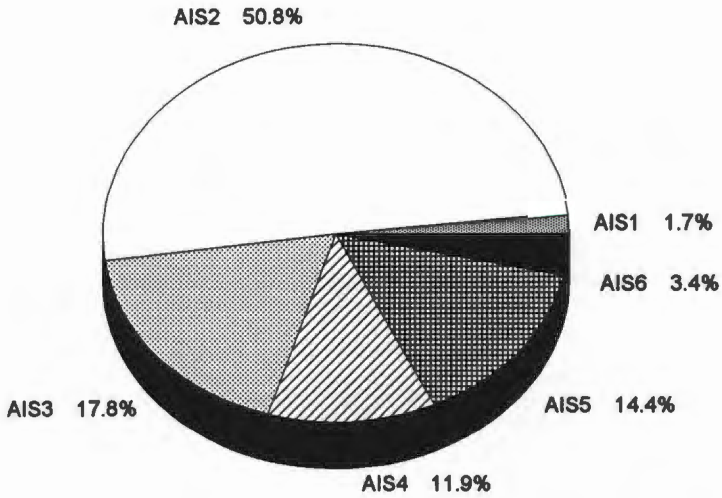

Figure 8.3 : Head lesions by AIS in Hospital Pedestrians (n = 118)

The majority of patients (73.0%) with injuries to the head had polytrauma. The most common combinations of injuries in these patients were:

- head and lower limb injuries (18.5%);
- head and face injuries (9.2%);
- head and upper limb injuries (9.2%);
- head, face and lower limb injuries (9.2%).

Although head and spinal column injuries are often said to occur together, only 12 of the 89 head injured patients (13.5%) had a concomitant spinal column injury. Furthermore, only five of these patients had spinal column injuries with AIS ratings of 3 or more.

There were 12 pedestrians (13.5%) who had minor head injuries or scalp lacerations (AIS 1) and were attended to in trauma unit and then discharged home with a Head Injury Form [5].

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[5] All patients with minor head injuries not requiring admission to hospital are discharged with a protocol which indicates when a patient should return to hospital for re-examination, e.g. vomiting, drowsiness, severe headaches.

Three patients (3.9%) died of their injuries while still in the trauma unit. Two of these patients had crushed skulls (AIS 6), one of whom became a donor (see Case Study A). The third patient had three AIS 5 injuries.

Case Study A

Mr J, was 23 years old and was hit by a car on the N2 freeway. On admission he had a GCS of 3, sluggish mid-size pupils, was haemodynamically unstable and was hypothermic (31°C). He required intubation and ventilation. He had a closed head injury (AIS 6) and a compound fracture of his left tibia and fibula (AIS 3). He was haemodynamically stabilised, transfused, warmed and taken for CT scan which revealed severe diffuse brain injury. Within an hour his pupils became fixed and dilated and he was pronounced brain dead. His family gave consent for organ donation and he was transferred to theatre for harvesting of his organs.

Seventy-four patients with head injuries were admitted to hospital. Twenty-two of these admissions (29.7%) went directly to an ICU where they spent an average of 7.9 days (±8.3).

Six of the admitted pedestrians (8.1%) died while in a ward or ICU. Two of the six had crushed skulls (AIS 6); two had severe closed head injuries and other severe injuries; and two had moderate head injuries (AIS 3) as well as other compounding factors such as severe hypothermia and/or shock.

Sixty-eight of the 89 patients with head injuries survived. However, 24 of these 68 patients (35.3%) were transferred to a convalescent hospital for the on-going management of their injuries.

Of the 89 patients with head injuries, 61 (68.5%) had positive BAC levels. These 61 patients had a mean BAC of 0.19 g/100ml (±0.08, range 0.03 - 0.35). The BAC positive pedestrians were nearly twice as likely to have sustained a head injury than their BAC negative counterparts (OR=1.77, P=0.05).

8.2.3.2 Facial Injuries

Fifty-five of the hospital pedestrians (28.1%) sustained an injury to the face. These 55 patients had 62 separate facial lesions (Table 8.3).

Table 8.3 : Facial lesions sustained by Hospital Pedestrians

TYPE OF LESION	NUMBER (n=62)	%
Fractures	11	17.7
Tongue laceration	1	1.6
Facial laceration, contusion and/or abrasion	50	80.7

Of the 55 patients with facial injuries, 19 (34.5%) had no other significant injuries while the remaining 36 patients (65.5%) had polytrauma. In the latter patients with facial trauma the most common combinations were:

- face and head injuries (16.7%);
- face, head and lower limb injuries (16.7%);
- face and lower limb injuries (11.1%).

As can be seen in Figure 8.4, the majority of facial injuries were minor in nature, with a median AIS of 2 (mean AIS=1.8).

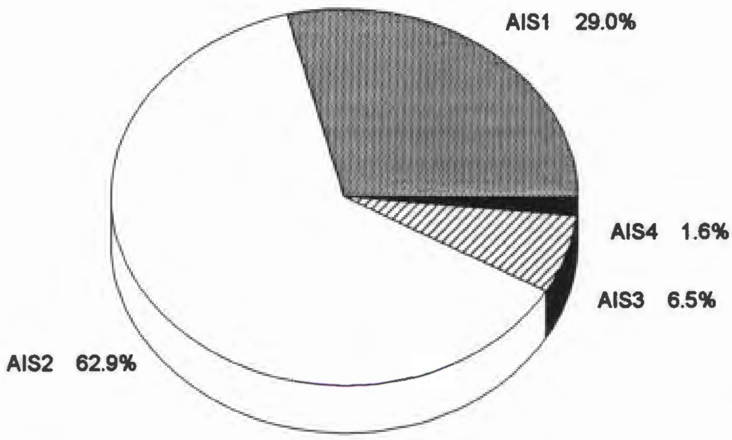

Figure 8.4 : Facial lesions by AIS in Hospital Pedestrians (n=62)

One patient with a facial injury (1.8%) died while in trauma unit but he also had a severe concomitant head injury (AIS 6). Fourteen patients (25.5%) with minor facial injuries (some of whom had other minor injuries) were treated in the trauma unit and discharged home.

Forty patients with facial injuries were admitted to hospital. Four patients were admitted directly to an ICU where they spent an average of 4.3 days (±5,0) but all of these patients also had severe head injuries.

One patient with a facial injury died while in the ward but the cause of his death was a severe closed head injury.

Thirty-nine patients admitted to hospital with facial injuries survived, of whom eight (20.5%) required on-going convalescent hospital management, mainly for their concomitant head or spinal column injuries.

Of the 55 patients with facial injuries 36 (65.5%) were BAC positive. These 36 pedestrians had a mean BAC of 0.18 g/100ml (±0.08). Blood alcohol positive pedestrians were nearly three times as likely to have sustained a facial injury than their BAC negative counterparts (OR=2.79, P=0.003), but this result was probably confounded by the large number of pedestrians who had both head and facial injuries.

8.2.3.3 Spinal Column Injuries

Twenty-one pedestrians (10.7%) sustained a spinal column injury. These 21 patients had 22 separate spinal lesions (Table 8.4). One patient had two non-contiguous lesions, viz. a fracture of the transverse process of the seventh cervical vertebra and a fracture of the lamina of the fourth cervical vertebra.

Table 8.4 : Spinal column lesions sustained by Hospital Pedestrians

TYPE OF LESION	NUMBER (n=22)	%
Fractures/dislocations		
With complete cord lesions	2	9.1
With incomplete cord lesions	2	9.1
With no cord damage	5	22.7
Acute strain/sprain	13	59.1

Of the 21 patients with spinal column injuries, 7 (33.3%) had no other significant injuries. However, in those who had polytrauma, spinal column injuries were most frequent (21.4%) in patients who had injured four or more body regions.

Four patients sustained spinal column injuries which resulted in cord lesions - all these patients had vertebral injuries at or above the third cervical vertebra.

All four of these patients were struck by heavy vehicles on roads where the speed limit was ≥80 km/hr. From Figure 8.5 it is clear that the majority of injuries were minor in nature with a median AIS of 1(mean AIS=1.9).

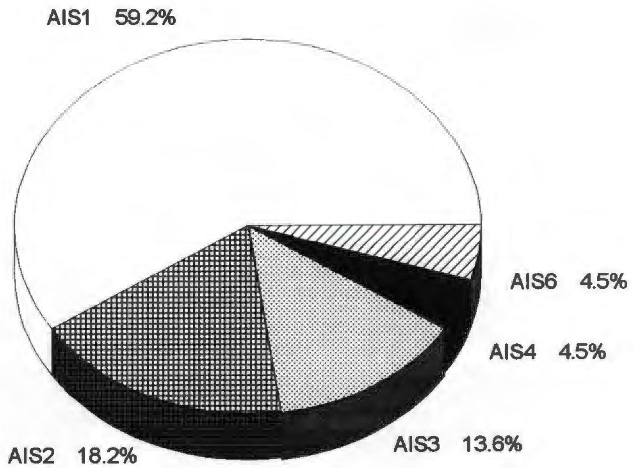

Figure 8.5 : Spinal column lesions by AIS in Hospital Pedestrians (n=22)

Three of the patients who had acute cervical strain/sprain and other insignificant lesions were discharged home after being attended in the trauma unit.

One of the four patients with a cord lesion died while in trauma unit (see Case Study B). The other three patients were transferred to a specialised spinal unit at another hospital for on-going management and rehabilitation of their injuries.

Case Study B

Mr S, a 33 year old male, was admitted to the trauma unit on a Saturday afternoon. He had fixed, dilated pupils and had been intubated by the Ambumedics. Being haemodynamically reasonably stable, ventilation was maintained until CT scan revealed diffuse brain injury (AIS5) and a fracture of his first cervical vertebra with complete transection of the spinal cord. At that stage, 5 hours after admission, ventilatory support was withdrawn and he died. He had a BAC level of 0.08 g/100ml.

Seventeen patients were admitted to hospital. Four were admitted directly to ICU, where they stayed for an average of 8.8 days (±7.4), all four having sustained severe polytrauma. One of these patients died while in the ICU. He had a severe closed head injury (AIS 5), a crushed pelvis (AIS 5) and a cervical vertebra fracture without spinal cord damage (AIS 3).

Sixteen patients with spinal column injuries survived but six (37.5%) of these were transferred to another hospital - three for the rehabilitative management of their spinal cord injuries and the other three for the convalescent management of lower limb orthopaedic injuries.

Of the 21 patients with spinal column injuries, 17 (81%) had positive BAC levels. These 17 pedestrians had a mean BAC of 0.21 g/100ml (±0.06). Pedestrians who were BAC positive appeared to be at no greater risk of sustaining a spinal column injury than their BAC negative counterparts (χ^2=2.9, P=0.08).

8.2.3.4 Thoracic Injuries

Twenty-six pedestrians (13.3%) sustained an injury to the thorax. These 26 pedestrians had 28 separate thoracic lesions (Table 8.5).

Table 8.5 : Thoracic lesions sustained by Hospital Pedestrians

TYPE OF LESION	NUMBER (n=28)	%
Tension pneumothorax	1	3.6
Fractured ribs		
Multiple ribs with bilateral flail chest	4	14.3
Multiple ribs with unilateral flail chest	2	7.1
Multiple ribs with lung contusion	3	10.7
Unilateral multiple ribs with HPT*	1	3.6
2-3 ribs unilaterally with HPT	5	17.9
2-3 ribs unilaterally without HPT	5	17.9
1 rib unilaterally without HPT	2	7.1
Rib tenderness, no fracture noted	4	14.3
Skin contusion	1	3.6

* HPT=haemopneumothorax

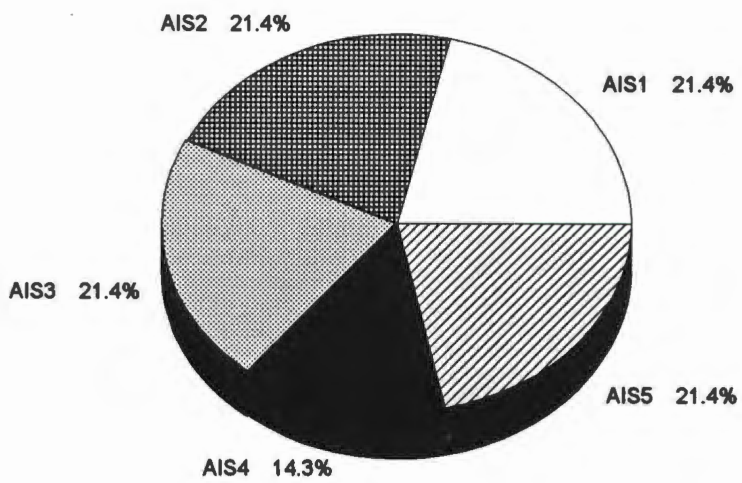

Figure 8.6 : Thoracic lesions by AIS in Hospital Pedestrians (n=28)

The thoracic lesions had a high overall severity rating (Figure 8.6), with a median AIS of 3 (mean AIS=2.9). Just over 15% of pedestrians were struck by minibus taxis (as opposed to 11% for all pedestrians) which have much higher bumpers than conventional saloon cars and flat front ends.

Of the 26 patients with thoracic injuries, only five had isolated chest injuries while the other 80.8% had polytrauma. The most frequent combinations in these latter patients with thoracic injuries were:

- thorax, lower limb, upper limb and head (19.0%);
- thorax, lower limb, abdomen, spinal column and head (14.3%);
- thorax, lower limb, abdomen and head (9.5%).

Three patients with minor thoracic injuries, such as rib tenderness, were treated in the trauma unit and then discharged home. One patient with severe polytrauma died of his injuries while in the trauma unit. He had multiple fractured ribs with a tension pneumothorax, a ruptured spleen and a severe closed head injury.

Twenty-two patients (84.6%) were admitted to the hospital. Seven patients were admitted directly to an ICU where they spent an average of 13.6 days (±16.2). All the patients who were admitted to hospital did well, even those with severe thoracic injuries (see Case Study C). However, seven of these patients (31.8%) were transferred to a convalescent facility for the after-care of their associated head or orthopaedic injuries.

Of the 26 patients with thoracic injuries, 20 (76.9%) were BAC positive. These 20 pedestrians had a mean BAC of 0.20 g/100ml (±0.08). Pedestrians who were BAC positive appeared to be at no greater risk of sustaining a thoracic injury than their BAC negative counterparts (χ^2=2.4, P=0.12).

Case Study C

Mr M, a 51 year old male, was knocked down on Koeberg Road, Milnerton by a motorcyclist at 18h50 on a Saturday. On admission he was confused and mildly shocked. He had a bilateral flail chest, ruptured bladder, fractured left femur and a fracture of the transverse process of C7. He was prophylactically intubated and ventilated and taken to theatre for internal fixation of his femur and bladder repair. He was admitted to the respiratory ICU where he spent 9 days, during which time he was taken back to theatre repeatedly - spending a total of 55 hours in theatre. He was transferred to an orthopaedic ward where he spent another 6 days, made an excellent recovery and was discharged home. Mr M had a BAC level of 0.25 g/100ml.

8.2.3.5 Abdominal Injuries

Twenty pedestrians (10.2%) sustained an injury to the abdomen. These 20 patients had 24 separate abdominal lesions (Table 8.6).

Table 8.6 : Abdominal lesions sustained by Hospital Pedestrians

TYPE OF LESION	NUMBER (n=24)	%
Massive ano-perineal tear	1	4.2
Urethral tear	2	8.3
Retroperitoneal haematoma	10	41.6
Bladder rupture	3	12.5
Liver laceration	1	4.2
Kidney laceration	2	8.3
Splenic rupture	1	4.2
Traumatic amputation of penis	1	4.2
Skin injury (AIS 1-2)	3	12.5

As can be seen in Figure 8.7, the majority of these lesions were serious in nature, with a median AIS of 3 (mean AIS=3) .

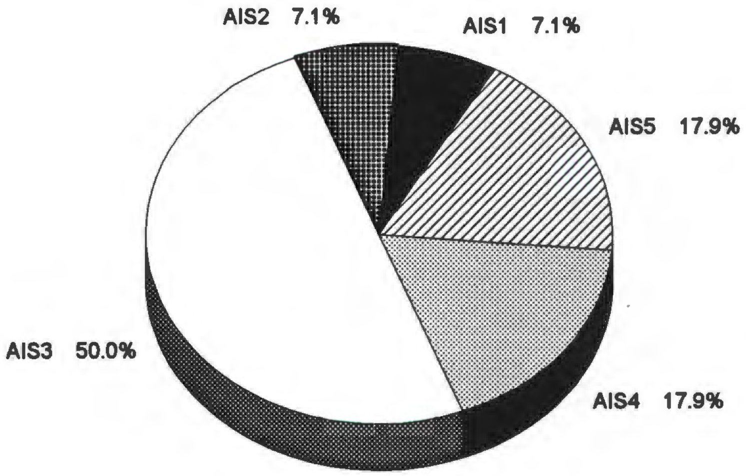

Figure 8.7 : Abdominal lesions by AIS in Hospital Pedestrians (n=24)

Sixty percent of the patients with abdominal injuries were struck by vehicles on roads with speed limits ≥80 km/hr and 25% were struck by heavy vehicles such as buses or minibus taxis.

Of the 20 patients with abdominal injuries, only three had isolated abdominal lesions. The other 17 patients (85%) had polytrauma. The most frequent combinations of the latter were:

- abdomen, head, lower limb, thorax and spine (17.6%);
- abdomen, head, lower limb and upper limb (11.8%);
- abdomen, head, lower limb and thorax (11.8%);
- abdomen, head, lower limb and face (11.8%).

One patient died while being resuscitated in the trauma unit. This patient had three severe (AIS 5) injuries, i.e. a closed head injury, bilateral flail chest and a ruptured spleen. His abdominal injury obviously contributed to his early demise, but could not be defined as the actual cause of death.

Nineteen patients were admitted to hospital. Nine were admitted directly to an ICU where they spent an average of 8.9 days (±8.8).

Two further patients died while in hospital. One patient, who had a crushed skull and a retroperitoneal haematoma, was declared brain dead and transferred to an ICU where permission was obtained from his relatives for organ donation. The other patient died as a result of a Gram-negative septicaemia from his abdominal injuries (see Case Study D).

Case Study D

Mr A was admitted to trauma unit at 05h00 after a suicide attempt: he had thrown himself in front of a bus. His injuries were severe. He had a closed head injury (AIS 4) and multiple abdominal injuries. Most notable were a crushed pelvis, ruptured bladder and amputated penis. He was intubated, haemodynamically stabilised and taken to theatre, where he spent many hours. Thereafter he was admitted to a surgical ICU where desperate attempts were made to stabilise him but he became progressively more shocked, developed a Gram-negative septicaemia and died on day 3. Mr A was BAC negative.

Seventeen of the 20 patients with abdominal injuries survived but eight of them (47.1%) were later sent to convalescent institutions for the on-going management of their concomitant injuries.

Of the 20 patients with abdominal injuries, 11 (55%) were BAC positive. These 11 pedestrians had a mean BAC of 0.20 g/100ml (±0.07). Pedestrians who were BAC positive appeared to be at no greater risk of sustaining an abdominal injury than their BAC negative counterparts (χ^2=0.12, P=0.7).

8.2.3.6 Upper Limb Injuries

Fifty-two pedestrians (26.5%) sustained an injury to the upper limb(s). These 52 pedestrians had 54 separate upper limb lesions, the majority of which (77.8%) were orthopaedic in nature (Table 8.7).

Table 8.7 : Upper limb lesions sustained by Hospital Pedestrians

TYPE OF LESION	NUMBER (n=54)	%
Skin injury	12	22.2
Joint injury	8	14.8
Tendon injury	1	1.9
Fractures		
Clavicle	11	20.4
Humerus	14	25.9
Scapula	3	5.6
Ulna	1	1.9
Radius	2	3.7
Hand (nil further specified)	2	3.7

As can be seen from Figure 8.8, most upper limb lesions were moderate in severity, with a median AIS of 2 (mean AIS=2).

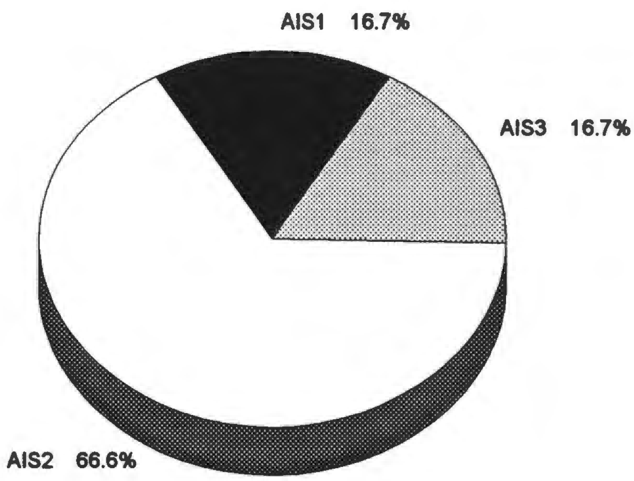

Figure 8.8 : Upper limb lesions by AIS in Hospital Pedestrians (n=54)

The left and right upper limbs appeared to be almost equally affected (Figure 8.9). However, nearly all pedestrians (93.8%) who had sustained both upper and lower limb lesions had ipsilateral injuries.

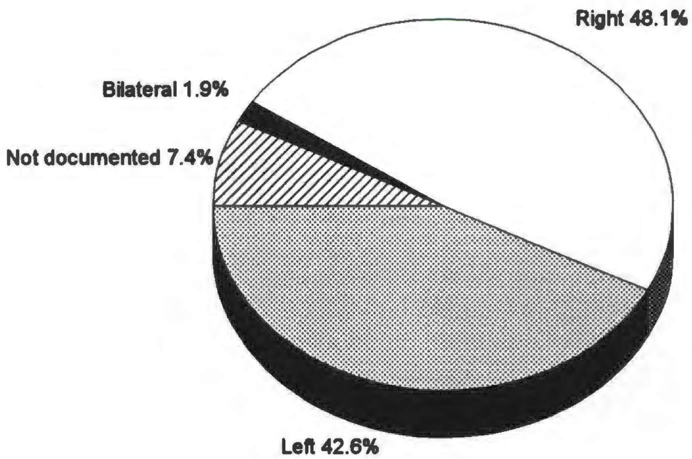

Figure 8.9 : Sides affected in upper limb injuries in Hospital Pedestrians (n=52)

Seventy-five per cent of patients with upper limb injuries had polytrauma. The most common combinations for these polytrauma patients with upper limb injuries were:

- upper limb and lower limb (17.9%);
- upper limb and head (15.4%);
- upper limb, head and lower limb (10.3%).

Two patients with upper limb injuries died while being resuscitated in trauma unit but both had severe concomitant head and/or abdominal injuries.

Thirty-nine patients with upper limb injuries were admitted to hospital. Thirteen were admitted directly to ICU for an average of 8.4 days (±9.7) but all these patients had other more severe injuries. Two of these polytrauma patients died in ICU.

Thirty-seven patients with upper limb injuries survived but 15 (40.5%) were transferred to a convalescent hospital for the after-care of their upper limb and other injuries.

Of the 52 patients with upper limb injuries, 36 (69.2%) were BAC positive. These 36 pedestrians had a mean BAC of 0.18 g/100ml (±0.08). Pedestrians who were BAC positive were no more likely to sustain an upper limb injury than their BAC negative counterparts (χ^2=1.48, P=0.2).

8.2.3.7 Pelvis and Lower Limb Injuries

Nearly three-quarters (70.4%) of the pedestrians sustained an injury to the pelvis or lower limb(s). These 138 patients sustained 232 separate lower limb lesions, i.e. on average each of these patients had 1.7 lower limb lesions (Table 8.8).

Table 8.8: Pelvis and Lower limb lesions sustained by Hospital Pedestrians

INJURY	LESIONS (n=232)	%
Skin injury	21	9.1
Joint injury	21	9.1
Tendon injury	14	6.0
Blood vessel injury	7	3.0
Traumatic amputation (below-knee)	3	1.3
Fractures		
Pelvis	28	12.1
Femur	29	12.5
Fibula	44	19.0
Tibia	59	25.4
Metatarsus	4	1.7
Calcaneus	1	0.4
Talus	1	0.4

Most of these lesions were orthopaedic in nature and, as can be seen in Figure 8.10, the majority were moderate in nature with a median AIS of 2 (mean AIS=2.3).

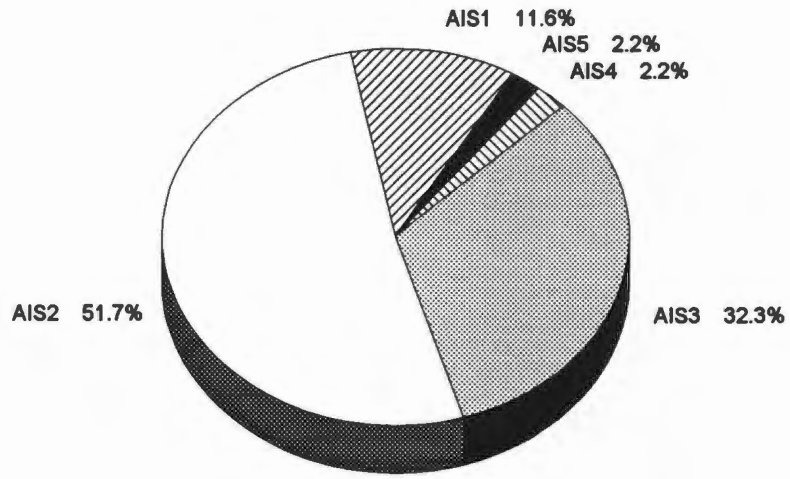

Figure 8.10 : Pelvis and Lower limb lesions by AIS in Hospital Pedestrians (n=232)

Left and right lower limbs were almost equally affected, but nearly one-quarter (21.1%) of these patients had sustained bilateral lesions (Figure 8.11).

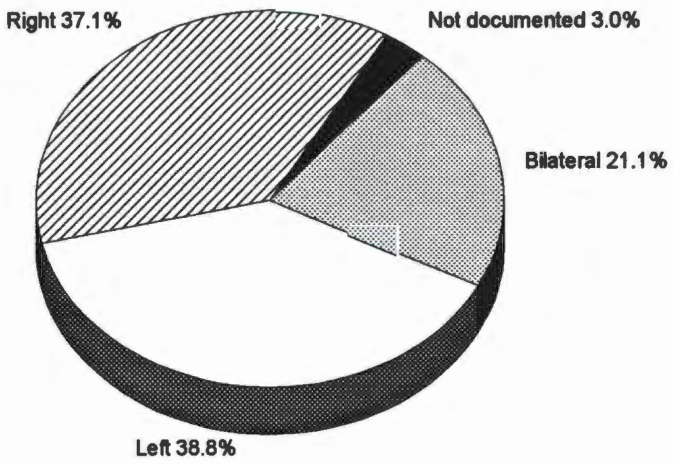

Figure 8.11 : Sides affected in lower limb injuries in Hospital Pedestrians (n=138)

Seventy-two of these pedestrians (52.2%) had isolated lower limb injuries. However, of the 66 who had polytrauma the most common combinations were:

- lower limb and head injury (18.2%);
- lower limb and upper limb injury (10.6%).

Four patients died while being resuscitated in trauma unit - one had a traumatic lower limb amputation only (see Case Study E) while the other three all had concomitant severe closed head injuries.

Case Study E

An unknown patient was found lying on the side of a highway at 20h00 on a Saturday evening. He was profoundly shocked and hypothermic. The Ambumedics were unable to find a vein for cannulation and he was rapidly transported to trauma unit. His only injury was a right below-knee traumatic amputation. On arrival in trauma unit he was bradycardic, had an unrecordable blood pressure and fixed dilated pupils. He was resuscitated and warmed but, despite all efforts, was certified dead approximately an hour later. He was BAC negative.

Ninety-seven patients with lower limb injuries were admitted to hospital. Seventeen were admitted directly to an ICU where they spent an average of 9.7 days (±8.7). All of these patients had polytrauma, three of whom died while in ICU.

Ninety-four patients survived but 23 (24.5%) were transferred to a convalescent hospital for the after-care of their injuries.

Of the 138 patients with lower limb injuries, 80 (58%) were BAC positive. These 80 pedestrians had a mean BAC of 0.19 g/100ml (±0.07). Pedestrians who were BAC positive were no more likely to sustain a lower limb injury than their BAC negative counterparts (χ^2=1.6, P=0.2).

8.2.4 THE SEVERITY OF INJURIES SUSTAINED

8.2.4.1 Introduction

Injury severity scores were calculated for hospital pedestrians using the conventional method as described by Baker et al. (1974b), i.e. using the sum of the squares of the highest AIS ratings in three different body regions. This method has, however, been found to have shortcomings (see Ch 7, p126), particularly in patients who have more than one significant lesion in the same body region. A new method of injury severity scoring was proposed in 1995 and called the New Injury Severity Score (NISS) (Osler, Baker & Long, 1996). It involves using the three highest AIS ratings regardless of body region. This score was therefore also calculated.

8.2.4.2 ISS versus NISS

The conventional ISS and NISS ratings were calculated for hospital pedestrians. As can be seen in Table 8.9, proportionally fewer patients obtained low injury severity scores using the new method. The overall median score for the ISS was found to be 9 (mean 14.3) while the overall median NISS was found to be 11 (mean 16.7). A statistically significant difference was found between these two results (Rank Sum=1374.5, $P<0.0001$), indicating that the NISS scores higher than the old method and is thus probably more representative in patients with polytrauma.

Table 8.9 : ISS versus NISS in Hospital Pedestrians (n=196)

	ISS		NISS	
Range	**n**	**%**	**n**	**%**
1 - 8	83	42.3	75	38.3
9 - 15	60	30.6	54	27.5
16 - 24	20	10.2	28	14.3
25 - 40	18	9.2	17	8.7
41 - 49	5	2.6	6	3.1
50 - 66	5	2.6	11	5.6
75	5	2.6	5	2.6

Although the two methods of calculating injury severity produced significant differences in most of the body regions (Table 8.10), the clearest differences were seen in patients who had head injuries or lower limb injuries.

Table 8.10 : ISS versus NISS according to body region injured

	ISS		NISS		DIFFERENCE*
REGION	**MEDIAN**	**MEAN**	**MEDIAN**	**MEAN**	**P VALUE**
Head	13	21.6	17	24.3	< 0.0001
Face	11	14.5	12	16.0	0.0001
Spine	14	24.0	17	26.0	0.0039
Thorax	22	26.5	22	28.0	0.11
Abdomen	35.5	37.8	35.5	39.1	0.0001
Upper limb	15.5	22.3	17	24.2	0.0006
Lower limb	9	14.5	12	16.9	< 0.0001

* Wilcoxon Signed Rank Test

As a result of these findings, injury severity is assessed according to the NISS for the rest of this thesis.

8.2.4.3 The severity of injuries sustained by Hospital pedestrians

Overall NISS ratings for hospital pedestrians were found to be fairly severe (Figure 8.12), with a median NISS of 11 and a mean 16.7.

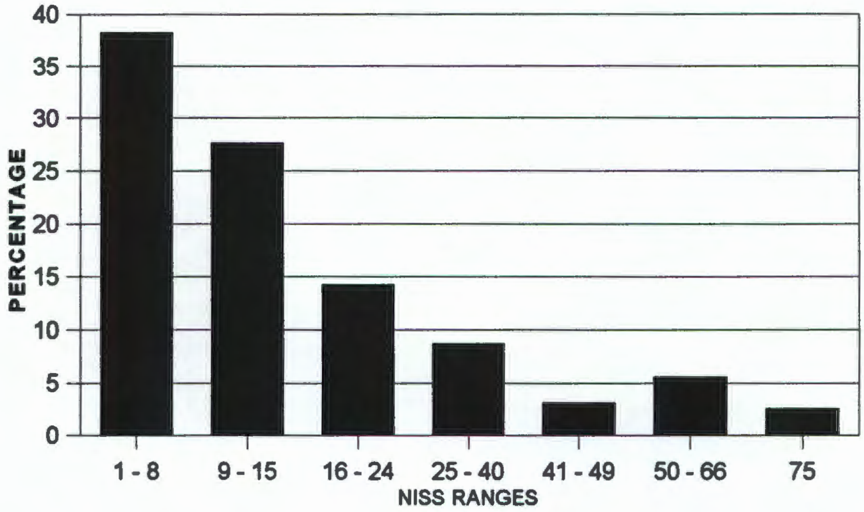

Figure 8.12 : NISS ratings in Hospital Pedestrians (n=196)

This study showed an interesting an unusual relationship between age and injury severity (Table 8.11). The elderly patients did not haver higher NISS scores than those in their teens and twenties - in fact the patients aged 30 to 39 years had the highest median NISS ratings.

Table 8.11 : NISS by age groups in Hospital pedestrians (n=196)

AGE GROUPS	NISS		
	n	MEDIAN	MEAN
< 20 years	16	9	14
20-29 years	68	9	13.7
30-39 years	46	17	25.5
40-49 years	35	9	13.5
50-59 years	20	13	17.4
60+ years	11	13	13.8

Pedestrians who were struck by heavy vehicles such as taxis sustained significantly more severe injuries than those who were struck by lighter vehicles, viz. median NISS ratings of 12 versus 8, respectively (Wilcoxon rank sum, P=0.024). As would be expected, pedestrians struck by vehicles on heavy flow roads sustained more severe injuries than those struck on light flow roads (median NISS = 12 versus 10) but this difference did not reach statistical significance. What was very interesting to note was that although many pedestrians were injured in 'informal' settlements they sustained significantly less severe injuries than those injured in other areas, viz. median NISS ratings of 9 versus 13 (Wilcoxon rank sum, P=0.05). This is possibly because vehicles travel much slower in these areas because their are no formal roads.

As would be expected, there was a clear trend between injury severity and the level of care required by the patients, viz. those patients who were discharged had the lowest NISS scores, while those patients who died had the highest NISS ratings (Table 8.12). The median NISS for patients who were admitted to hospital or who died (in the prehospital phase or while in hospital) was 17 (IQR 10-15).

Table 8.12 : NISS by level of care required in Hospital pedestrians (n=196)

		NISS	
LEVEL OF CARE REQUIRED	n	MEDIAN	MEAN
Discharged	57	5	5.4
Admitted to a ward*	108	12	14.9
Admitted to an ICU*	21	41	39.7
Died in ward/ICU	6	62.5	51.7
Died in Trauma Unit	4	75	58.5

* Excluding those who subsequently died of their injuries

Although a direct correlation between individual NISS ratings and BAC levels could not be established, there was a definite trend between NISS ranges and BAC groups, particularly in the higher NISS ranges (Figure 8.13).

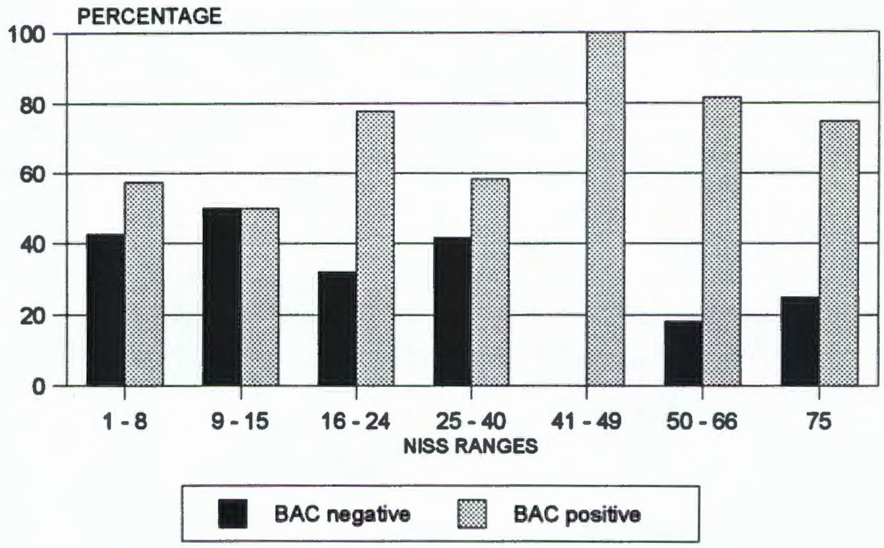

Figure 8.13 : NISS ranges by BAC group in Hospital Pedestrians (n=196)

8.3 MORTUARY PEDESTRIANS

8.3.1 INTRODUCTION

Injuries sustained by the 31 pedestrians who died in the pre-hospital phase were also coded, using the 1990 revision of the AIS with the assistance of a Forensic Pathologist.

8.3.2 CAUSE OF DEATH

The cause of death could be definitely assigned by the pathologist in 19 of the 31 cases, i.e. they only had one AIS 6 injury. In six cases there were two or more AIS 6 injuries and so a definite single cause could not be ascertained. Six cases did not have any AIS 6 injuries, but had polytrauma with ISS ratings between 35 and 59. In the latter cases, the highest AIS was taken as the most likely cause of death (Table 8.13). Overall, head injuries appeared to be the single largest cause of death.

Table 8.13: Causes of death in Mortuary pedestrians (n=31)

REGION	CAUSE OF DEATH DEFINITE n (%)	PROBABLE n (%)	POSSIBLE n (%)	TOTAL n (%)
Head	12 (38.7)	3 (9.7)	3 (9.7)	18 (58.1)
Spine	1 (3.2)	3 (9.7)	0	4 (12.9)
Thorax	6 (19.4)	0	0	6 (19.4)
Abdomen	0	0	3 (9.7)	3 (9.7)

8.3.3 THE TYPE OF INJURY BY BODY REGION

All these cases had polytrauma: on average each had five lesions. The most common lesions were to the head, chest, lower limb(s) and abdomen (Table 8.14).

Table 8.14: Injuries sustained by Mortuary Pedestrians (n=31)

BODY REGION	PATIENTS n	%
Head	26	83.9
Face	9	29.0
Spinal column	10	32.2
Thorax	26	83.9
Abdomen	20	64.5
Upper limb(s)	11	35.4
Lower limb(s)	24	77.4

8.3.3.1 Head Injuries

Of the 31 mortuary pedestrians, 26 (83.9%) had a documented head injury, involving 31 separate lesions (Table 8.15).

Table 8.15: Head lesions sustained by Mortuary Pedestrians

TYPE OF LESION	NUMBER (n=31)	%
Crush*	10	32.3
Severe brain stem injury	5	16.1
Massive cerebral contusion, haematomas	11	35.5
Scalp laceration with massive blood loss	5	16.1

* massive destruction of both skull and brain

From Figure 8.14 it can be seen that almost half of all the head lesions had AIS ratings of 6 and that the median AIS was 5 (mean AIS=4.8).

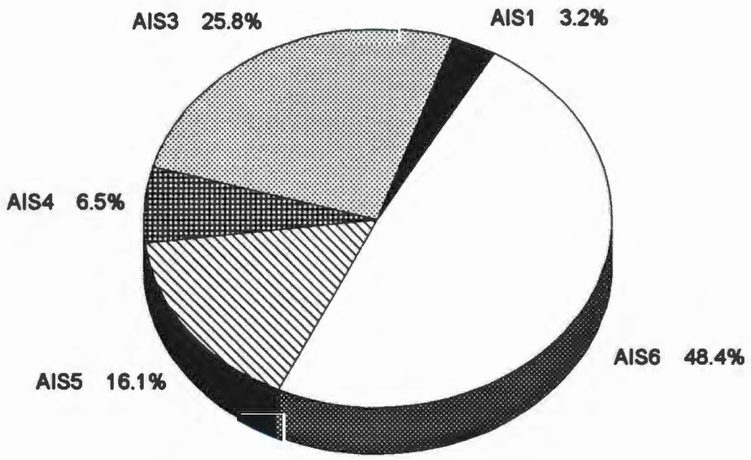

Figure 8.14 : Head lesions by AIS in Mortuary Pedestrians (n=31)

Eighteen of the 26 mortuary pedestrians (69.2%) with head injuries were BAC positive at the time of their death. These 18 pedestrians had a mean BAC of 0.23 g/100ml (±0.1). Furthermore, 11 of the 15 pedestrians (73.3%) who definitely or probably died of head injuries were BAC positive.

8.3.3.2 Facial Injuries

Of the 31 mortuary pedestrians, 9 (29.0%) had a documented facial injury involving 10 separate lesions. Eight of the lesions were skin lacerations, contusions or abrasions while two lesions were fractures of the mandible.

Nine of the ten facial lesions sustained by mortuary pedestrians had AIS ratings of 1 and one lesion had an AIS rating of 2.

Two-thirds of cases with facial injuries were BAC positive, with a mean BAC of 0.16 g/100ml (±0.03).

8.3.3.3 Spinal Column Injuries

Of the 31 mortuary pedestrians, 10 (32.3%) had a documented spinal column injury involving 11 separate lesions (Table 8.16). All the spinal column injuries would have caused complete cord paralysis.

Table 8.16: Level of spinal column lesions sustained by Mortuary pedestrians

INJURY SUSTAINED	LESIONS (n=11)	%
First to third cervical spine lesion with complete cord paralysis	6	54.5
Fourth to seventh cervical spine lesion with complete cord paralysis	1	9.1
Thoracic spine lesion with complete cord paralysis	4	36.4

Fifty percent of pedestrians with spinal column injuries were BAC positive at the time of their death. These five pedestrians had a mean BAC of 0.33 g/100ml (±0.07).

8.3.3.4 Thoracic Injuries

Of the 31 mortuary pedestrians, 26 (83.9%) had a documented thoracic injury, involving 37 separate lesions (Table 8.17).

Table 8.17: Thoracic lesions sustained by Mortuary Pedestrians

INJURY SUSTAINED	LESIONS (n=37)	%
Ruptured aorta	7	18.9
Ruptured pulmonary artery	1	2.7
Ruptured heart	3	8.1
Lacerated lung	4	10.8
Bilateral fractured ribs with flail chest	5	13.5
Unilateral fractured ribs	11	29.7
Haemo/pneumothorax	4	10.8
Skin injury	2	5.4

As can be seen in Figure 8.15, the majority of thoracic injuries were severe, with a median and mean AIS of 4.

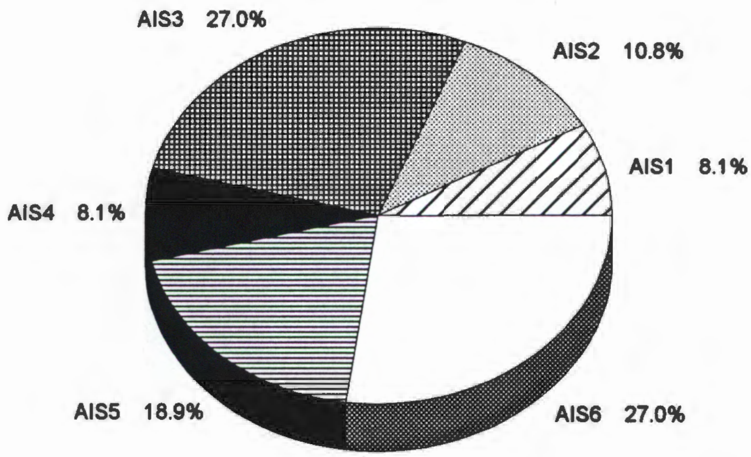

Figure 8.15 : Thoracic lesions by AIS in Mortuary Pedestrians (n=37)

Seventeen of the 26 pedestrians (65.4%) with thoracic injuries were BAC positive at the time of their death. These 17 pedestrians had a mean BAC of 0.20 g/100ml (±0.09).

8.3.3.5 Abdominal Injuries

Of the 31 mortuary pedestrians, 20 (64.5%) had documented abdominal injuries involving 26 isolated lesions (Table 8.18).

Table 8.18: Abdominal lesions sustained by Mortuary Pedestrians

INJURY SUSTAINED	LESIONS (n=26)	%
Liver laceration	13	50.0
Spleen laceration	3	11.5
Kidney laceration	1	3.8
Perineum laceration	1	3.8
Colon contusion	1	3.8
Lacerated abdominal artery	1	3.8
Skin injury	6	23.2

As can be seen in Figure 8.16, the majority of abdominal injuries were severe in nature, with a median AIS of 4 (mean AIS=3.5).

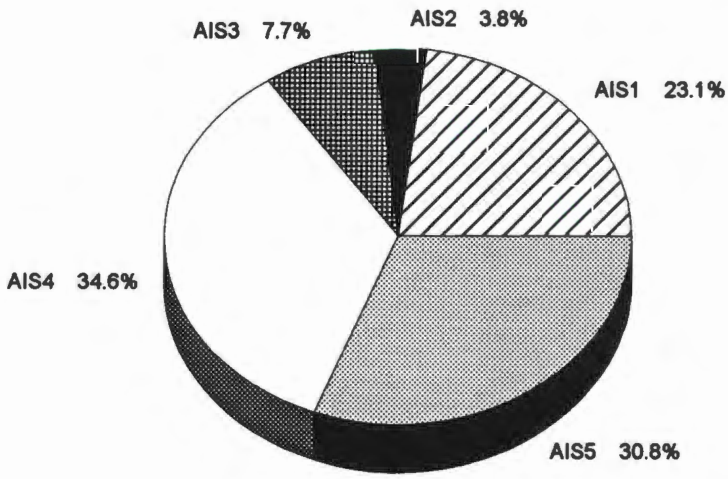

Figure 8.16 : Abdominal lesions by AIS in Mortuary Pedestrians (n=26)

Sixty-five percent of cases with abdominal injuries were BAC positive at the time of their death. These 13 pedestrians had a mean BAC of 0.21 g/100ml (±0.11).

8.3.3.6 Upper Limb Injuries

Of the 31 mortuary pedestrians, 11 (35.5%) had documented upper limb injuries involving 13 isolated lesions (Table 8.19).

Table 8.19: Upper limb lesions sustained by Mortuary Pedestrians

TYPE OF LESION	NUMBER (n=13)	%
Fractures		
Clavicle	2	15.4
Humerus	4	30.8
Radius	1	7.7
Ulna	1	7.7
Skin injury	5	38.5

Nearly two-thirds (61.5%) of upper limb lesions were fractures. The overall severity of upper limb injuries was mild to moderate - all lesions had either a 1 or 2 AIS rating.

Upper limb lesions were equally divided between the left and right sides of the body.

Nine of the eleven cases (81.8%) with upper limb lesions were BAC positive at the time of their death. These 9 pedestrians had a mean BAC of 0.25 g/100ml (±0.11).

8.3.3.7 Pelvis and Lower Limb Injuries

Of the 31 mortuary pedestrians, 24 (77.4%) had documented pelvic or lower limb injuries involving 35 isolated lesions (Table 8.20). More than three-quarters (82.9%) of the lesions were fractures or dislocations - almost half of which were pelvic fractures.

Table 8.20: Pelvis and Lower limb lesions sustained by Mortuary Pedestrians

TYPE OF LESION	NUMBER (n=35)	%
Fractures		
Pelvis	12	34.3
Femur	7	20.0
Fibula	6	17.1
Tibia	3	8.6
Knee dislocation	1	2.9
Skin injury	6	17.1

As can be seen in Figure 8.17, the pelvic and lower limb lesions were moderate in severity with a median AIS of 2 (mean AIS=2.3).

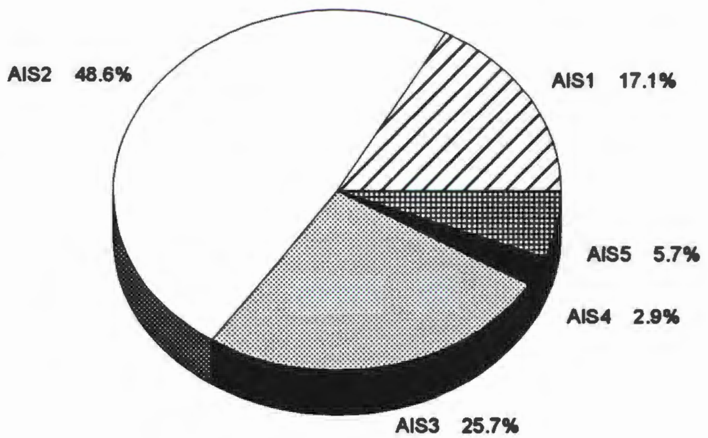

Figure 8.17 : Pelvis and lower limb lesions by AIS in Mortuary Pedestrians (n=35)

Lesions of the pelvis and lower limbs were equally divided between the left and right sides of the body.

Three-quarters of cases with pelvic or lower limb injuries were BAC positive at the time of their death. These 18 pedestrians had a mean BAC of 0.20 g/100ml (±0.09).

8.3.4 INJURY SEVERITY IN MORTUARY PEDESTRIANS

The NISS versus the ISS did not produce any significantly different results in Mortuary pedestrians. The mean injury severity score for Mortuary pedestrians was 70 (median 75) using both methods of scoring.

8.4 DISCUSSION

To the author's knowledge this study includes the most comprehensive analysis of the injuries sustained by pedestrians in developing countries. Indeed, there is very little literature on the topic even from developed countries.

In order to put the comparisons made in this chapter into perspective, it is necessary to first outline some of the differences between pedestrian studies conducted in developed countries and this one conducted in Cape Town.

The majority of the studies reviewed from developed countries such as the USA, Australia and the UK were conducted at Level I trauma units or centres. In these regions, patients are usually triaged by Advanced Trauma Life Support (ATLS) personnel at the scene of the collision and then taken to an appropriate facility.

This means, in general, that Level I trauma facilities only treat patients with moderate to severe injuries, the majority of whom require hospital admission. Furthermore, these developed countries also tend to have good hospital infrastructures, their ambulance communication services are sophisticated, helicopter transportation is often used and all emergency service staff are well trained.

Groote Schuur Hospital is a tertiary facility and as such the trauma unit should operate as a Level I facility. In practice this does not occur. Although the ambulance personnel in the Cape metropole are reasonably well trained and are capable of triaging patients correctly, there is a dearth of Level II and Level III facilities in the Cape metropole and consequently patients with mild or moderate injuries are taken to GSH out of necessity. Consequently this facility sees many patients who are 'inappropriate' (Peden, Van der Spuy & Abrahams, 1996). Furthermore, due to hospital staff constraints and budgetary cuts, the availability of beds in the hospital has been drastically reduced - particularly in Intensive Care Units. This means that only the most 'deserving' patients are admitted to ICUs. It also causes some patients who, in an ideal situation, should be admitted overnight for observation to be discharged after assessment.

Another difference between the results obtained in developed and developing countries is that in Cape Town 67.4% of all pedestrian deaths occur in the prehospital phase (National Trauma Research Programme, 1990). Also, as was seen by the map on p105, patients are transported considerable distances to GSH (without the aid of helicopters) and many do not reach hospital within the 'golden hour'. Consequently, some critically injured patients die on their way to the hospital.

8.4.1 INJURIES SUSTAINED BY HOSPITAL PEDESTRIANS

Lower limb lesions and head injuries were the most common injuries seen in the pedestrians who arrived alive at hospital. This correlates with both the mechanism of injury and the pattern of injuries documented in many other pedestrian studies (Atkins et al., 1988; Hill et al., 1993; Vestrup & Reid, 1989). The classic triad of injuries (knee, pelvis and head) described by Farley in 1969 could not be demonstrated in this study.

The overall injury severity of Hospital pedestrians was moderate to severe and most pedestrians had at least two lesions. This is the case in most pedestrian studies (Hall & Fisher, 1972; Hill et al., 1993; Wyss et al., 1990).

Almost half of the pedestrians had polytrauma. These patients were more likely to have been injured on roads with high volumes of traffic and high speed limits (between 80 and 120 kmph). These results confirm those of previous studies which have found a direct correlation between the speed of the vehicle and the injury severity (Lerer, 1992a; Zivot & Di Maio, 1993). Consequently, the admission rate for such patients was high and many required ICU management, particularly those with head and visceral injuries.

The polytrauma patients were also more likely to have consumed alcohol and had higher BAC levels than the patients who had single system injuries, confirming that alcohol pre-selects for severity of injury (Glucksman, 1994; Raffle, 1989).

The most common lesions in Hospital pedestrians were fractures to the lower limbs, most notably to the tibia, fibula, femur and pelvis, but substantial numbers of patients also sustained visceral injuries. These results were also found by Balogun & Abereoje (1992) in Nigeria and Brainard et al. (1989; 1992) and Wyss et al. (1992) in some developed countries.

Patients with head injuries were generally the most severely injured and many required admission to an ICU. Consequently, head injured patients had a high mortality rate and many were left with permanent disabilities. Furthermore, this study indicated a direct correlation between alcohol intoxication and head injury, confirming previous findings that alcohol and head injuries commonly co-exist in injured pedestrians (S. Lee et al., 1990; Rutherford, 1977; Vestrup & Reid, 1989). In fact, this study found that patients who were BAC positive at the time of their collision were twice as likely to sustain a head injury than their sober counterparts.

Although patients with head injuries commonly also had injuries to other regions of the body, there were very few patients who had both head and spinal column injuries despite the notion that these two types of injuries often co-exist.

With regard to spinal column injuries, the majority were minor in nature but there were four Hospital pedestrians who sustained cord damage. One of these patients died in hospital while the other three were transferred to a spinal unit for the long-term management of their injuries. Although this study could not show a direct correlation between alcohol intoxication and spinal column injuries it did find that patients who had spinal injuries also had very high BAC levels.

In general, patients who sustained visceral injuries had very high injury severity scores, particularly those with abdominal or thoracic visceral injuries. In fact, patients with abdominal lesions were by far the most severely injured and many required ICU management. More than half of these patients were injured on roads with high speed limits and one-quarter were hit by heavy vehicles, such as buses or minibus taxis, thus confirming that speed is a factor which influences injury severity and is amenable to modification (MacKay, 1994). As in most instances of severe injury, patients with visceral lesions had exceptionally high BAC levels.

A quarter of Hospital pedestrians had upper limb injuries and three-quarters had lower limb injuries. The majority of these limb injuries were orthopaedic in nature. Although right sided limb injuries are more common in countries where cars travel on the left hand side of the road (MacKay, 1994), this could not be demonstrated in this study. The left and right sides were equally affected although a significant number of pedestrians had bilateral injuries. In patients who had both upper and lower limb injuries, an ipsilateral dyad was evident, as has been found in other studies (Brainard et al., 1992).

8.4.2 INJURIES SUSTAINED BY MORTUARY PEDESTRIANS

Almost 14% of all the pedestrians in this study died in the prehospital phase and were taken directly to the mortuary. Most of these died as a result of a head or thoracic injury, as has been found in other studies (Atkins et al., 1988; Brainard et al., 1989; Sevitt, 1973).

All the Mortuary patients had polytrauma, the most common combinations being lesions to the head, lower limbs and thorax.

Since three-quarters of the Mortuary pedestrians were BAC positive at the time of their collision and the majority died as a result of a head injury it was not surprising that this study found alcohol to be a major risk factor for head injury. This confirms Rutherford's (1977) finding that drunk pedestrians have a greater likelihood of sustaining and dying of a significant head injury.

8.4.3 INJURY SEVERITY

Both the 'old' ISS and the new version of this score, the NISS, were calculated in this study. The NISS was found to be superior since it produced consistently higher injury severity scores which more accurately reflected the polytrauma most pedestrians sustained. This was most notable among patients who had multiple injuries in one body region, particularly when the head and lower limbs were involved. These results confirm those of authors who have recently advocated this modified version of the ISS (Osler et al., 1996).

Patients between 30 and 39 years of age had the highest NISS ratings. Patients in this age range were also more likely to be BAC positive and had the highest mean BAC levels, suggesting once again that alcohol intoxication pre-selects for severity (Dischinger et al., 1988; Soderstrom & Eastham, 1987a).

As has been reported in many studies of this nature, a direct relationship was found between speed and injury severity (Baker et al., 1992; Lerer, 1992a; Zivot & Di Maio, 1993; Hall & Fisher, 1972), and vehicle size and injury severity (Baker et al., 1992). In areas where vehicle speed is likely to be lower, as in 'informal settlements', injury severity was also found to be lower than in higher speed areas.

There was very little difference between the NISS and the ISS in Mortuary pedestrians because the majority of these cases obtained a score of 75 using either method. This confirms the findings of Osler et al. (1996) who suggest that the NISS is of greatest benefit in the lower injury severity ranges (NISS<9). In other words, the NISS is more capable of differentiating survival potential in patients with less severe injuries or multiple injuries in one body region.

8.5 CHAPTER SUMMARY

This chapter has outlined the injuries and injury severity sustained by both Hospital and Mortuary pedestrians. The risk of sustaining different types of injuries in relation to alcohol intoxication was also assessed.

The next chapter will address some of the postcrash factors, such as management and outcome, following a pedestrian collision.

CHAPTER NINE

THE MANAGEMENT OF INJURED PEDESTRIANS

> *"Alcohol intoxication appears to affect the initial evaluation and management of trauma patients. ... early knowledge of the BAC level in trauma patients is both necessary and important in the interpretation of clinical findings and may lead to decreased use of certain invasive diagnostic procedures."* (Jurkovich et al., 1992:708)

9.1 INTRODUCTION

The previous chapter has presented the type of injuries sustained by both Hospital and Mortuary pedestrians, as well as the severity of these injuries. This chapter looks at how the body responds to injury, what management is needed and how well pedestrians recover after such an insult. These results pertain only to Hospital pedestrians (n=196).

A short section on the costs incurred by fatally and non-fatally injured pedestrians is also included.

9.2 THE BODY'S RESPONSE TO INJURY

9.2.1 INTRODUCTION

Systolic blood pressure (SBP), respiratory rate and the Glasgow Coma Scale (GCS) were documented for all Hospital pedestrians in order to calculate the Revised Trauma Score (RTS), which is a measure of physiological derangement as a result of injury.

This section presents the results of these three indicators and then goes on to present the RTS and TRISS results.

9.2.2 SALIENT INDICATORS

9.2.2.1 Systolic Blood Pressure

Systolic blood pressure (SBP) was unrecordable in 5 pedestrians (Table 9.1). In those patients with recordable blood pressures (n=191) the mean SBP was 125.4 mmHg (±23.8), with a range of 60 to 195 mmHg.

Table 9.1 : Systolic blood pressure in Hospital Pedestrians (n=196)

SBP RANGE* (in mmHg)	n	%
0	5	2.6
1-49	0	0
50-75	7	3.6
76-89	3	1.5
90+	181	92.3

* Ranges as prescribed for the calculation of the Revised Trauma Score

There were no significant differences in SBP for gender or race. Furthermore, there were no significant differences in SBP with age, despite the fact that many of the elderly pedestrians may have been hypertensive before their injury. There was, however, an indirect correlation between SBP and NISS ($r=-0.36$, $P<0.001$), i.e. as the injury severity increased the systolic BP decreased (Figure 9.1).

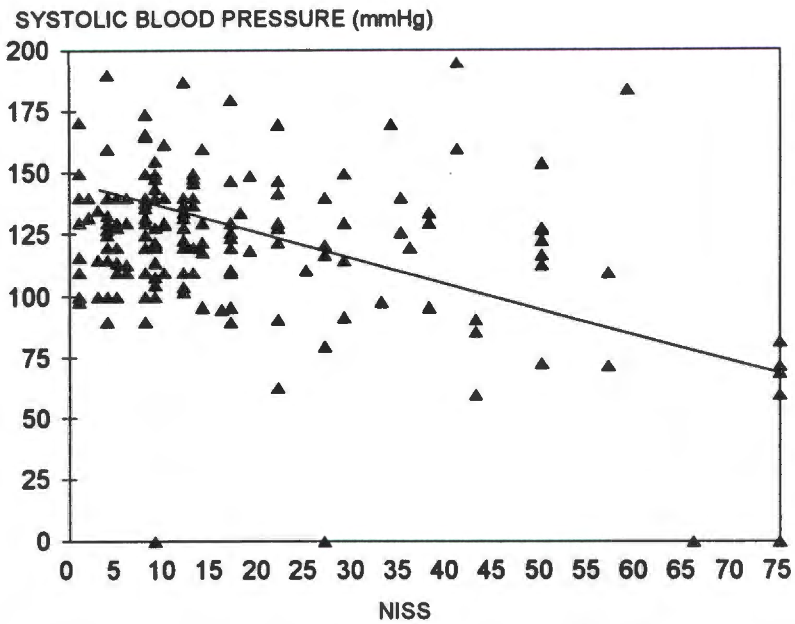

Figure 9.1 : **Systolic blood pressure versus NISS in Hospital Pedestrians (n=196)**

There were significant differences in mean SBP depending on the body region injured. Moreover, patients who sustained polytrauma had significantly lower systolic blood pressures than those with single system trauma (T=2.4, P=0.02). This applied particularly to polytrauma patients who had sustained injuries to the spinal column or abdomen (Table 9.2).

Table 9.2 : **Mean systolic blood pressure in polytrauma pedestrians by body region injured**

POLYTRAUMA INCLUDING	$\bar{x}$ SBP (mmHg) WITH INJURY	$\bar{x}$ SBP (mmHg) WITHOUT INJURY	P VALUE*
Head injury	112.3	127.8	NS
Facial injury	125.6	110.6	NS
Spinal column injury	90.7	121.4	0.004
Abdominal injury	83.1	124.4	<0.0001
Thoracic injury	115.3	117.0	NS
Upper limb injury	116.0	117.4	NS
Lower limb injury	113.7	124.6	NS

* t-test

There was no statistically significant relationship between systolic blood pressure and alcohol.

9.2.2.2 Respiratory Rate

Spontaneous respiratory rates could not be recorded in 22 pedestrians, i.e. those who had been intubated and ventilated by Ambumedics in the pre-hospital phase or where this was done immediately on admission to the Trauma Unit (Table 9.3). In the 174 pedestrians who had measurable respiratory rates, the mean rate was 20 breaths/min (±5.8), with a range of 8 - 40 breaths/min.

Table 9.3 : Spontaneous respiratory rate in Hospital Pedestrians (n=196)

RANGE* (in breaths/min)	n	%
0#	22	11.2
1-5	0	0
6-9	1	0.5
10-29	159	81.1
30+	14	7.1

* Ranges as prescribed for the calculation of the Revised Trauma Score
\# Intubated and ventilated patients

There were no significant differences in respiratory rate for gender, race or age but there was a direct correlation between respiratory rate and NISS (r=0.22, P=0.0044), i.e. as the injury severity increased, the respiratory rate increased (Figure 9.2).

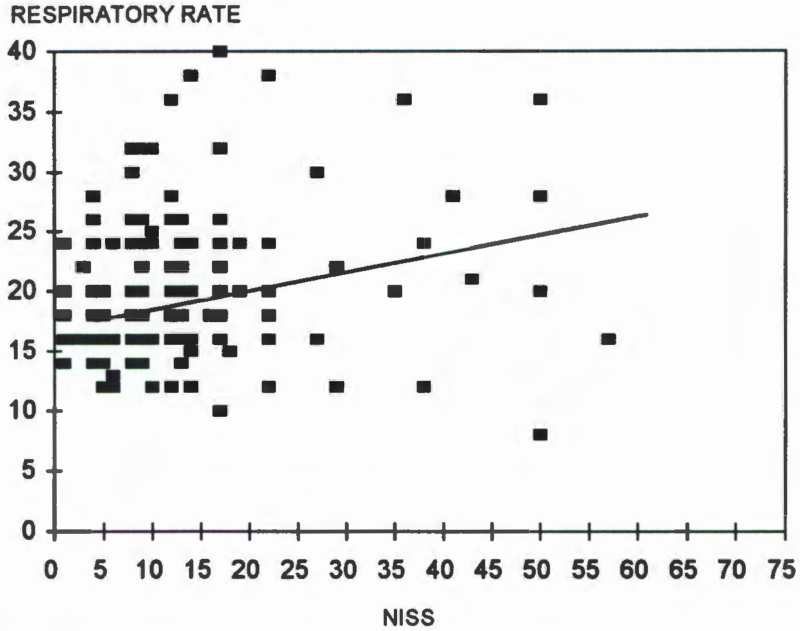

Figure 9.2 : **Respiratory rate versus NISS in Hospital Pedestrians (n=196)**

Of the 22 patients who required intubation and ventilation, 18 (81.8%) had polytrauma. Fifteen of these 18 patients were intubated and ventilated because of severe closed head injuries (AIS 5 - 6) while the remaining three were ventilated for thoracic injuries, i.e. multiple fractured ribs and/or flail chest. Of the four patients with single system injuries who required ventilation, three had severe head injuries and one was profoundly hypovolaemic due to a traumatic below-knee amputation.

There were no overall associations between alcohol and respiratory rate. However, 16 of the 22 patients who required ventilation were BAC positive while six were BAC negative but this difference did not reach statistical significance (χ^2 =0.9, P=0.3).

9.2.2.3 The Glasgow Coma Scale

The Glasgow Coma Score could be correctly calculated in 174 patients. In the 22 patients who were either ventilated and/or paralysed the verbal and motor components were each assigned a score of 1. Although this method is not standard practice [1] and is less than optimal, it was utilised so that the GCS could be used in the calculation of the Revised Trauma Score and TRISS for all patients.

The median GCS for all 196 patients was found to be 14 (mean 13.2), with 80.6% of patients having a GCS of between 13 and 15 (Table 9.4). Less than half of the patients were completely lucid (GCS = 15) and 12.2% could be considered comatose on admission (GCS $\leq$8).

Table 9.4 : Glasgow Coma Scale in Hospital Pedestrians (n=196)

RANGE*	n	%
3	7	3.6
4-5	6	3.1
6-8	11	5.6
9-12	14	7.1
13-15	158	80.6

* Ranges as prescribed for the calculation of the Revised Trauma Score

As severe head injury is almost invariably associated with a low GCS and as such patients often also have other serious lesions it was expected that there would be a strong negative association between GCS and NISS ($r=-0.76$, $P<0.001$), i.e. as the severity of injury increased the GCS decreased (Figure 9.3).

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1 The GCS is usually scored out of 10 if the patient is ventilated, out of 9 if the patient is paralysed, and out of 4 if the patient is ventilated and paralysed.

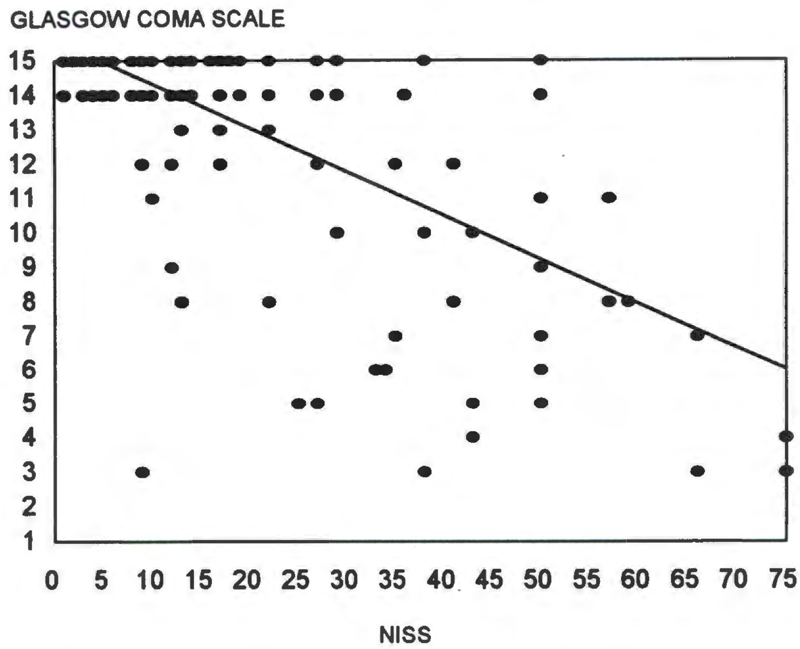

Figure 9.3 : GCS versus NISS in Hospital Pedestrians (n=196)

Patients with polytrauma had significantly lower GCS ratings than patients with single system injuries (P<0.0001). Since GCS is a measure of level of consciousness it stands to reason that polytrauma patients with head injuries would have low GCS scores but it was interesting to note that polytrauma patients without a head injury but with spinal column, abdominal or thoracic injuries also had low scores (Table 9.5). The latter results are possibly due to the fact that such patients usually have very high NISS ratings and are often in shock, are BAC positive or may even have consumed illicit drugs (all of which lower the level of consciousness).

We expected patients with head injuries to have low GCS ratings. However, it was the polytrauma patients with head and abdominal injuries who had the lowest GCS scores. The possible reasons for this were:

- patients with abdominal injuries were very severely injured - their mean NISS rating was 44.2 (±18.9);
- 82.4% of these patients had concomitant severe head injuries; and
- 52.9% required ventilation.

Table 9.5 : GCS in polytrauma pedestrians by body region injured (n=90)

POLYTRAUMA INCLUDING	MEDIAN GCS	MEAN GCS
Head injury	14	11.3
Facial injury	14	12.8
Spinal column injury	12	10.3
Abdominal injury	8	9.1
Thoracic injury	14	11.2
Upper limb injury	14	11.7
Lower limb injury	14	12.2

Patients who were BAC +ve had significantly lower GCS ratings (median = 14, mean = 12.6) than those patients who were BAC -ve (median = 15, mean = 14.1) (Wilcoxon Rank Sum Test, P=0.0001).

9.2.3 THE REVISED TRAUMA SCORE

The total unweighted RTS (see Ch 7, p133) was calculated for all 196 injured pedestrians. One patient had a score of 0 (lowest score) and 146 patients had scores of 12 (highest score). There were 32 patients (16.3%) who had unweighted RTS ratings of 10 or less [2] (Figure 9.4).

2 Patients with unweighted RTS ratings of 10 or less have high mortality rates (up to 30%) and commonly require Intensive Care management (Boffard, 1993).

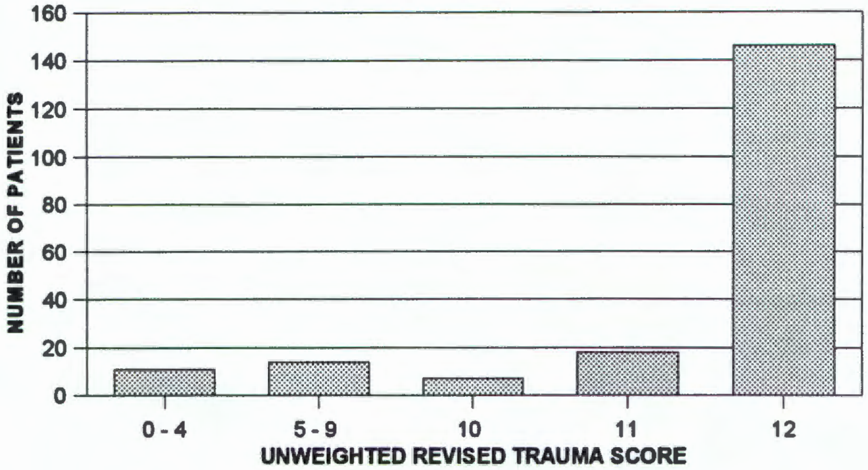

Figure 9.4 : Unweighted RTS ratings in Hospital Pedestrians (n=196)

Of the 32 pedestrians with unweighted RTS ratings of 10 or less:

- 19 (59.4%) required admission to an ICU
- 9 (28.1%) required admission to a ward, of whom 5 died; and
- 4 (12.5%) died while being resuscitated in Trauma Unit.

The overall mortality rate for injured pedestrians with unweighted RTS ratings of 10 or less was thus 28.1%.

Furthermore, BAC positive pedestrians were more than twice as likely to have RTS ratings of 10 or less than their BAC negative counterparts (OR=2.6, P=0.05).

Weighted RTS ratings were calculated for the computation of the TRISS (probability of survival) which is presented in the following section.

9.2.4 PROBABILITY OF SURVIVAL

All patients who were admitted to hospital wards or ICUs or who died soon after reaching hospital (n=139) were included in the calculation of TRISS in order to identify unexpected deaths or unexpected survivors. [3]

A PRE chart (see Ch 7, p137) was constructed for these 139 pedestrians as shown in Figure 9.5. According to this chart, patients whose co-ordinates fall above the P_s 50 isobar have survival probabilities of less than 50%, while patients whose co-ordinates fall below the line have survival probabilities exceeding 50%.

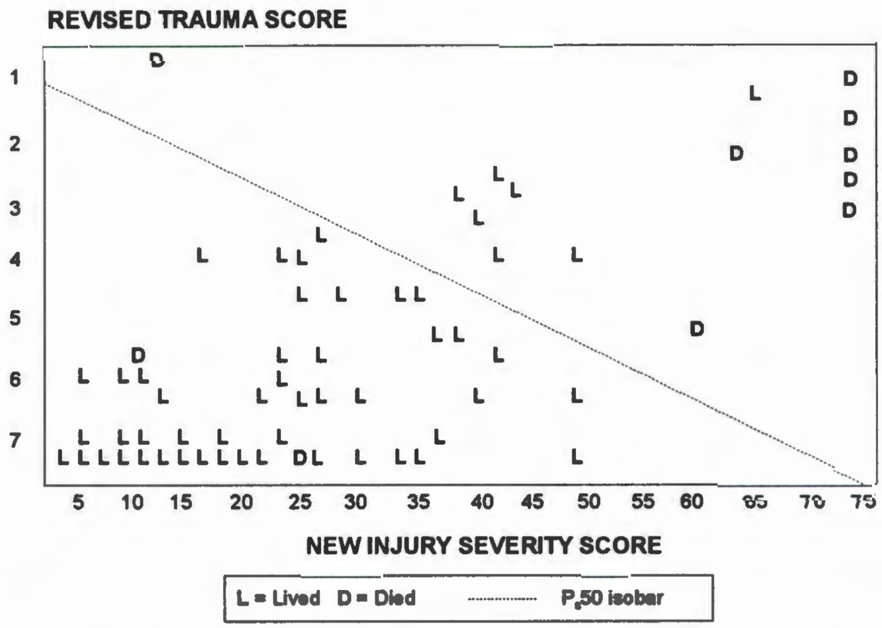

Figure 9.5 : PRE chart for pedestrians admitted to hospital wards or ICUs or who died soon after reaching hospital (n = 139)

Ten pedestrians died of whom two were "unexpected deaths" according to this methodology, i.e. they should have survived (see Case Study A and B).

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[3] According to TRISS methodology only patients admitted to hospital for ≥3 days should be included in the analysis. Since this method misses early unexpected deaths, in this study all patients who were not discharged after initial care were included.

Case Study A

Mr X had a NISS rating of 22 and a weighted RTS of 7.84. Although he had a fairly severe head injury, he did not have a CT scan, but was observed overnight for possible complications. Early the following morning he was awake and lucid and was thus discharged home with a Head Injury Form. He was brought in to Trauma Unit late the same day but was dead on arrival. A medico-legal postmortem indicated an extensive extradural haematoma. In this instance the TRISS was accurate, but the patient's management was less than optimal.

Case Study B

Mr C, a 40 year old man, presented to Trauma Unit with a moderate to severe head injury. This was his only injury. He was haemodynamically stable on admission and breathed spontaneously. A CT scan revealed multiple contusions and infarctions in the right parietal lobe as well as an extensive subdural haematoma and generalised cerebral oedema. Clinically he had a poor prognosis despite having a NISS rating of 13 and a RTS of 5.9. He died seven days later from his head injury. In this instance TRISS overestimated his probability of survival because the NISS did not accurately reflect the severity of his head injuries.

Seven patients were "unexpected survivors", i.e. they should have died according to TRISS methodology. All of these patients had been managed in an ICU.

According to TRISS methodology, 20 of these 139 pedestrians (14.4%) should have died. Only ten died (7.2%). The difference between the expected and actual mortality rate, the 'Z' value, was significant (P<0.001). This difference could have been influenced by the injury severity match between our sample and that of the baseline group (American Major Trauma Outcome Study). In order to test whether this was so the 'M' statistic (p138) was calculated (Table 9.6).

Table 9.6 : 'M' statistic calculation for Hospital Pedestrians

	FRACTION OF PATIENTS WITHIN RANGE	
PROBABILITY OF SURVIVAL : RANGE	STUDY GROUP (g)	BASELINE GROUP (f)
0.96-1.00	0.101	0.036
0.91-0.95	0.014	0.017
0.76-0.90	0.065	0.029
0.51-0.75	0.043	0.044
0.26-0.50	0.058	0.045
0.00-0.25	0.719	0.828

The 'M' statistic for pedestrians in this study was found to be 0.89, indicating that there was a good match in injury severity mix between our pedestrians and the patients in the baseline group.

Overall therefore, both the 'Z' and 'M' values were significant, which indicates that our group of pedestrians did better than predicted when compared to the baseline patients in the American Major Trauma Outcome Study.

9.3 THE MANAGEMENT OF INJURED PEDESTRIANS

9.3.1 INTRODUCTION

This section briefly discusses the management of hospital pedestrians with regard to the level of care they require, their length of hospital stay and their disposal from hospital.

9.3.2 TIME DELAY TO HOSPITAL TREATMENT

Just over half (53.7%) of all the pedestrians who arrived alive at hospital presented within one hour of sustaining their injury. The mean delay to presentation time was 74 minutes with a median time of 60 minutes (Figure 9.6). The range of time was 6 - 340 minutes, but it should be remembered that patients were not included in the study if their injury occurred more than six hours prior to presentation.

Patients with severe injuries (NISS $\geq$25) arrived at the trauma unit an average of one hour (61.5 min $\pm$50.3) after the collision while those with minor injuries (NISS <9) presented 79.6 minutes ($\pm$69.4) after their injury was sustained.

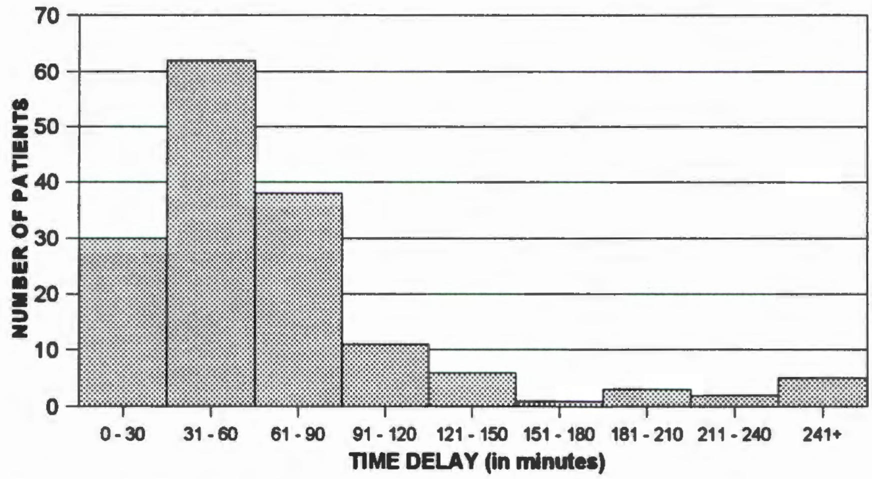

Figure 9.6 : Delay to treatment in Hospital Pedestrians (n=196)

9.3.3 LEVEL OF CARE REQUIRED

The placement of the injured pedestrians after initial treatment in the trauma unit is indicated in Figure 9.7.

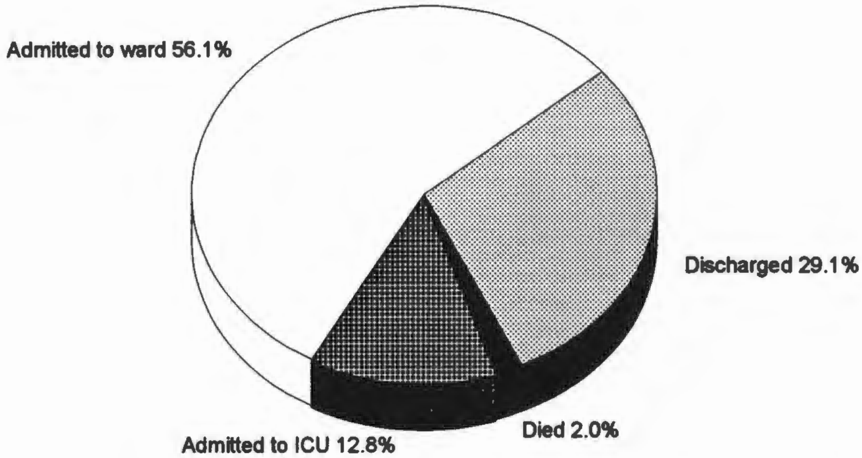

Figure 9.7 : Level of care received by Hospital Pedestrians (n=196)

Of the 196 pedestrians in this study, 57 (29.1%) were seen in the trauma unit, treated and discharged home. Just over half of these 57 patients (57.9%) were male and they were an average of 35.3 years old (±12.3, range 14 - 61 years). The majority of these discharged patients had minor injuries such as contusions, lacerations and abrasions. Their median NISS rating was 5 (range 1 - 13).

Three patients died while being resuscitated in the trauma unit and one patient died in theatre shortly after presentation. All four patients were male and were an average of 35.5 years old (±13.7, range 23 - 55 years). Three of these four patients had severe closed head injuries while the other patient had a traumatic below-knee amputation (NISS score of 9). This latter patient died as a result of hypovolaemia. According to TRISS methodology none of these deaths were unexpected.

One hundred and ten patients (56.1%) were admitted to a hospital ward. Nearly three-quarters (72.7%) of these patients were male and were an average of 34.8

years old (±13.8, range 13-70 years). In general these 110 patients sustained moderate injuries with a median NISS of 12 (range 1 - 50). According to TRISS methodology one patient should have died but this patient was in fact an "unexpected survivor". Two other patients, both of whom had good TRISS scores, died, i.e. they were "unexpected deaths". Both of these patients had isolated severe closed head injuries.

Twenty-five patients were admitted directly to an ICU. They were predominantly male (76%) and were an average of 35.0 years old (±9.3, range 18 - 56 years). The injuries sustained by these 25 patients were severe, with a median NISS of 43 (mean NISS of 44.3). Sixty percent of these patients required ventilatory support. Four patients died while in ICU. According to TRISS methodology all four deaths were expected.

There were no statistically significant differences in the BAC profiles of those patients who were treated and discharged and those who were admitted (χ^2=1.2, P=0.27). However, within the admission group a significant proportion of BAC positive pedestrians required ICU management (Table 9.7).

Table 9.7 : Placement by BAC in Hospital Pedestrians (n=196)

LEVEL OF CARE REQUIRED	BAC +ve (n=120)	BAC -ve (n=76)
Discharged	31 (54.4)	26 (45.6)
Admitted		
to ward	66 (60.0)	44 (40.0)
to ICU	20 (80.0)*	5 (20.0)
Died in Trauma Unit	3 (75.0)	1 (25.0)

* $\chi 2$ = 2.7, P < 0.05

There were no statistically significant differences in mean BAC for patients in the different placement categories (Table 9.8).

Table 9.8 : Level of care required by mean BAC (n=196)

LEVEL OF CARE REQUIRED	% BAC +ve	MEAN BAC g/100ml (±SD)	BAC RANGE g/100ml
Discharged	54.4	0.20 (±0.08)	0.06 - 0.33
Admitted to ward	60.0	0.19 (±0.19)	0.03 - 0.36
Admitted to ICU	80.0	0.19 (±0.07)	0.08 - 0.31
Died in Trauma Unit	75.0	0.13 (±0.04)	0.08 - 0.17

However, when 0.08 g/100ml is used as a cut-off point and the levels of care for hospital pedestrians are simplified, a distinct trend is evident. As can be seen in Figure 9.8 the results obtained in this study take on a dramatic perspective when compared to randomly sampled uninjured pedestrians (as indicated in the lowest slice of the pyramid).

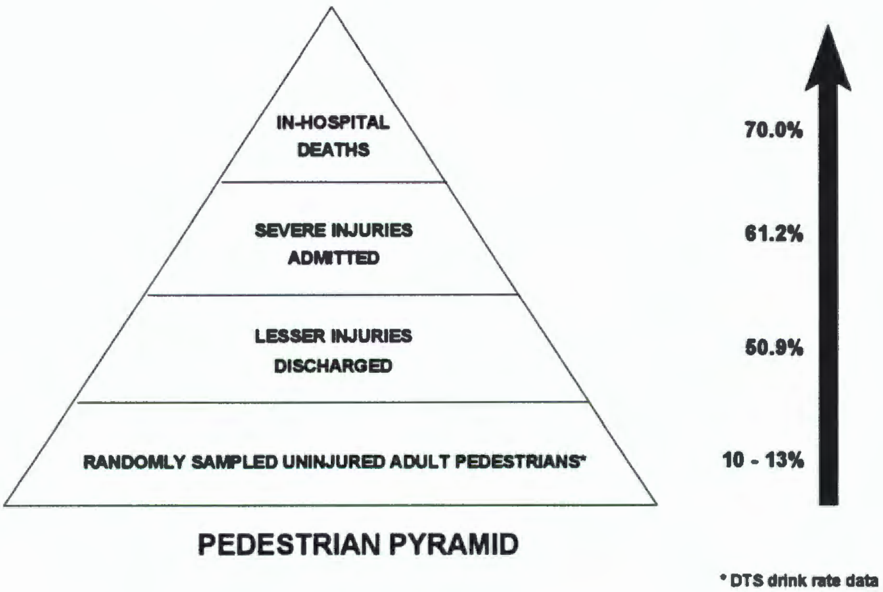

Figure 9.8: Pyramid indicating the proportion of Hospital Pedestrians who had BAC levels ≥0.08 g/100ml (n=196)

9.3.4 LENGTH OF HOSPITAL STAY

The 135 patients who were admitted to a ward or an ICU spent a total of 1682 days in hospital. On average these patients spent 12.5 days (±17.5, range 1 - 86) in hospital (Table 9.9).

Table 9.9 : Average days spent in hospital (n=135)

PLACEMENT	$\bar{x}$ DAYS IN ICU (±SD)	$\bar{x}$ DAYS IN WARD (±SD)	AVERAGE ADMISSION (±SD)
Admitted to ward	0	9.1 (±13.8)	9.1 (±13.8)
Admitted to ICU	7.7 (±7.9)	19.8 (±21.5)	26.6 (±24.2)
All admissions	1.4 (±4.5)	11.1 (±15.3)	12.5 (±17.5)

Polytrauma patients spent considerably longer in hospital than patients who had single system trauma (15.7 days versus 7.8 days, $P<0.0001$). Polytrauma patients with abdomen, chest or upper limb injuries required long hospitalisations, the latter probably required long hospitalisation period because of other injuries, such as thoracic and abdominal, which often accompany upper limb injuries (Table 9.10).

Table 9.10 : Length of hospital stay in polytrauma pedestrians by body region injured (n=90)

POLYTRAUMA INCLUDING	MEAN DAYS SPENT IN HOSPITAL Days (±SD)
Head injury	14.6 (±18.6)
Facial injury	14.5 (±18.0)
Spinal column injury	12.2 (±13.9)
Abdominal injury	21.2 (±22.7)
Thoracic injury	21.4 (±18.1)
Upper limb injury	22.1 (±23.0)
Lower limb injury	18.6 (±19.0)

Blood alcohol positive pedestrians who required admission to a hospital ward or to an ICU spent marginally longer in hospital than did their sober counterparts (12.8 days versus 11.9 days) but this difference did not reach statistical significance.

9.3.5 INTERVENTIONS REQUIRED

Four types of interventions were assessed, viz. surgery, standard x-rays, Computerised Tomography (CT) scan and blood transfusions. These interventions were chosen because they are often undertaken on traumatised patients, require expertise and special equipment to conduct and are also costly.

Only seven of the 196 pedestrians (3.6%) did not require any of the above-mentioned interventions. Of the other 189 patients nearly 20% required 3 or 4 interventions (Figure 9.9).

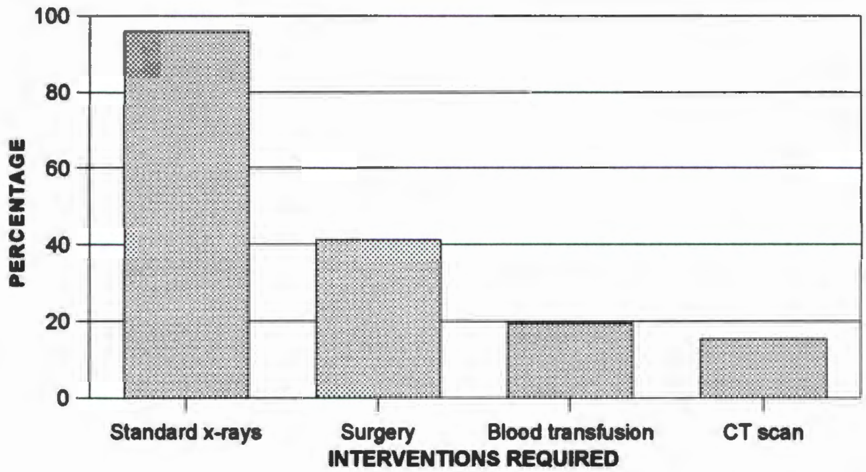

Figure 9.9 : Interventions required by Hospital Pedestrians (n=196)

On average, pedestrians required at least two interventions, but BAC positive pedestrians were at least twice as likely to require multiple interventions (OR=2.1, P=0.05).

9.3.5.1 Surgery

Eighty-one pedestrians (41.3%) required surgery. They were predominantly male (74.1%), black (55.6%) and were an average of 34.2 years old (±11.9, range 16-67).

Fifty-nine of the 110 direct ward admissions (53.6%) required surgery. These 59 patients spent a total of 7945 minutes (132.4 hours) in theatre. On average each of these patients spent 134.7 minutes in theatre (±128.2, range 20 - 750 minutes).

Twenty-one of the 25 direct ICU admissions (84%) required surgery. These 21 patients spent a total of 5325 minutes (89 hours) in theatre. On average each of these patients spent 254 minutes in theatre (±181, range 55 - 600 minutes).

One patient died while having emergency surgery soon after presentation.

Fifty-six patients with polytrauma and 25 patients with single system trauma required surgery. Patients with polytrauma were more than five times as likely to require surgery than their single system trauma counterparts (OR=5.3, 95%CI=2.75-10.4, P<0.0001). Many polytrauma patients who needed an operation required multi-discipline surgery (Table 9.11).

Table 9.11 : Surgery required in polytrauma pedestrians (n=56)

SURGICAL DISCIPLINE INVOLVED	n (%)
Orthopaedic surgery	37 (66.1)
Neurosurgery	12 (21.4)
General surgery	24 (42.9)
Maxillo-facial surgery	5 (8.9)
Thoracic surgery	1 (1.8)

Of the 25 patients with single system trauma:

- 20 (80%) required orthopaedic surgery to a limb;
- 3(12%) required neurosurgery for an isolated head injury;
- one patient required maxillo-facial surgery; and
- one patient required a laparotomy.

Blood alcohol positive pedestrians were no more likely than their sober counterparts to require surgery (χ^2=0.27, P=0.6). However, 53 of the 81 patients who did require surgery (65.4%) were BAC positive at the time of admission and their mean BAC was 0.18 g/100ml (±0.07, range 0.03 - 0.36). This result, although not statistically significant, has clinical implications because of the interactions of anaesthesia and alcohol.

9.3.5.2 Standard x-rays

All pedestrians except eight (4.1%) had at least one body region x-rayed, the most common being the lower limb. On average each patient required at least two separate body regions x-rayed, e.g. head and lower limb but there were some patients who had multiple body regions x-rayed (Figure 9.10).

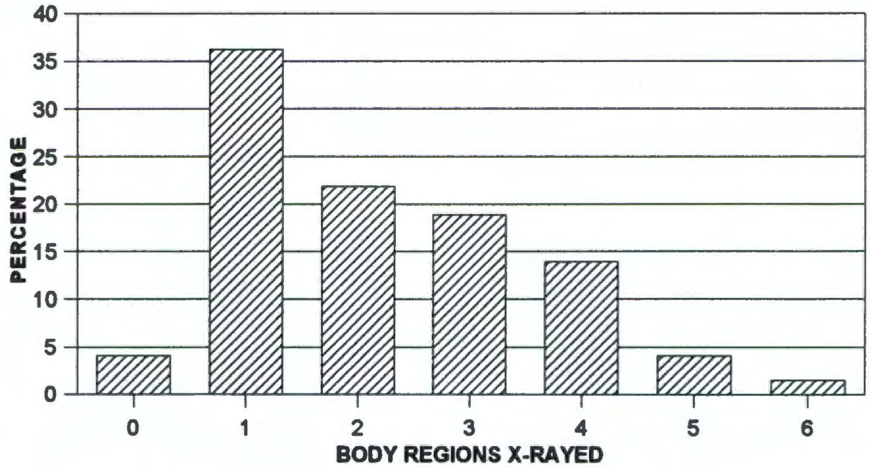

Figure 9.10 : Number of body regions x-rayed in Hospital Pedestrians

All patients with polytrauma had at least three body regions x-rayed but more than a third of these patients required four or more body regions to be assessed radiologically. Two-thirds of patients with single system trauma needed only one body region x-rayed.

Since almost all patients required x-rays there was no correlation between the need for x-ray and other variables such as BAC, age, injury, etc.

9.3.5.3 CT scan

Of the 196 pedestrians, 30 (15.3%) required a CT brain scan. Twenty-three of these (76.7%) had pathology noted, while 7 (23.3%) had normal scans. Six of the seven patients who were thought to have a severe head injury but who had normal CT scans were BAC positive at the time, with a mean BAC of 0.21 g/100ml (±0.08, range 0.11 - 0.31) (see Case Study C).

Case Study C

An unknown 19 year old youth was brought in unconscious to Trauma Unit. He had a GCS of 7 and was immediately intubated and ventilated. He had small, sluggishly reactive pupils. No information regarding his collision was available. He was presumed to have a severe closed head injury and was therefore sent for CT scan. The CT scan indicated that "no focal intracranial pathology was identified". He was sent to an ICU where he gradually woke up over the next 6 hours and extubated himself. The following day he was noted to be lucid and communicative with a GCS of 15. He was discharged home directly from ICU. His BAC was 0.21 g/100ml.

A further 10 patients were assessed by the author to have a significant head injury but were not sent for CT scan. One of these patients who was discharged subsequently died (see Case Study on p200).

9.3.5.4 Blood transfusion

Thirty-eight of the 196 pedestrians (19.4%) required blood transfusion. On average these 38 patients required 5 units of blood, with one patient requiring 30 units (Figure 9.11). This latter patient had severe abdominal injuries (including ruptured bowel and a lacerated bladder), a traumatic amputation of his right leg and a severe head injury. He died from multi-organ failure after two days in ICU.

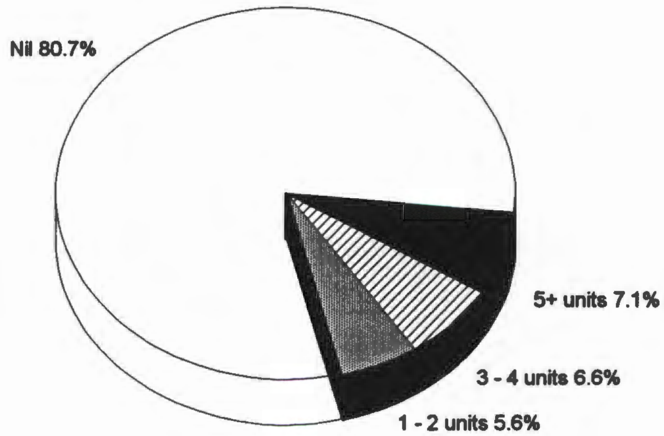

Figure 9.11 : Units of blood required by Hospital Pedestrians (n=196)

Of the 38 pedestrians who required blood 29 (76.3%) had polytrauma. The most probable reasons for administration of blood products in these polytrauma patients is outlined in Table 9.12. On average these 29 patients required 5.8 (±5.6) units of blood.

Table 9.12 : Blood required in polytrauma pedestrians by probable cause (n=29)

PROBABLE REASON FOR BLOOD TRANSFUSION	n	$\bar{x}$ UNITS OF BLOOD REQUIRED (±SD)
Lower limb injury (excluding pelvis)	12	3.2 (±1.3)
Abdominal injury	11	8.1 (±7.9)
Pelvic injury	5	6.8 (±1.9)
Head injury	1	7.0

Nine patients who had single system trauma required blood:

- 4 for lower limb injuries;
- 2 for pelvic injuries;
- 2 for head injuries; and
- 1 for an abdominal injury.

These nine patients required an average of 3.8 (±2.6) units.

9.3.6 DISPOSAL FROM HOSPITAL AFTER WARD/ICU ADMISSION

Of the 135 patients admitted to hospital, six died after admission - two while they were in a ward and four while they were in an ICU. Four of these six pedestrians were BAC positive at the time of their collision.

Of the surviving 129 patients, 95 (73.6%) were discharged directly home while 34 (26.4%) were transferred to a convalescent hospital for on-going management of their injuries. Twenty-five of these latter patients (73.5%) had been BAC positive at the time of their collision.

The main reasons for the need for convalescent care were:

- severe head injuries (AIS 3-5) in 16 cases (47.1%); and
- orthopaedic injuries to the lower limbs or spine in 18 cases (52.9%).

Some patients did, however, have combinations of the above-mentioned problems.

9.4 RESULTANT DISABILITY IN HOSPITAL PEDESTRIANS

9.4.1 INTRODUCTION

At the time of this study no objective disability scoring methods were available for injured patients. The author therefore estimated the disability of the surviving pedestrians at the time of their discharge or transfer to another hospital, and based this assessment on the injuries which had been sustained. Both physical impairment and functional disability were assessed. Although these two concepts are interrelated, a distinction was made on the basis of the patients' injuries, the management they required, their age and their occupational status. For example, a computer programmer who sustained a closed fracture of the tibia (AIS 2) would be physically impaired for a period of about 3 months (physical impairment) but would probably return to daily and occupational functions relatively rapidly and much earlier (functional disability). On the other hand, a manual labourer with the same injury would have the same physical impairment but be functionally disabled for a much longer period of time.

During 1994 the Injury Impairment Scale (IIS) was developed and published by the Committee on Injury Scaling (1994). This scale was developed to reflect the overall impairment of bodily function at one year after a single injury. Since many of the pedestrians included in this study had polytrauma, the IIS for the single severest lesion was documented. This is still less than optimal (there are often inter-relations between injuries in different body regions) but until the Committee for Injury Scaling presents a better solution this is the only way to assess long term disability in such instances.

9.4.2 CLINICAL JUDGEMENT OF DISABILITY

From the subjective clinical assessment made, it was found that nearly than half of the 186 surviving pedestrians would be physically impaired for 8 weeks or more but that only 29% of them would be functionally disabled for a similar time period. Twenty five pedestrians (13.4%) were assessed to have sustained both permanent physical impairment and permanent functional disability using this method (Table 9.13).

Table 9.13 : Physical impairment and functional disability incurred by surviving pedestrians (n=186)

LENGTH OF TIME	PHYSICAL IMPAIRMENT n (%)	FUNCTIONAL DISABILITY n (%)
None	24 (12.9)	27 (14.5)
Short (< 8 weeks)	48 (25.8)	80 (43.0)
Long (≥ 8 weeks)	89 (47.8)	54 (29.0)
Permanent	25 (13.4)	25 (13.4)

Twenty of the 25 pedestrians (80%) left with a permanent handicap had severe brain damage as a result of a head injury and four or the 20 were also left paraplegic. The other five pedestrians with permanent disabilities had colostomies, amputated limbs, etc.

Of the 57 pedestrians who were treated and discharged, it was estimated that 23 (40.4%) would have short-term and 11 (19.3%) would have long-term physical impairment. The other 23 (40.4%) would have no physical impairment. However, only two pedestrians (3.5%) would have long-term and 30 (52.6%) short-term functional disability.

All of the 108 patients who survived after being admitted directly to a hospital ward had sustained some degree of disability. In 25 patients (23.1%) both physical impairment and functional disability were short-term(≤8 weeks). In 73 instances (67.6%) physical impairment was long-term; of these 26 had short-term functional disability while the remaining 47 had suffered functional disability for periods greater than 8 weeks. The remaining 10 patients (9.3%) had suffered both permanent physical impairment and functional disability.

Twenty-one of the 25 patients admitted to an ICU survived. Of these 21 pedestrians, 15 (71.4%) were left with permanent functional and physical handicaps. The other six pedestrians were left with long-term disability and impairment.

Eighteen of the 25 pedestrians (72%) left with a permanent handicap had positive BAC levels. These 18 had a mean BAC of 0.15 g/100ml (±0.07).

9.4.3 THE INJURY IMPAIRMENT SCALE

The objective assessment by means of the IIS yielded results which were strikingly similar to those of the preceding subjective clinical assessment.

The IIS predicted that 13 (7.0%) of 186 surviving pedestrians would be left with a disability so great that they would not be able to perform any useful functions (grade 5) while a further 15 (8.1%) would only be able to perform some normal functions (grade 3). Eleven of the 13 with grade 5 IIS ratings were alcohol positive, as were nine of the 15 with grade 3 ratings. These results did not, however, reach statistical significance (Table 9.14).

Table 9.14 : IIS by BAC in surviving pedestrians (n=186)

Injury Impairment Scale		BAC-ve n (%)	BAC+ve n (%)	ALL n
0 =	Normal function: No impairment	29 (44.6)	36 (55.4)	65
1 =	Impairment detectable but does not limit normal function	32 (42.1)	44 (57.9)	76
2 =	Impairment level compatible with most but not all normal functions	4 (23.5)	13 (76.5)	17
3 =	Impairment level compatible with some normal functions	6 (40.0)	9 (60.0)	15
4 =	Impairment level significantly impedes some normal functions	0	0	0
5 =	Impairment level precludes most useful function	2 (15.4)	11 (84.6)	13
6 =	Impairment level precludes any useful function	0	0	0

This objective scale therefore indicated that 28 pedestrians would be left with a disability at one year which would preclude some or all normal activities. The subjective clinical assessment of disability suggested that 25 pedestrians would be left permanently disabled, i.e. there was an almost 90% agreement between the two measures.

9.5 THE COSTS INCURRED BY PEDESTRIANS

9.5.1 TREATMENT COSTS

A very crude estimate of the medical costs incurred by patients was made. It was based on the cost to the hospital, depending on the length of hospital admission and the interventions performed (Table 9.15). The cost to the State for medico-legal postmortems was also included.

Table 9.15 : Fee structure used to deduce treatment costs (in 1993 Rands)

Treatment*	
Seen in Trauma unit and discharged:	
R55 (basic) + R153 (x-rays, medicines, laboratory) + R78 (professional fee)	
Admitted to the hospital (per day):	
Ward	R258 (basic) + R78 (professional fee)
ICU	R766 (basic) + R78 (professional fee)
High Care	R409 (basic) + R78 (professional fee)
Medications	R102 per stay
Laboratory services	R51 per stay
Radiology	R51 per body region x-rayed
Operations	(R144 [basic] + R7.49/min [<60min] + R10.00/min [$\geq$60min]) per operation
Blood products**	
Crossmatch fee:	R110
Products:	
Whole Blood	R183 per unit
Red Blood Cell Concentrate	R161 per unit
Fresh Frozen Plasma	R150 per unit
Platelets	R834 per six-unit pack
Medico-legal postmortem***	
Per case	R750

* Fee structure obtained from GSH Fees Office, November 1993

** Blood product costs obtained from GSH Blood Bank, based on fees charged by the Western Province Blood Transfusion Services, November 1993

*** Estimated cost of postmortem, obtained from Dr H. Scholtz, Department of Forensic Medicine, UCT, November 1993

These are the maximum fees that can be charged to a patient and are considerably lower than the real hospital expenses. Furthermore, the cost of convalescent care and follow-up out-patient visits were not factored into the cost estimate and so the amounts presented below should be seen as under-estimates of overall management.

Using the fee structure (Table 9.15) it was calculated that the 196 hospital pedestrians cost the hospital a total of R881 409.50, while the 31 mortuary pedestrians cost a total of R23 250, so that these 227 patients cost the State almost R1 million. Table 9.16 shows the average amount spent on each pedestrian according to their treatment category as well as the total amounts incurred.

Table 9.16 : Medical costs of managing pedestrians (N=227)

Treatment category	n	Total Rands	Mean cost/patient (1993 Rands)
Treated & discharged	57	15 426.00	270.63
Pre-hospital deaths/Died in Trauma	35	33 195.90	948.45
Admitted to ward	110	465 454.10	4 231.40
Admitted to ICU	25	390 583.50	15 623.34
Total	**227**	**904 659.50**	**3 985.28**

On average, patients requiring ward admission cost R551.77 (±181.61) to treat per day, while those requiring ICU management cost R3082.50 (±2835) per day.

It cost an average of R4185.26 (±7155.3) to treat a BAC positive pedestrian (from admission to discharge) while their sober counterparts cost an average of R3657.41 (±6868.69). Although this difference of R527.85 per patient did not reach statistical significance, in monetary terms it amounts to nearly R1.3 million per year.

9.5.2 COMPOSITE COSTS

The composite costs[4] of traffic collisions were estimated by the Division of Roads and Transport Technology of the Council for Scientific and Industrial Research in 1991 (De Haan, 1993). The author adjusted these costs for the 1992 and 1993 inflation rates (see Ch 4, p68).

De Haan's composite costs were calculated per collision and not per person but since all the pedestrians included in this study were involved in one-on-one collisions the number of collisions equalled the number of casualties. Using the composite costs which had been adjusted for inflation, the 227 pedestrians included in this study cost the State more than R8.2 million, or R36 353 per patient (Table 9.17).

Table 9.17 : Composite costs for pedestrians (N=227)

TYPE OF COLLISION	n	UNIT COST* (1993 Rands)	TOTAL COST (1993 Rands)
Fatal	35	102 497.59	3 587 415.63
Serious	135	32 756.45	4 422 120.25
Minor	57	4 356.99	242 648.35
Total	**227**	**139 611.03**	**8 252 184.23**

* After De Haan, 1993

4 Composite costs include the "value of lost output, property damage, pain, suffering and loss of amenities of life, medical expenses, administrative costs, legal costs and other miscellaneous costs such as the value of lost time and towing costs" (De Haan, 1993:3-1).

9.6 DISCUSSION

This thesis has confirmed previous findings that pedestrians involved in collisions are at high risk of severe injury and that they are likely to require admission to a hospital ward (Atkins et al., 1988). It has also confirmed that these pedestrians place significant demands on hospitals and hospital staff and that intoxicated pedestrians place even more demand on these services. These demands have been quantified for the South African context.

Although this study showed a high incidence of alcohol intoxication in injured pedestrians it could not assign causality because it was descriptive in nature. A few good case-control studies have, however, been conducted in developed countries (Haddon et al., 1961; Irwin et al., 1983) and have proved that alcohol is a causal factor in pedestrian collisions. There is good reason to believe that this also applies in South Africa.

9.6.1 POSTCRASH HOST FACTORS

9.6.1.1 The body's response to injury

Three parameters, namely systolic blood pressure, respiratory rate and GCS, were assessed in order to obtain the Revised Trauma Score, which is a measure of physiological derangement as a result of trauma.

The majority of patients were normotensive on presentation. However, a clear negative correlation between injury severity and systolic BP was evident. That is, as the injury severity rose, the blood pressure dropped. This type of result is expected since patients who are severely injured are more likely to have lost blood and therefore to be hypovolaemic. Probably for the same reason as just stated, systolic blood pressure was lower in patients with polytrauma, particularly those with spinal column injuries and abdominal injuries. There was no relationship between alcohol intoxication and systolic blood pressure, despite the vasodilatory effects of alcohol.

Just over 11% of the pedestrians required intubation and ventilation as a result of their injuries. These patients usually had a head injury or a significant thoracic injury. Although alcohol did not appear to alter the respiratory rate of patients who were breathing spontaneously (despite its depressant effects), it was interesting to note that three-quarters of the patients who required ventilation were BAC positive. This relationship was probably related to the head injury and the resulting need for ventilation, i.e. it was not directly related to alcohol.

Less than half of the pedestrians had GCS scores of 15 out of 15. A large number had GCS scores of 14 which could have either been due to a minor head injury or as a result of alcohol intoxication. Since alcohol intoxication and head injury appear to go hand-in-hand (Vestrup & Reid, 1989) it was not surprising that patients who were BAC positive had significantly lower GCS than patients who were sober.

The overall unweighted RTS ratings indicated that the majority of patients had little or no physiological derangement as a result of their injury. What this study did serve to confirm, however, was that patients with unweighted RTS scores of 10 or less are likely to need ICU management and that their mortality rate is high (Boffard, 1993).

9.6.1.2 Probability of survival

There were two "unexpected" deaths among this cohort of injured pedestrians and seven "unexpected" survivors. Overall, ten of the 196 patients who arrived alive at hospital subsequently died, i.e. the mortality rate for in-patients was 5.1%. This result is in keeping with a result obtained by Atkins et al. (1988) in the UK but much lower than the results found in other countries such as the USA and Australia who quote mortality rates for pedestrians of between 22% and 34% (Brainard et al., 1989; Hill et al., 1996). The low mortality rate found in our study could be because :

- two-thirds of our pedestrian deaths occur in the prehospital phase (National Trauma Research Programme, 1990);
- many of the severely injured pedestrians do not arrive at the hospital within the 'golden hour' and consequently some of these patients die during transportation and are then labelled 'prehospital' deaths;
- many patients with minor or moderate injuries are triaged and therefore are not taken to level I trauma facilities; or
- the studies cited may include only pedestrians admitted to a ward or ICU and not those with less severe injuries who are seen and discharged, but this is not clear from the literature.

9.6.1.3 Management of injured pedestrians

More than half of all the injured pedestrians required admission to a hospital ward for the management of their injuries. A further 12.8% required direct admission to an ICU and significantly more of these patients were BAC positive. Most of the international studies reviewed indicated that between 63% (Wyss et al., 1990) and 85.2% (Brainard et al., 1989) of patients required admission to hospital but it must be remembered that these studies were conducted at Level I trauma facilities which only receive more severely injured patients. However, the low admission rate at GSH could also be due to the fact that there are a limited number of beds available due to staff and budget cuts and hence some patients who should be observed overnight are sent home.

Although a smaller proportion of patients in this study required ICU management than has been found in international studies, proportionally more of these patients required intubation and ventilation, i.e. 60% in this study versus 47% in the literature (Brainard et al., 1989). Once again, this is a reflection of the limited number of ICU beds available - patients have to have very severe injuries and/or require ventilation in order to get into an ICU bed at GSH.

This study could not show a direct correlation between injury severity and alcohol intoxication as has been found in some other studies (Bradbury, 1991; Jehle & Cottington, 1988). It did, however, show a definite trend between alcohol-relatedness and the "level of care" required - the latter often being used as a proxy for injury severity.

This study confirmed the finding of Brainard et al. (1989) that BAC positive pedestrians are more likely to require multiple interventions than their sober counterparts. In fact, this study indicated that BAC positive pedestrians were twice as likely to require multiple investigations or interventions. For instance, two-thirds of pedestrians who were suspected of having a severe head injury and required a CT scan were subsequently found to have normal scans but very high BAC levels. In addition, two-thirds of the pedestrians requiring surgery were BAC positive. Although it could not be said that BAC positive pedestrians were more likely to require surgery, it is clinically important to know that many pedestrians who have surgery could be BAC positive and therefore the alcohol-related problems of anaesthesia should be anticipated.

On average patients spent 12.5 days in hospital. This result is similar to those obtained by Brainard et al. (1989) and Hill et al. (1993; 1996). Furthermore, BAC positive patients required slightly longer hospitalisation periods than their sober counterparts, confirming Jehle & Cottington's (1988) results.

9.6.1.4 Resultant disability in injured pedestrians

The majority of pedestrians who survived were sent home after treatment - all with varying levels of temporary disability. But nearly one-quarter of admissions required transfer to a convalescent hospital for the post-acute management of their injuries. These results are twice as high as those found by Vestrup & Reid (1988) in Canada.

Nearly one-sixth of surviving pedestrians sustained a permanent disability. Eighty percent of these patients had severe closed head injuries while the other 20% were permanently disabled as a result of an amputated limb, colostomy, etc. Three-quarters of permanently disabled patients were BAC positive at the time of their collision, suggesting that alcohol not only preselects for injury severity but also preselects for significant resultant disability.

The two methods which were used to assess disability in this cohort of injured pedestrians, viz. clinical judgement and the IIS, were found to be comparable despite the modification made to the IIS as suggested by Massoud & Wallace (1996). This modification was made because the IIS does not take into consideration accumulative disability as a result of multiple injuries. For instance, a patient with a tib/fib fracture and a fracture of the humerus would be considerably more disabled than a patient who had either one of these fractures since he would not be able to use crutches. A new method of combining different injuries to obtain an overall disability score is therefore required.

9.6.2 POSTCRASH ENVIRONMENTAL FACTORS

9.6.2.1 Time delay to treatment

Just over half of all the pedestrians in this study arrived at hospital within the 'golden hour', and the mean presenting time was 74 minutes. This is about three times longer than that quoted in some other studies (Teanby et al., 1993b) but the results are skewed by the long delays to presentation in patients with minor injuries. What is, however, disturbing is that only 70% of the severely injured pedestrians (NISS $\geq$25) reached the hospital within the 'golden hour' despite the fact that the Cape Metropolitan Study had shown that 100% of these patients are transported by ambulance (National Trauma Research Programme, 1990). Possible reasons for this situation include:

- sometimes pedestrians are hit by a car, land up at the side of the road and are only discovered some time later;
- at times there is a delay in reaching a telephone or another communication system to call an ambulance to the scene;
- incorrect directions are frequently given to the ambulance communication division by the caller and therefore the ambulance personnel have to find the patient;

- considerable time is occasionally spent resuscitating patients at the scene of the collision by ambulance staff because, although Cape Town has one of the best ambulance services in the country, it is only since 1995 that these personnel have been applying ATLS principles to the management of injured patients and they very seldom 'scoop and run' from the scene of a collision (Personal communication, Dr P. Malan, ex-METRO, 28 November 1996);

- the drainage area for GSH is extensive (see map on p76) and it can take up to half an hour to transport a patient from the fringes of the area to GSH.

9.6.2.2 Trauma facility audit

The 'Z' and 'M' scores obtained using TRISS methodology indicated that the outcomes in this Cape Town pedestrian study were comparable to those of the MTOS. This supports Demetriades & Sofianos (1992) and Eisenberg's (1993) suggestion that TRISS can be applied to South African hospitals and does not support Fowler (1991), who said that the methodology was too sophisticated to be used in a developing country.

Based on the severity of the pedestrian's injuries and their physiological derangement as a result of these injuries, TRISS methodology predicted that 20 pedestrians would die, but only 10 patients died. These results were statistically significant, implying that the care received by this cohort of pedestrians was in fact superior to that received by the patients in the MTOS.

9.6.2.3 Cost of treating injured pedestrians

The 227 pedestrians included in this study cost the State almost R1 million to treat, based on the fee structure at GSH and not on the actual cost of management, equipment, personnel, etc. As would be expected, patients who required ICU admission cost nearly six times more per day than those patients who were admitted to a ward.

Due to the methodology used to estimate costs in this study it was expected that the results would be conservative. However, when compared with a comprehensive costing study undertaken in the Respiratory ICU of GSH it was found that the results compared favourably. Potgieter, Hammill, Gough et al. (1995) found that it cost R2 112 per day to treat a patient admitted to their ICU as a result of a motor vehicle collision. Considering that pedestrians are usually more severely injured than any other category of road-user (Wyss et al., 1990) and that they thus cost significantly more to treat (Hendrie & Rosman, 1994), our estimations of R3 082.50 per patient per day in ICU is probably quite realistic.

Our data also confirms previous findings (Bradbury, 1991; Jehle & Cottington, 1988; Jurkovich et al., 1992) that BAC positive patients are more expensive to treat than their sober counterparts.

According to Miller et al. (1989), medical costs are only the "tip of the iceberg" and indirect costs such as pain and suffering, time off work, etc. account for more than half of the overall costs involved in motor vehicle collisions.

Using the cost analysis suggested by De Haan (1993) the composite cost of the 227 pedestrians included in this study was more than R8.2million or R36 353 per patient. This means that in South Africa nearly R1 billion is spent annually on pedestrian collisions.

9.7 CHAPTER SUMMARY

This chapter has discussed some of the postcrash factors involved in pedestrian collisions, such as the time delay to treatment, the management required to treat such patients and the costs incurred.

It has furthermore highlighted the fact that BAC positive pedestrians tend to place more of a burden on hospitals and hospital staff since they require longer hospitalisation, often have unnecessary procedures performed, sustain more significant disabilities and ultimately cost the State more to treat than their sober counterparts.

CHAPTER TEN

ALCOHOL ASSESSMENT IN TRAUMA PATIENTS

> *"Addressing the trauma patient's possible AOD [alcohol and other drugs] use problems - a known risk factor for traumatic injury - increasingly appears to many clinicians to be an important part of good medical practice".* (Rostenberg, 1995:29).

10.1 INTRODUCTION

Trauma should be viewed as a condition such as cancer or cardiovascular disease since it also occurs as a result of socio-environmental factors and consequently has underlying risk factors (Rostenberg, 1995). When a patient is admitted to hospital with a disease it is his/her right to expect that the underlying cause of the condition be sought and addressed. For example, after a heart attack, diet and exercise start as soon as the patient is stabilised and education becomes a major focus of their ongoing management. However, in trauma patients, the underlying cause, in many instances alcohol, is seldom sought and less often addressed.

In the USA it has been found that, although many trauma centres have alcohol screening facilities, less than 55% of patients are routinely screened for alcohol (Soderstrom & Cowley, 1987b). Furthermore, in those centres which do screen patients, positive alcohol results are used only to address the patient's immediate medical needs and not to confirm or address any underlying alcohol abuse problems. In South Africa routine surveillance for alcohol or other drugs in injured patients is not undertaken at any of the major trauma units.

The purpose of this chapter is thus threefold: firstly, to define the most commonly used alcohol terms, as such terms are often used incorrectly; secondly, to outline the reasons why routine alcohol surveillance should be undertaken on all injured patients and, lastly, to discuss useful methods of assessing alcohol intoxication in such patients.

10.2 DEFINITION OF ALCOHOL TERMS

A lot of confusion surrounded the classification of alcohol use disorders until the World Health Organisation (WHO) became involved in the formulation of specific definitions after World War II. Since then there has been significant progress in the standardisation of these terms. By 1990 clear distinctions had been made between the different types of alcohol use disorders which are outlined below.

The term 'alcohol' in its purest sense denotes 'ethyl alcohol or ethanol', a liquid which is obtained from the action of yeast on sugar, but in colloquial terms it usually refers to a "drink such as beer, wine and whiskey that can make people drunk" (Collins English Dictionary, 1988:22).

Alcohol intoxication is defined as a "state in which alcohol is present in an organism and causes alterations in the physiological or biochemical functioning" (Rix, 1983:60). Most countries have a legal definition of alcohol intoxication - for instance, in South Africa it is illegal to drive a vehicle with a BAC concentration of 0.08 g/100ml or more. Alcohol intoxication should not be confused with alcohol impairment since the latter is usually a clinical definition. Individuals who have developed a high tolerance for alcohol often exhibit few signs of intoxication, even after drinking large quantities, but this does not mean that they are not impaired since impairment may occur at levels as low as 0.04 g/100ml. The term 'drunk' or 'drunkenness' refers to the behaviour displayed by someone who is intoxicated with alcohol, although a study has demonstrated that people may behave in a 'drunken' manner if they are convinced that the non-alcoholic beverage they have consumed was alcohol (Lang, Goeckner, Adesso et al., 1975). Drunkenness therefore may be defined as a "behaviour, or behaviours, displayed by an individual who has consumed, or believes that he has consumed, alcohol" (Rix, 1983:60).

The term alcoholism was eliminated from the 9th Edition of the International Classification of Diseases (World Health Organisation, 1978) and replaced by two distinct categories: 'alcohol abuse' and 'alcohol dependence'. The terms 'alcoholism' and 'chronic alcoholic' are, however, still used in many trauma-related publications.

The terms alcohol abuse, excessive drinking and alcohol-related disability appear to be largely synonymous. According to the 10th edition of the International Classification of Diseases (ICD-10) alcohol abuse is the "harmful use of alcohol". It is diagnosed when there is a pattern of alcohol use which has persisted for more than one month or has occurred repeatedly in the previous 12 months (US Department of Health and Human Services, 1990:184).

The term 'alcohol dependence' refers to a syndrome or constellation of potential signs and symptoms. A list of nine such symptoms has been defined in the ICD-10 and alcohol dependence syndrome is diagnosed when an individual has at least three of these features (US Department of Health and Human Services, 1990).

Finally, the term 'alcohol-related trauma' applies to the combination of alcohol use (BAC > 0 g/100ml) or alcohol intoxication (BAC $\geq$0.08 g/100ml) and is involved in a traumatic incident such as a motor vehicle collision, a fall or an assault.

10.3 THE ROUTINE ASSESSMENT OF ALCOHOL IN INJURED PATIENTS

In recent years the awareness of traumatic injury as a major public health problem has grown and injury prevention has become a primary goal of legislators, policy makers and planners in many countries. Preventative measures such as mandatory seat belt and helmet laws, drinking and driving laws, redesigning roads and adding fire retardants to furniture, building materials and toys have been implemented (Rostenberg, 1995). But, according to Gentillelo, Duggan, Drummond et al. (1988), there is "an obvious flaw in the delivery of trauma care today" since the major cause of traumatic injury - substance abuse and dependence - has been virtually ignored.

Five reasons why alcohol levels should be routinely determined in injured patients are outlined below:

10.3.1 THE RISK OF INJURY

The risk of injury is increased by both the immediate use and the chronic use of alcohol, as well as by its withdrawal.

The immediate effects of alcohol on the brain are either depressing or stimulating in nature, depending on the quantity consumed. Either way, alcohol results in impairment which increases the likelihood of injury since it produces poor judgement, increased reaction time, lowered vigilance and decreased visual acuity (Table 10.1). Physiologically, alcohol also lowers blood pressure and depresses consciousness and respiration. Alcohol also has analgesic and general anaesthetic properties (L.S. Smith, 1979a).

Table 10.1 : The effects of alcohol on the body

- Decreases the level of consciousness.
- Impairs motor function, diminishes co-ordination and balance and increases reaction time.
- Impairs judgement.
- Impairs perception and cognitive abilities.
- Increases risk-taking behaviour.
- Affects emotions and reduces inhibitions, especially feelings of anger and depression, and increases impulsiveness.
- Chronic use causes underlying medical problems which may result in the effects of the injury being more severe.

Adapted from Rostenberg (1995:13).

10.3.2 COMPLICATION OF ASSESSMENT AND MANAGEMENT

The knowledge of an injured patient's alcohol status can significantly improve the medical treatment and injury outcome since the immediate effects of alcohol intoxication can complicate the assessment and diagnosis. Alcohol withdrawal symptoms can also complicate management.

Since alcohol has a potent effect on the central nervous, the cardiovascular and the respiratory systems it may complicate or lengthen the time taken to assess the nature, extent and severity of injury. In addition, alcohol may increase the severity of an injury. For instance, a patient with a head injury (who is also severely intoxicated) may sustain additional damage because the brain is sensitive to fluctuating body temperature, lack of oxygen and lowered blood pressure - all of which can be caused by alcohol.

Furthermore, many patients with traumatic injuries present with altered levels of consciousness ranging from mild agitation to coma. The effects of alcohol can mimic these symptoms and mask the fact that a head injury had been sustained.

Another problem is that the accurate assessment of an injured patient depends of his/her ability to give a reliable history as well as to feel pain in response to a clinician's examination. Since alcohol has analgesic properties, intoxicated patients may not report pain or exhibit tenderness. This is problem is of particular concern in patients with abdominal injury, since these lesions are difficult to evaluate without a patient's co-operation (Rostenberg, 1995).

Alcohol also has a significant synergistic effect with a number of medications, particularly those used for pain relief and sedation in an emergency setting. The interaction of alcohol with such drugs can lead to excessive sedation and can even cause hypotension and respiratory depression to the point of apnoea.

Alcohol intoxication may also complicate surgery. Knowing a patient's alcohol status may influence the anaesthetist's choice of anaesthetic drug. Frequent, prolonged heavy use of alcohol may cause the liver to metabolise alcohol and other drugs more rapidly. In this case a standard dose of anaesthetic may produce less than the expected effect. Alternatively, if the liver tissue has been damaged by chronic alcohol use, the standard dose of anaesthetic may have greater or more prolonged effects. In addition, intoxicated patients undergoing surgery are at greater risk of aspirating vomitus and also do not tolerate hypovolaemia and hypoxia well. Their recovery from anaesthesia may also be prolonged (Rix, 1983).

During their management, persons who are dependent on alcohol may experience withdrawal symptoms or delirium tremens (DT) such as anxiety, agitation, fever, tachycardia, hallucinations and seizures. In such patients, withdrawal symptoms may commence almost immediately and tend to dissipate within 72 hours. If, however, alcohol has been combined with other drugs, this period may be significantly longer.

The symptoms of DT can mimic or overlap with symptoms of injury or the complications thereof, thus confusing the clinical picture. For example, an injured patient who develops a fever on the second day may be thought to have an infection associated with the injury when, in fact, he/she is experiencing withdrawal symptoms. The agitation and restlessness experienced by some patients suffering from withdrawal symptoms can be dangerous in some instances or even aggravate the severity of an injury, e.g. a patient with a cervical spine injury should not move or extend his/her neck.

Unrecognised withdrawal states can sometimes also lead to expensive and unnecessary diagnostic testing, medical mismanagement or prolonged hospital stays (Rostenberg, 1995).

Since patients who are acutely intoxicated at the time of presentation are more difficult to assess, emergency personnel often request additional diagnostic procedures to clarify their clinical picture. Jurkovich et al. (1992) have shown that intoxicated patients undergo significantly more diagnostic and therapeutic procedures in the emergency department than do non-intoxicated patients. In their study intoxicated patients were more likely to require intubation and ventilation as well as intracranial pressure monitoring, peritoneal lavage and CT scan. Intoxicated patients were also more likely to be admitted to hospital overnight for simple observation.

10.3.3 UNDERLYING CHRONIC DISEASES

Patients with alcohol problems often have underlying medical or psychiatric conditions which can complicate their management. Alcohol intoxication appears to exacerbate pre-existing conditions such as cardiac disease, shock, impaired blood clotting and infectious diseases (Soderstrom, 1994a).

Alcohol abusers also tend to have a higher incidence of certain psychiatric conditions such as depression and anxiety (Rostenberg, 1995). It has been found that more than half of those who abuse alcohol and other drugs have experienced problems significant enough to fulfill the diagnosis of a psychiatric disorder (Regier, Farmer, Rae et al., 1990). Problems such as depression may complicate a trauma patient's rehabilitative phase since their behaviour may alienate treatment staff. It is also a concern that, alcohol use has been accepted, and in some instances even encouraged, among patients with severe disabilities such as spinal cord injuries (Kraus, 1992). Such attitudes are particularly troublesome and can prevent such patients from receiving the necessary treatment.

10.3.4 TRAUMA RECIDIVISM

Patients who are alcohol positive at the time of their injury are greatly at risk for subsequent reinjury. In fact, there is even a school of thought that trauma is more a marker for alcohol abuse than the other way round (Maull, 1982).

International studies have shown that "... readmission for second and third traumatic injuries are strongly related to untreated substance use problems in this subgroup of trauma patients" (Rostenberg, 1995:3).

Sims, Bivins, Obeid et al. (1989) found that 44% of 263 trauma patients followed up for 5 years subsequently sustained two or more traumatic insults which required hospitalisation and that 67% of these patients misused alcohol. This finding was corroborated by Rivara, Koepsell, Jurkovich et al. (1993b) who found that patients who were intoxicated at the time of their initial trauma were 2.5 time more likely to be re-injured within 18 months than those patients who were sober.

10.3.5 TRAUMA OUTCOME

Alcohol appears to have some implications on trauma outcome although there are conflicting findings. Some studies show a protective effect, others demonstrate a harmful effect, and still others show no effect at all. P.F. Waller, Stewart, Hansen et al. (1986) found that intoxicated drivers were more likely to die or suffer serious injury and Dischinger et al. (1988) noted that traffic crash victims who were intoxicated were more likely to die at the scene of the injury. Soderstrom & Eastham (1987a) found that alcohol use immediately prior to trauma had no effect on survival while Ward et al. (1982) found that it actually improved a patient's chances of survival. These latter studies have, however, been severely criticised by J.A. Waller (1988:1632) who claims that the "... analysis may be limited only to inpatients, with little or no knowledge about those not injured, those with injuries not requiring treatment, those seen only in the emergency department, or those who died at the scene".

What does appear to be a problem in alcohol-related trauma is the likelihood of patients sustaining some type of complication during their recovery phase. Rivara et al. (1993a) found that acute intoxication played no role in the final outcome after trauma but that chronic alcohol use in trauma patients was associated with more infections during their hospitalisation - most notably pneumonia.

10.3.6 WHY ROUTINE ALCOHOL SCREENING IS NOT UNDERTAKEN

The previous sections have discussed five good reasons why the levels of alcohol intoxication should be assessed in trauma patients. Why then is this not done more frequently or routinely?

There appear to be many barriers to doing routine alcohol screening. Chang, Astrachan, Weil et al. (1992) have noted that although clinicians feel that "alcoholism is a treatable disease" they also feel that "alcoholics are difficult to treat". Gentilello et al. (1988) suggests that this pessimism among the medical fraternity is related to the fact that physicians are usually exposed to chronic alcoholics who "refuse advice regarding sobriety and seem beyond the call of reason". These patients are often manipulative or combative and therefore clinicians respond with pessimism, avoidance, ridicule and helplessness.

Lowenstein, Weissberg & Terry (1990) suggest that the pessimism on the part of emergency department staff is not warranted since studies have shown that alcoholic patients often welcome offers of help for their dependence problem (Gentilello et al., 1988).

Many emergency physicians feel that they can accurately assess a patient's alcohol status without the use of a screening tool. Unfortunately many studies have shown that clinical assessment is not reliable and that doctors constantly over-estimate their ability to accurately assess patients (Rostenberg, 1995). In addition, many doctors in trauma units regard alcohol testing as "clinically not important" since other life-threatening conditions must necessarily take precedence (Soderstrom, 1994a:128). Although it is true that "patients with elevated BAC's are usually in no condition to benefit from counselling services prior to leaving the ED [emergency department]" (Soderstrom, 1994a:128) alcohol screening definitely assists in the clinical assessment and management of patients and also gives physicians the opportunity to identify and refer potential alcoholics to appropriate centres.

Since time is always of the essence in a busy trauma and emergency unit, a rapid and dependable method of measuring blood alcohol would therefore not only aid in the evaluation of patients but also avoid any unnecessary delays in the management of such patients (Gibb, Yee, Johnson et al., 1984).

10.4 METHODS OF ASSESSING ALCOHOL INTOXICATION

A number of alcohol screening tests are available which are quick and easy to perform. These include biological markers, such as blood alcohol concentration, and questionnaires which may be self-administered or involve interviews. The Department of Health and Human Services in the USA recommends the combined use of blood alcohol concentration and a simple questionnaire. It further recommends that "BACs be obtained routinely for all hospitalized trauma patients aged 14 and over at the time of admission to the emergency room or trauma center" and that "patients with BACs above 20 mg/dl (.02 percent) be considered for further AOD [alcohol and other drugs] assessment" (Rostenberg, 1995:33).

10.4.1 BIOLOGICAL MARKERS OF ALCOHOL

There are three types of laboratory screening tests currently available for the measurement of alcohol intoxication, namely blood, breath and urine. Since urine testing for alcohol is not often used in the emergency department setting it will not be reviewed in this section.

10.4.1.1 Blood Alcohol Analysis

Blood alcohol is reported to be the most obvious and specific test for problem drinking and alcohol abuse in trauma populations (Salaspuro, 1994) and has been successfully used as a screening tool in many emergency department studies (Chang et al., 1988; Cherpitel, 1993; Cherpitel, Parés, Rodés et al., 1992; Fine, Steer & Scoles, 1978;). There is also strong support for its routine use in all emergency departments (Maull, 1982; Soderstrom & Cowley, 1987b). This may be possible in first world countries where there is easy access to the equipment required to analyse blood and the results are available within an hour but it is not currently a viable option in developing countries.

In South Africa many hospital chemical pathology laboratories do not have the gas chromatography apparatus to analyse blood for alcohol. Blood therefore has to be sent to the closest Forensic Chemistry Department at the Department of Health and this can be most cumbersome, e.g. in Durban it means that blood is to be sent to Pretoria and there are considerable delays in obtaining the results, sometimes for up to six weeks. This is particularly unsatisfactory when accurate measurements are required 'on the spot'. In addition, blood alcohol analysis in South Afirca is costly - each specimen costs approximately R32.50 to process (personal communication, M. Loubser, Head: Forensic Chemistry Department, Department of Health, Cape Town, 29 June 1996).

10.4.1.2 Breath Alcohol Analysis

In early 1910, Cushny stated that the "exhalation of volatile materials from the lungs is exactly analogous to the evaporation from aqueous solutions, and that the pulmonary cells seem to be freely passive in the process" (cited in Uken, 1979:56). Approximately 20 years later it was proposed that breath be used as a test for intoxication but it was not until the 1950's that breath analysis was first used to estimate blood alcohol (ibid). Since that time the analysis of breath for alcohol has been used by American traffic law enforcement agencies (Dubowski, 1992).

According to the manufacturers of the Lion Alcolmeter S-D2, it is "intended for use whenever a rapid, on-the-spot blood alcohol measurement is required". They also advocate its use in traffic law enforcement, medicine, industrial safety and research since it is easy to use and robust enough to withstand repeated use and rigorous field conditions (Lion Laboratory Ltd). But breath alcohol meters were not widely employed by health care professionals to assess alcohol levels in patients before the late 1980s (U.S. Department of Health and Human Services, 1994). The main reason why breath analysis was not used in injured patients was because it was problematic in unco-operative and unconscious cases. Initially nasal specimens of breath were used and these consistently showed lower results and more variability than the conventional methods of breath or blood alcohol analysis (Gibb et al., 1984; Wenzel & McDermott, 1985). This problem was largely overcome by a group of researchers in Sweden who designed a mouth cup-device which could be used to capture end-expiratory air in unconscious or unco-operative patients (Falkensson, Jones & Sörbo, 1989). With this modification they obtained a good correlation between breath and blood specimens, indicating that breath analysis with this type of device would be useful for the bedside analysis of alcohol in hospital emergency units.

Since the late 1980's breath analysis has been successfully used in screening trauma patients for acute alcohol intoxication and has been found to be a useful marker (Cherpitel, 1989; Salaspuro, 1994). Gibb et al. (1984) found that there was an excellent overall correlation between breath analysis and blood alcohol results. They also found that the correlation was even stronger in co-operative patients ($r=0.963$, $P<0.001$) while in unco-operative patients, although less, the correlation was still significant ($r=0.723$, $P=0.001$). They also concluded that the chance of obtaining a false-positve was "virtually impossible" and the chance of obtaining a false-negative reading was one in 10 000 (ibid:518).

Recently breath analysis has been used in studies in South Africa. Hedden & Wannenburg (1994) used a slightly modified version of the Lion Alcolmeter S-D2 on traffic trauma patients admitted to Addington Hospital in Durban. They reported that there were "no problems encountered in the breathalyser use with patients with impaired level of consciousness, chest trauma and probable airway obstruction" (Hedden & Wannenburg, 1994:1076). A more recent study by Stein, Boshoff, Abrahams et al. (1996) at Tygerberg hospital found that results obtained with a Lion Alcolmeter S-D2 correlated very well ($r=0.62$, $P<0.001$) with BAC levels in a cohort of trauma patients.

Overall, breath analysis has been found to be acceptable to patients. It is also cheap and non-invasive and gives a high percentage of positive results (Thomson, 1983; Wiseman, Tomson, Barnett et al., 1982).

10.4.1.3 Biological markers of chronic alcohol use

There are a number of laboratory screening tools which can determine whether a patient is a chronic user of alcohol or not. Most of these tests measure the injury to liver cells or red blood cells which result from long-term use of alcohol. The most commonly used tests are gamma-glutamyltransferase (GGT) and mean corpuscular volume (MCV). These tests are, however, not particularly sensitive since they may be raised in many other disease processes and may therefore give false positives (U.S. Department of Health and Human Services, 1994).

One of the most promising laboratory tests which has reached the market in the last five years is carbohydrate-deficient transferrin or CDT (Stibler, 1991). CDT will be particularly useful as an indicator of heavy alcohol consumption since it is capable of distinguising persons with alcohol use disorders both from total abstainers and from 'normal social' drinkers with a sensitivity of 91% and a specificity of 99%.

In trauma patients Spies, Emadi, Newmann et al. (1995) have found that CDT is a much better marker for alcoholism than any of the other conventional laboratory markers. G.S. Smith, Soderstrom and Dischinger (1996) evaluated CDT in severely injured patients and found that it shows promise as a marker for heavy drinking.

Only one study using CDT has been undertaken in South Africa. Parry and Morojele (1996b) used this biological marker in their cohort of residents in the Lesotho Highlands Water Project area and found that it could reliably detect people with alcohol problems.

10.4.2 SCREENING QUESTIONNAIRES

10.4.2.1 Assessing acute alcohol intoxication

There are very few formal questionnaires which have been designed to assess acute alcohol intoxication, as most concentrate on chronic alcohol use. However, the underlying principles for assessing acute intoxication appear to be to ask about specific amounts of drinking rather than average amounts; to define a single drink; to inquire about specific amounts of beer, wine, and hard liquor; and to inquire about the frequency, quantity and occasions of heavy use with separate questions (US Department of Health and Human Services, 1994).

There is some concern however about the use of terms such as 'few', 'many' and 'regularly' which some authors believe could be assigned different meanings by different people. Baumrind (1983 cited in Hays, Bell, Damush et al., 1994) has gone so far as to suggest that these types of questionnaires are "bad measurement practices" but Hays et al. (1994) claim that these concerns are overstated although they agree that the use of more quantitative options is a safer general strategy.

Many clinicians and researchers assume that the value of direct questions regarding alcohol consumption is limited because people tend to deny having an alcohol use problem. However, a number of reviews on the validity of such self-report tools conclude that they are an important source of data (Babor, Stephens & Marlatt, 1987; Sobell & Sobell, 1990).

Cherpitel has published a number of papers on the validity of self-report measures (Cherpitel, 1989; 1992; 1993; 1995). She suggests that the validity of such self-report measures vary greatly depending on the number of variables included, the population studied and the criterion used (Cherpitel, 1992). Overall she found that the "validity of self-reported alcohol consumption in emergency room settings is much higher than that found in studies of other populations" (ibid:207), possibly because these patients feel that accurate reports of their alcohol consumption may be important in their emergency care. This was corroborated by Nilssen, Ries, Rivara et al. (1994) who suggest that if trauma patients are screened soon after presentation in the emergency room the pain of their injury could motivate them to admit a drinking problem. They caution, however, that some patients may be 'eager to please', and under-report their drinking or even lie.

Other studies have found that self-reported alcohol consumption is only moderately reproducible and that non-alcoholic persons report their recent intake of alcohol more reliably than those who are intoxicated (Longnecker, Newcomb, Mittendorf et al., 1992). This, however, has been disputed by Midanik (1988) who states that there is no evidence that patients who are intoxicated at the time of their interview give less reliable or valid responses than those who are sober.

One major factor in the validity of self-reported measures of alcohol consumption appears to be "... the cultural context of drinking in a country" (Cherpitel et al., 1992:204). Self-report measures appear to be more reliable in countries in which a high alcohol consumption and frequent drinking are to some degree socially acceptable.

10.4.2.2 Assessing chronic alcohol consumption

There are a number of instruments which have been designed to assess chronic alcohol use. The three most commonly used are the Michigan Alcohol Screening Test (MAST), the CAGE [1] and the Alcohol Use Disorder Test (AUDIT).

The MAST was developed in 1971 as a structured interview with 25 questions (Selzer, 1971). This was modified some years later to include 13 of the original 25 questions - this questionnaire is known as the Short MAST or SMAST (Selzer, Vinokur & Van Rooijen, 1975).

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1 CAGE is an acronym based on the four questions asked:

* Have you ever felt you should cut down on your drinking?
* Have people annoyed you by criticising your drinking?
* Have you ever felt bad or guilty about your drinking?
* Have you ever had an eye opener first thing in the morning to steady your nerves?

The CAGE is a very short (four questions), simple questionnaire and can be incorporated into routine history taking. It was produced in 1974 and validated in 1984 (Ewing, 1984; Mayfield, McLeod & Hall, 1974).

The Alcohol Use Disorder Identification Test (AUDIT) was developed by the World Health Organisation and consists of 10 questions (Babor & Grant, 1989).

Numerous other tests, inter alia the Self-Administered Alcohol Screening Test (Swenson & Morse, 1975), the Alcohol Dependence Scale which is now incorporated into the DSM-IV (American Psychiatric Association, 1994) and the TWEAK (Russel, Martier, Sokol et al., 1991), have been developed for specific groups of patients, e.g. adolescents and pregnant women.

Only two of the instruments designed to assess chronic alcohol use have been validated in first world trauma populations, i.e. the SMAST (Cherpitel, 1995; Rivara et al., 1993a) and the CAGE (Cherpitel, 1995). The CAGE has been found to be particularly useful in trauma patients since it is very brief and can be incorporated into the initial examination of patients (Nilssen, Ries, Rivara et al.;1994).

The CAGE has been successfully used in a few studies in South Africa (Kew, 1994; London, Myers, Nell et al., 1994; Parry & Morojele, 1996; Schoeman, Parry, Lombard et al., 1994). Schoeman and colleagues (1994) used the CAGE on a cohort of tuberculosis patients while Parry & Morojele (1996) used it on inhabitants living in the Lesotho Highlands Water Project area. Both studies found that it was a useful instrument when a cut-off point of 2 (out of 4) was applied. Kew (1994) used the CAGE on hostel dwellers in a gold mine in South Africa and preliminary results appear satisfying. Only one study has found the CAGE to be of little or no use in the

South African setting. London and colleagues (1994) found that the CAGE was not valid when used on farm workers in the Ceres district since some of the questions were unacceptable or misinterpreted by subjects. Unfortunately the CAGE has not been validated in any trauma-related studies but one is scheduled for 1997 (Peden, Van der Spuy & Sidzumo, 1996b).

10.4.3 CLINICAL ASSESSMENT OF ALCOHOL INTOXICATION

According to L.S. Smith (1979a) the clinical features of alcohol intoxication are due largely to the effect of the drug on intellect, voluntary movement, speech, sensation, reflexes, cardiovascular and gastro-intestinal functions.

The clinically intoxicated person may appear to be lightly, moderately, heavily or very heavily intoxicated or stuporose. These gradations are not well demarked but tend to involve a subtle progression. For practical purposes clinical categories are linked to corresponding blood alcohol concentrations (Table 10.2) but there are wide variations depending on whether the person being assessed is an 'experienced' or 'inexperienced' drinker.

There have been a number of studies which have shown that clinical assessment of alcohol is inaccurate and that the correlation between clinical estimation and actual BAC are poor (Holt et al., 1980; Rutherford, 1977; Sobell, Sobell & Van der Spek, 1979). Sobell and colleagues (1979) found that trained observers could only identify between 50% and 67% of subjects who were intoxicated. Holt and colleagues (1980) found that doctors who clinically assessed patients for alcohol intoxication missed 7% of cases with BACs over the legal limit for driving in the UK, 13% of those who had positive BACs and mis-diagnosed alcohol intoxication in 3.5% of patients who had zero BAC levels.

Table 10.2 : Clinical categories of alcohol intoxication and corresponding blood alcohol levels

BAC (g/100ml)	'INEXPERIENCED' DRINKER	'EXPERIENCED' DRINKER
0 - 0.05	'Sober'	'Sober'
0.06-0.09	Lightly intoxicated	'Sober'
0.10-0.15	Moderately intoxicated	Lightly intoxicated
0.16-0.20	Heavily intoxicated	Moderately intoxicated
0.21-0.25	Heavily to very heavily intoxicated	Moderately to heavily intoxicated
0.26-0.30	Very heavily intoxicated	Heavily to very heavily intoxicated
0.31-0.40	Stuporose to comatose	Very heavily intoxicated to stuporose
0.41+	Comatose to death	Comatose to death

(A)	Lightly intoxicated : flushed face, dilated pupils, euphoria, some loss of restraint.
(B)	Moderately intoxicated : (A) + sluggish pupils, inco-ordinated finer movements, rombergism, slurring of speech, staggering on turning.
(C)	Heavily intoxicated : (A), (B) + pupils dilated and very sluggish, nystagmus, inco-ordination of skilled movements, staggering gait.
(D)	Very heavily intoxicated : (A), (B), (C) + flushed or pale face, contracted or dilated pupils, apathetic mood, mental confusion and disorientation, gross inco-ordination of movement, marked rombergism, nausea and vomiting.

Adapted from Le Roux & Smith, 1964:131-141

There are a few studies which advocate the use of clinical evaluation. Walsh & MacLeod (1988) found that clinical estimation of alcohol intoxication is accurate in co-operative patients but in patients with head injuries or with depressed levels of consciousness the assessment is more difficult. They found the smell of alcohol, slurring of speech, neuromuscular inco-ordination and blood-shot eyes to be particularly useful markers of alcohol intoxication. There are, however, many clinical signs or symptoms of acute alcohol intoxication, including unsteady gait, rombergism, 'shaky' handwriting, lateral nystagmus, sweating and nausea and vomiting, to name a few. Lateral nystagmus has been found to be an excellent sign of severe intoxication, i.e. BAC $\geq$0.15 g/100ml, however, it does not appear to be particularly useful as a screening tool (Cooper et al., 1979).

It is possible that the smell of alcohol on a patient's breath influences the assessment. This, however, is problematic because alcohol itself is odourless and tasteless but the non-alcoholic constituents or congeners in alcoholic beverages have an odour. These odours may persist on the breath for many hours after the BAC level had returned to zero or may be present on a patient's clothing (L.S. Smith, 1979b). The intensity of the smell is consequently "... not necessarily related to the amount of alcohol consumed nor the blood alcohol level" (Ward-Smith, 1960 quoted in Smith, L.S., 1979b).

Most of the tests which are used in the clinical evaluation of alcohol intoxication are therefore not sensitive, particularly when there are low levels of intoxication (L.S. Smith, 1979b). In fact, according to Loftus (1957 quoted in L.S. Smith, 1979b) "it is nearly inconceivable to base the diagnosis of sober or not sober solely upon the clinical examination" .

10.5 CONCLUDING REMARKS

There is strong evidence that routine screening for acute alcohol intoxication in injured patients is warranted. Furthermore, there also appears to be a need to assess such patients for possible chronic alcoholism.

Routine BAC has been advocated for first world countries which have the available technology but this is not a feasible option in a developing country such as South Africa.

Clinical assessment of patients for alcohol use is clearly not a reliable proposition and self-report measures appear to have much variability, depending on the acceptability of heavy drinking in a particular country. The latter is also controversial in terms of quantifying the amount consumed.

Breath alcohol analysis has been proven to be both accurate and valid in trauma patients and by means of a small modification to the equipment it can be used for all patients, irrespective of their ability to co-operate with the test. Furthermore, breath alcohol analysis is acceptable to patients, cheap and gives 'on-the-spot' results. This option appears to be the best for the South African trauma situation.

Some measures which may be of benefit in assessing chronic alcoholism are self-report measures such as the CAGE or biochemical markers such as CDT. In a country with a known high level of chronic alcoholism this captive audience, i.e. trauma patients, may be a valuable starting point in addressing our alcohol problem.

10.6 CHAPTER SUMMARY

This chapter has outlined five reasons why screening trauma patients for acute alcohol intoxication is necessary and has presented some possible methods for assessing alcohol use.

The next chapter will present the results of the subsidiary aim of this study which was to assess the accuracy of four methods of assessing alcohol intoxication in the cohort of injured pedestrians.

CHAPTER ELEVEN

A COMPARISON OF FOUR METHODS OF ALCOHOL ASSESSMENT IN INJURED PEDESTRIANS

"Studies have shown that many emergency physicians believe that they can recognize an intoxicated patient without screens and that they consistently overestimate their ability to do so" (Rostenberg, 1995).

11.1 INTRODUCTION

Many patients seen in a trauma facility are BAC positive on presentation. This thesis confirms that injured pedestrians have a high incidence of acute alcohol intoxication and that acute intoxication appears to confound their initial evaluation and management. For these reasons it is essential that a quick, cheap and accurate method of assessing alcohol is available for use as an adjunct to clinical assessment.

This chapter presents the results of an evaluation of the accuracy of three methods of assessing alcohol intoxication (self-evaluation, clinical assessment and breath alcohol analysis) against the 'gold standard', i.e. blood alcohol concentration (BAC) for the purpose of the doctor receiving the patient. Although the results presented in this section pertain to injured pedestrians only (n=196), they can probably be generalised to all trauma patients since these pedestrians were a heterogenious group with regard to injury severity.

A short section on the potential usefulness of breath analysis as a legal screening tool is also included.

11.2 BLOOD ALCOHOL ANALYSIS

The BAC results of injured pedestrians have been presented in Chapters 6, 8 and 9 but a short overview will be presented in this section because BAC was used as the 'gold standard' against which each of the other three methods of alcohol assessment were compared.

The BAC ranges used in this section are those suggested by Cooper, Schwär & Smith (1979) since they correspond roughly to the clinical assessment of alcohol intoxication (see Ch 10, p248).

Using these categories, few patients were found to be mildly or moderately intoxicated but more than 40% of the pedestrians were severely intoxicated (Figure 11.1).

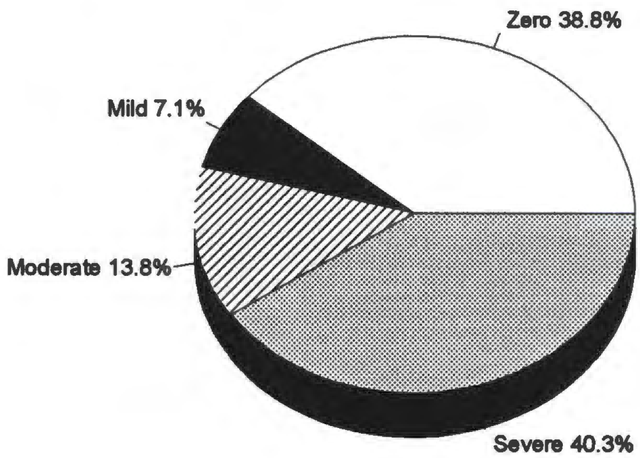


Figure 11.1 : BAC categorised according to 'mild', 'moderate' and 'severe' intoxication (n=196)

Although this method of assessing alcohol intoxication is undoubtedly the most accurate, it is costly and not practical as a baseline measure in South Africa (see Ch 10, p241). In clinical practice BAC determination is time-consuming and results are required 'on-the-spot'.

11.3 SELF-EVALUATION OF ALCOHOL INTOXICATION

All patients who were able to reply were asked three questions, in their home language, about their alcohol consumption in the six hours prior to their collision:

- have you been drinking?
- how much have you been drinking?
- what have you been drinking?

11.3.1 ACKNOWLEDGEMENT OF ALCOHOL CONSUMPTION

One hundred and sixty-five patients (84%) were capable of answering the questions regarding their alcohol consumption. Ninety-two pedestrians (46.9%) acknowledged having taken alcohol (Figure 11.2).

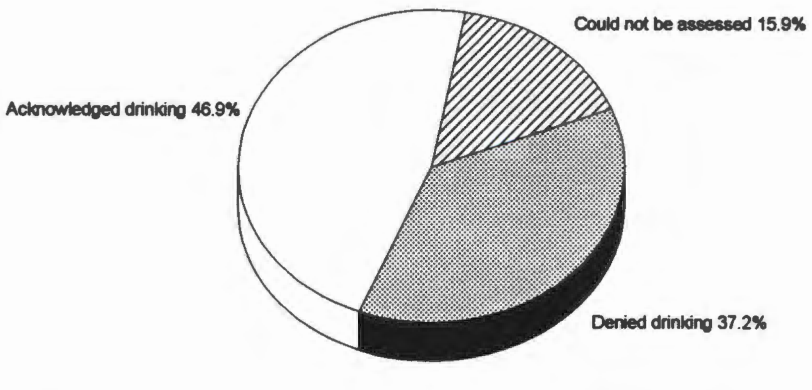


Figure 11.2 : Pedestrian's assessment of their alcohol state (n=196)

Of the 31 patients who could not give answers (non-responders), 22 were ventilated and nine were unconscious or unco-operative. There were no statistically significant differences with regard to BAC between the responders and non-responders (Table 11.1). Since most of the patients who were unable to answer questions were severely injured, it was not unexpected that this group had lower Glasgow Coma Scores, higher NISS ratings and higher Injury Impairment Scores.

Table 11.1 : Characteristics of self-evaluation responders versus non-responders

	RESPONDERS (n = 168)	NON-RESPONDERS (n=31)	DIFFERENCE
Mean age (years)	35.3 (±13.5)	33.1 (±8.5)	NS*
Mean BAC (g/100ml)	0.115 (±0.1)	0.122 (±0.1)	NS*
Median GCS	15 (IQR 1)	6 (IQR 2)	P < 0.001**
Median NISS	9 (IQR 9)	41 (IQR 32)	P < 0.001**
Median IIS	1 (IQR 1)	5 (IQR 3)	P < 0.001**

* t-test
** Kruskall-Wallis test

11.3.2 THE AMOUNT OF ALCOHOL CONSUMED

The conventional method of categorising alcohol consumption (asking patients how many standard drinks they had consumed and converting this into grams of absolute alcohol) was not possible in this cohort of pedestrians because many of the patients had been drinking in 'shebeens' where a communal cup is used. They consequently had no idea of how many 'standard drinks' they had consumed. It was therefore necessary to ask patients to categorise how much they had drunk in comparison to their usual consumption.

Of the 92 patients who acknowledged drinking alcohol, 25 (27.2%) said that they had consumed less than their usual amount, 41 (44.6%) said that they had consumed their regular amount of alcohol and 26 (28.3%) said that they had consumed more than usual. Seventy-three pedestrians indicated that they had not consumed any alcohol at all. For the purpose of tabulation those who said that they had consumed less than usual were labelled 'mildly intoxicated', those who had consumed their regular amount were labelled 'moderately intoxicated' and those who had consumed more than usual were labelled 'severely intoxicated'.

The correlation between self-evaluation and BAC was relatively good (r_s=0.789, $P<0.05$). However, when these results were analysed in more depth certain discrepancies became apparent.

There was a high level of agreement between self-evaluation and BAC in patients who said they had not consumed any alcohol, i.e. of the 73 patients who denied drinking alcohol 63 (86.3%) had zero BAC levels (Table 11.2).

Table 11.2 : Self-evaluation of level of intoxication versus BAC level

	BLOOD ALCOHOL CONCENTRATION*			
SELF-EVALUATION	None	Mild	Moderate	Severe
No alcohol (n = 73)	63 (86.3)	5 (6.8)	2 (2.7)	3 (4.1)
'Mildly intoxicated' (n = 25)	2 (8.0)	4 (16.0)	4 (16.0)	15 (60.0)
'Moderately intoxicated' (n = 41)	2 (4.9)	4 (9.8)	8 (19.5)	27 (65.9)
'Severe intoxicated' (n = 26)	0	0	3 (11.5)	23 (88.5)

* Blood alcohol levels categorised into groups according to Smith (1979:155), i.e. mild = BAC 0.01-0.09 g/100ml; moderate = BAC 0.10-0.15 g/100ml and severe = BAC 0.16+ g/100ml

There was also good agreement in those labelled 'severely intoxicated'. However, patients who indicated that they had consumed about the same ('moderately intoxicated') or less than usual ('mildly intoxicated'), generally under-estimated their true alcoholic state as reflected by their BAC status (Table 11.2).

The discrepancies in self-evaluation were confirmed by looking at the mean BACs in the different categories (Figure 11.3). Patients who were labelled as either 'mildly' or 'moderately intoxicated' had higher than expected mean BAC levels (0.156 g/100ml and 0.182 g/100ml, respectively). There were also very wide BAC ranges in these two categories.

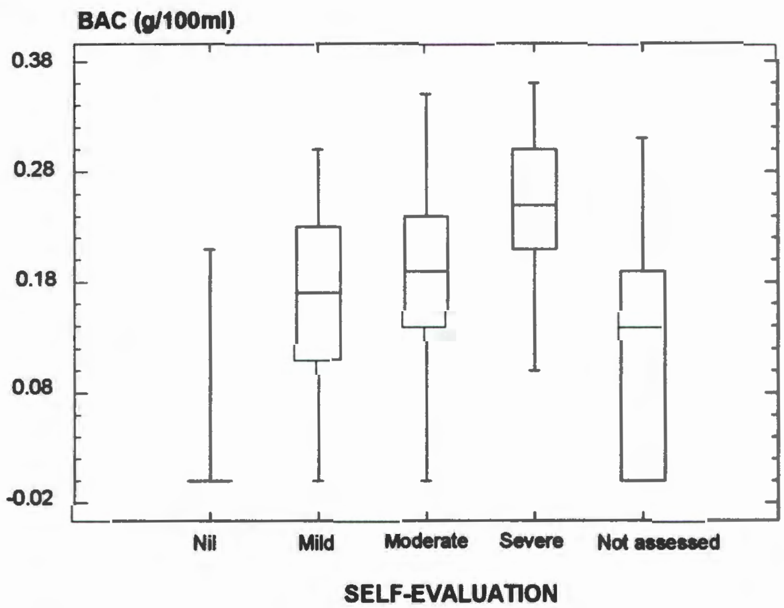


Figure 11.3 : Self-evaluation of level of intoxication by BAC (n=196)

Overall, self-evaluation was found to be a poor indicator of the level of intoxication although it was very specific (96%), i.e. it could accurately identify patients who had not been drinking. It is therefore useless in the clinical situation unless the patient denies alcohol use or is highly intoxicated, both of which are relatively easy to spot. In the intermediate categories, i.e. mildly or moderately intoxicated, self-evaluation is unreliable.

11.3.3 THE TYPE OF ALCOHOLIC BEVERAGE CONSUMED

The ninety-two pedestrians who acknowledged drinking alcohol before their collision were questioned about the type of drink that they had consumed.

Beer was the most commonly consumed alcoholic beverage, followed by wine (Figure 11.4). However, some patients had consumed combinations of alcoholic drinks. The type of beer (commercial or sorghum) was not differentiated in questions and replies.

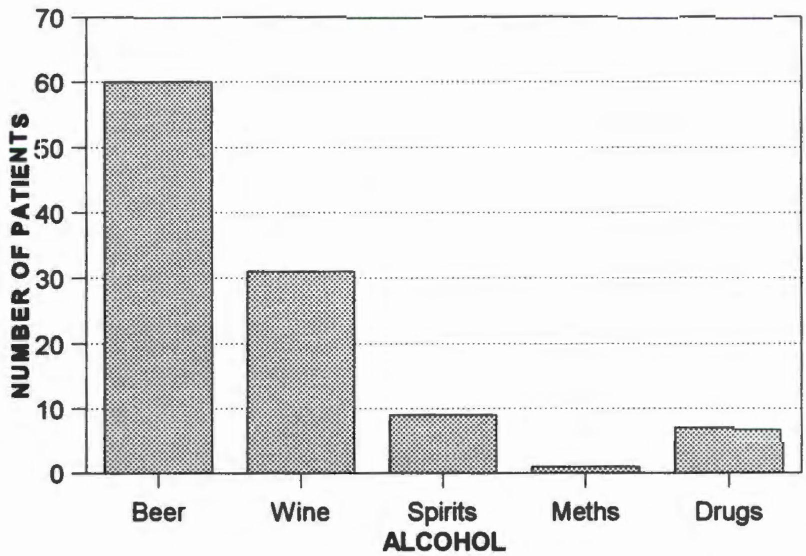


Figure 11.4 : Type of alcoholic beverage consumed by pedestrians (n=92)

It was interesting to note that although patients were not directly questioned regarding their drug usage, seven of the 92 pedestrians (7.6%) volunteered information on the simultaneous use of cannabis.

11.4 CLINICAL ASSESSMENT OF ALCOHOL INTOXICATION

Six clinical parameters (excluding the Glasgow Coma Scale and haemodynamic parameters) were used to objectively evaluate whether patients were intoxicated or not and, if so, to what degree. The first three parameters were 'quick and easy' measures, while the second set of three parameters were more detailed.

The rapid clinical assessment involved assessing the smell of alcohol, slurring of speech and inappropriate behaviour (Table 11.3). This type of assessment is routinely used by law enforcement agencies at road-side sobriety check points. These parameters, however, still tend to be subjective on the part of the observer. Deciding what is 'appropriate behaviour' also depends on culture and previous behavioural activity.

Table 11.3 : Rapid clinical assessment for alcohol intoxication

	BAC+ve n (%)	BAC-ve n (%)	All n (%)
Smell of alcohol			
Yes	105 (87.5)	2 (2.6)	107 (54.6)
No	13 (10.8)	73 (96.1)	86 (43.9)
Not assessed	2 (1.7)	1 (1.3)	3 (1.5)
Slurring of speech			
Yes	63 (52.5)	3 (3.9)	66 (33.7)
No	29 (24.2)	67 (88.2)	96 (49.0)
Not assessed	28 (23.3)	6 (7.9)	34 (17.3)
Behaviour			
Inappropriate	32 (26.7)	4 (5.3)	36 (18.4)
Appropriate	66 (55.0)	66 (86.8)	132 (67.3)
Not assessed	22 (18.3)	6 (7.9)	28 (14.3)

Table 11.3 further indicates that the smell of alcohol was the most reliable parameter (it correctly predicted 87.5% of BAC+ve pedestrians) while inappropriate behaviour was the worst indicator of alcohol intoxication (it could only accurately predict 26.7% of BAC+ve pedestrians). This latter sign was, however, difficult to assess with any objectivity since many patients were in obvious discomfort.

As a screening tool, the smell of alcohol was found to be both sensitive and specific (Table 11.4). However, as was pointed out in Ch 10 (p249) the smell of alcohol is usually due to congeners and can take days to leave the body. Clearly though, if the smell is present, it means that alcohol has been drunk recently and the absence of the smell usually, but not always, indicates no drinking. The other two parameters (slurring of speech and inappropriate behaviour), although very specific, i.e. they could identify who was BAC negative, had poor sensitivities.

Table 11.4 : The accuracy of rapid clinical assessment parameters

	Smell of alcohol	Slurring of speech	Inappropriate behaviour
Sensitivity	88.9	68.5	32.7
n	105	63	32
95% CI	82 - 95	55 - 79	19 - 53
Specificity	97.3	95.7	94.3
n	73	67	66
95% CI	91 - 100	88 - 99	85 - 98

A more detailed clinical assessment, such as could only reasonably be carried out by a doctor or nurse, was also performed on the pedestrians. This included assessing pupil size, pupil reaction and lateral nystagmus. These three parameters were chosen because other useful clinical signs such as rombergism, unsteady gait or poor memory are not feasible to test in severely injured patients.

As can be seen in Table 11.5 it was not possible to assess the size and reaction of three patients' pupils because their eyes were swollen closed. Fifty-three patients (27.0%) could not be evaluated for nystagmus since this test is not possible in unco-operative patients, nor is it possible in patients whose eyes are swollen closed.

Table 11.5 : Detailed clinical assessment for alcohol intoxication

	BAC+ve n (%)	BAC-ve n (%)	All n (%)
Pupil size:			
≥ 4mm	33 (27.5)	20 (26.3)	53 (27.0)
< 4mm	85 (70.8)	55 (72.4)	140 (71.4)
Not assessed	2 (1.7)	1 (1.3)	3 (1.5)
Pupil reaction			
Sluggish	47 (39.2)	6 (7.9)	53 (27.0)
Brisk	62 (51.7)	65 (85.5)	127 (64.8)
Fixed	9 (7.5)	4 (5.3)	13 (6.6)
Not assessed	2 (1.7)	1 (1.3)	3 (1.5)
Lateral nystagmus			
Present	42 (35.0)	3 (3.9)	45 (23.0)
Absent	35 (29.2)	63 (82.9)	98 (50.0)
Not assessed	43 (35.8)	10 (13.2)	53 (27.0)

The classic pupil changes seen in acute alcohol intoxication were masked by the abnormalities seen as a result of head injuries. However, when the confounding effect of head injury was excluded these three parameters still remained poor indicators.

Overall, these three parameters combined performed poorly as a screening test for acute alcohol intoxication. On its own, lateral nystagmus was found to be the most accurate test (Table 11.6) but its greatest advantage is at identifying intoxication, i.e. those over 0.08 g/100ml (see Ch 10, p249).

Table 11.6 : The accuracy of detailed clinical assessment parameters

	Pupil size ≥4mm	Sluggish pupil reaction	Lateral nystagmus
Sensitivity	28.0	39.8	54.5
n	33	47	42
95% CI	13 - 46	30 - 60	42 - 64
Specificity	73.3	92.0	95.5
n	55	69	63
95% CI	61 - 85	86 - 98	88 - 99

Overall, the usefulness of these six clinical parameters was limited but the smell of alcohol (P=0.0001) and lateral nystagmus (P=0.07) appeared to be the best predictors when all six parameters were entered into a reverse stepwise logistic regression model with 'alcohol positive' as the outcome. The smell of alcohol was probably the sign most often relied on.

Since the parameters used to assess clinical intoxication have been found to be unsatisfactory, the classification of patients into consumption categories was probably a purely subjective assessment and therefore the results do not warrant presentation in this thesis.

With the exception of the smell of alcohol and lateral nystagmus the other parameters used in clinical assessment performed poorly. However, the smell of alcohol cannot identify the level of intoxication while lateral nystagmus is excellent at identifying patients who have BAC levels at or above 0.08 g/100ml but is not particularly good at identifying who had or had not consumed alcohol.

11.5 BREATH ALCOHOL ANALYSIS

11.5.1 INTRODUCTION

Breath Alcohol Concentration (BrAC) was assessed in all 196 pedestrians using a modified Lion Alcolmeter S-D2, as was described in detail in the methodology chapter (p82). Seventy-six patients (38.8%) were found to have zero BrAC results. This correlated 100% with the BAC results (Figure 11.5). Thus a zero reading on the BrAC is 100% reliable indication that no alcohol would be found in the blood.

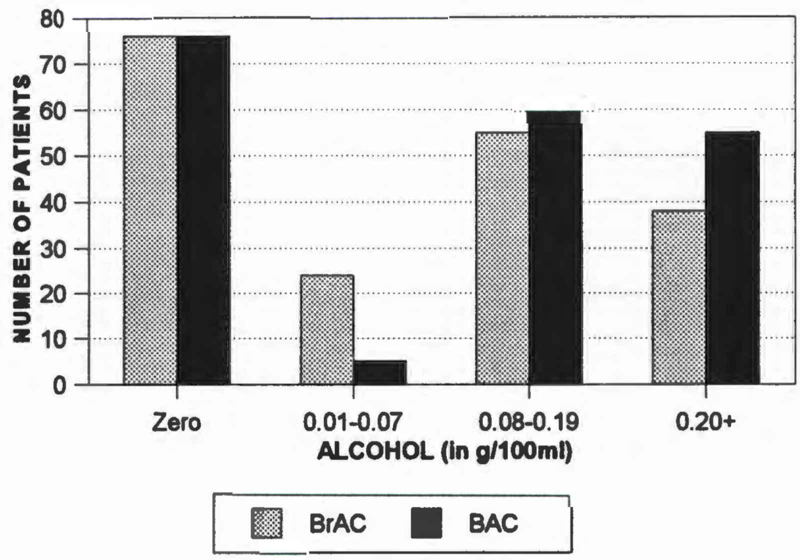


Figure 11.5 : Distribution of alcohol levels in all patients by breath and blood (n=196)

The method used to obtain breath alcohol samples differed according to the patient's ability to co-operate with the procedure and therefore patients were divided into the following three categories:

Co-operative:

One hundred and thirty patients (66.3%) were able to 'actively' blow into the breathalyser for the stipulated time period.

Unco-operative:

Forty-five patients (23.0%) were unable to deliver the required breath sample because they were unconscious, had facial injuries, were confused due to a minor head injury, were too intoxicated or because they simply refused. In these patients the breath sample was obtained 'passively', i.e. the cup device was placed over their nose and mouth and they were allowed to breathe into it until a fine mist developed on the inside of the container, indicating saturated vapour in the expired air, i.e. an alveolar sample.

Ventilated:

Twenty-one patients (10.7%) were intubated and ventilated within minutes of their arrival in the unit. In order not to compromise their oxygenation, breath samples were obtained from the expiratory valve of the ventilator in these patients, i.e. end-tidal air.

The mean BrACs for patients in the three categories were significantly different. All unco-operative patients were BAC positive - this group of patients also had significantly higher breath and blood alcohol levels than the other two groups (Table 11.7).

Table 11.7 : Mean BrAC according to patient's ability to co-operate

	Co-operative (n = 130)	Unco-operative (n = 45)	Ventilated (n = 21)
Alcohol Positive*	46.2%	100%	71.4%
Mean BrAC (in g/100ml)	0.08 (±0.10)	0.14 (±0.07)	0.06 (±0.07)
Mean BAC (in g/100ml)	0.08 (±0.11)	0.21 (±0.06)	0.12 (±0.10)
t-test	1.31	8.91	4.27
P value	NS	0.0001	0.0004

* BAC ≥0.01 g/100ml

From Table 11.7 it can also be seen that the discrepancy between the breath and blood alcohol results in co-operative patients was negligible, but that the differences obtained in the unco-operative and ventilated groups were substantial. These latter differences are in all probability due to the methods used to obtain breath samples in these patients, i.e. it was difficult to obtain end-tidal air with the open cup device.

As a result of the group differences indicated above, the mean BrAC in all 196 patients (0.09 g/100ml) was significantly different from the mean BAC obtained (0.12 g/100ml) (T = 7.74, p = 0001).

11.5.2 SUBSTITUTING BREATH ALCOHOL FOR BLOOD ALCOHOL

In order to decide whether measuring BrAC is an accurate and acceptable substitute for BAC, two types of statistical procedures need to be performed, viz. correlation analysis and agreement.

11.5.2.1 Correlation analysis

Correlation analysis measures the strength of relationship between two variables. It is a statistical procedure which has been used for years to decide whether two measurements are associated. However, according to Bland and Altman (1986), if two methods are designed to measure the same quantity it would be very unusual if the two did not correlate well.

It is therefore not surprising that an excellent overall correlation was obtained (Figure 11.6) between breath and blood alcohol (n=196, r=0.888, P=0.0001).

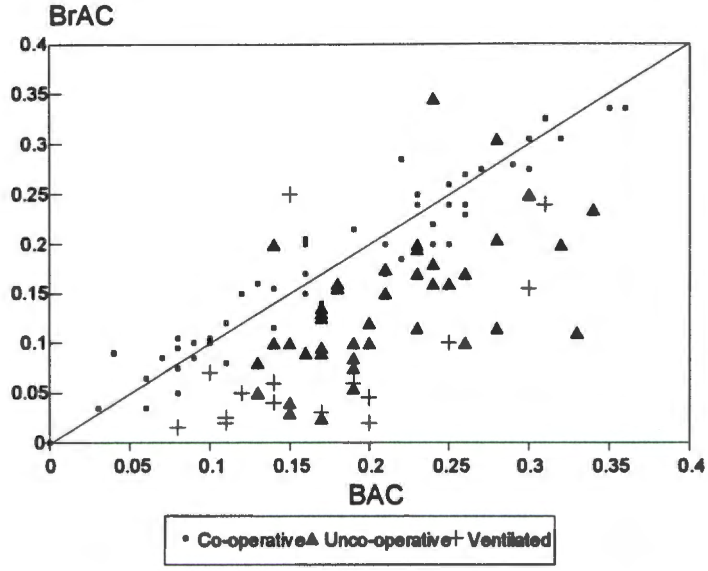


Figure 11.6 : **Overall correlation between breath and blood alcohol in all pedestrians (n=196)**

The degree of association between the two techniques was, however, influenced by how co-operative the patients were when the breath sample was taken.

As can be seen in Figure 11.7, the correlation was almost linear in co-operative patients (n=130, r=0.985, P=0.0001).

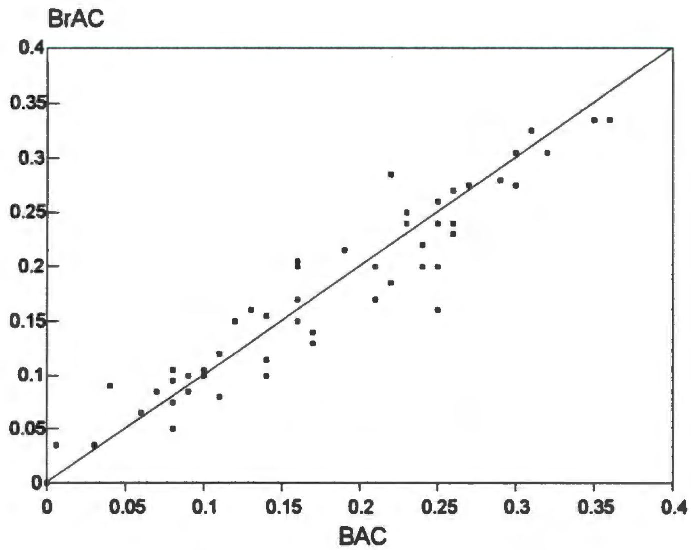


Figure 11.7 : **Correlation between breath and blood alcohol in co-operative pedestrians only (n=130)**

However, as can be seen in Figures 11.8 and 11.9, in unco-operative and ventilated patients the associations were less impressive, but still significant (n=45, r=0.61, P=0.0001 and n=21, r=0.70, P=0.0004, respectively).

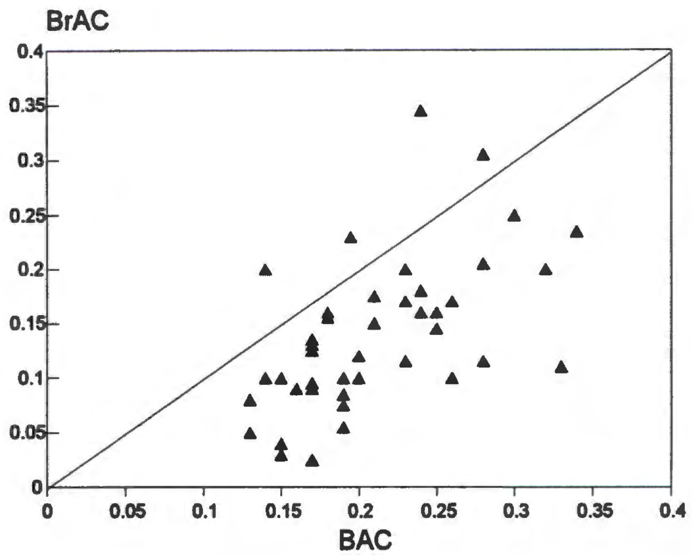


Figure 11.8 : **Correlation between breath and blood alcohol in unco-operative pedestrians only (n=45)**

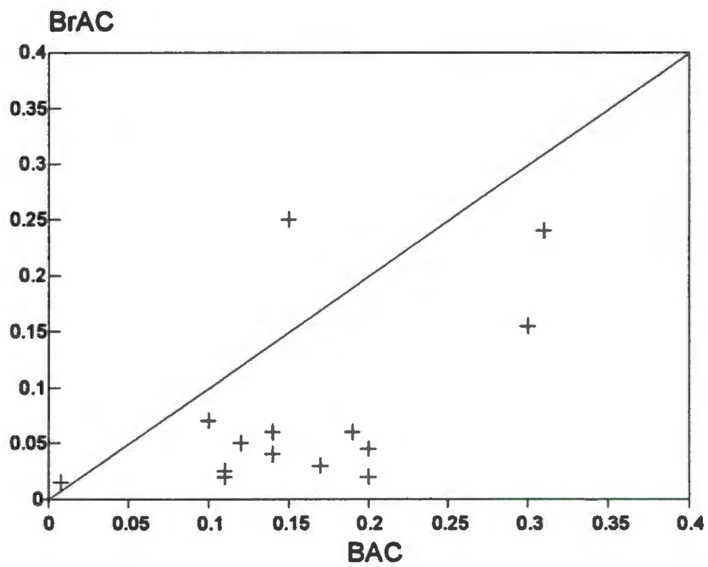


Figure 11.9 : **Correlation between breath and blood alcohol in ventilated pedestrians only (n=21)**

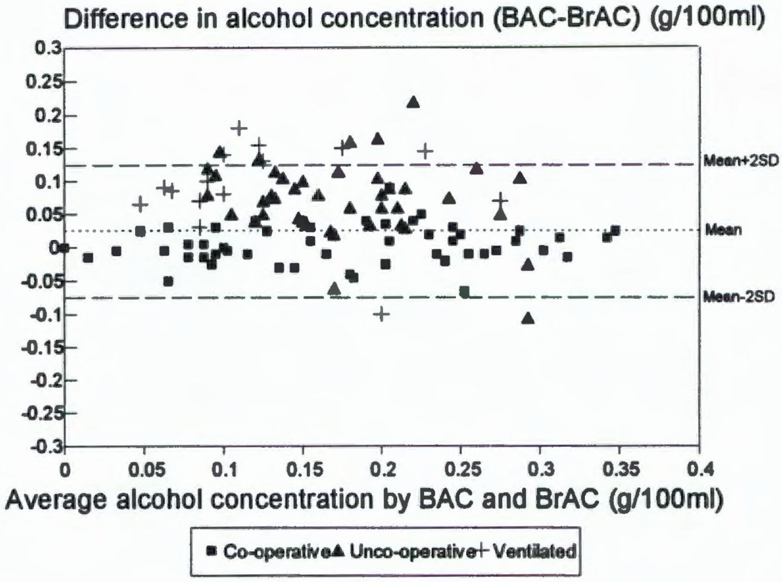
11.5.2.2 Strength of agreement

Although the two techniques used for measuring alcohol in this study correlated very well, it does not necessarily mean that they agree. Since it is unlikely that the two methods will agree exactly, it is necessary to find out how much the new method (in this case BrAC) differs from the old (BAC) and whether this difference is small enough not to cause problems in clinical interpretation.

According to Bland and Altman (1986) the most appropriate method of assessing agreement is to plot the difference between the two methods against their means and follow this with some simple calculations.

Basically, if there is good agreement, 95% of the differences between the two measures should lie between two standard deviations (SD) above and two SDs below. These boundaries are referred to as 'limits of agreement' and should be narrow enough to be clinically insignificant.

Using these statistical and graphical procedures, the agreement between breath and blood alcohol in all patients was found to be fair but the limits of agreement were very wide (±0.10 g/100ml above or below the mean difference) (Figure 11.10).

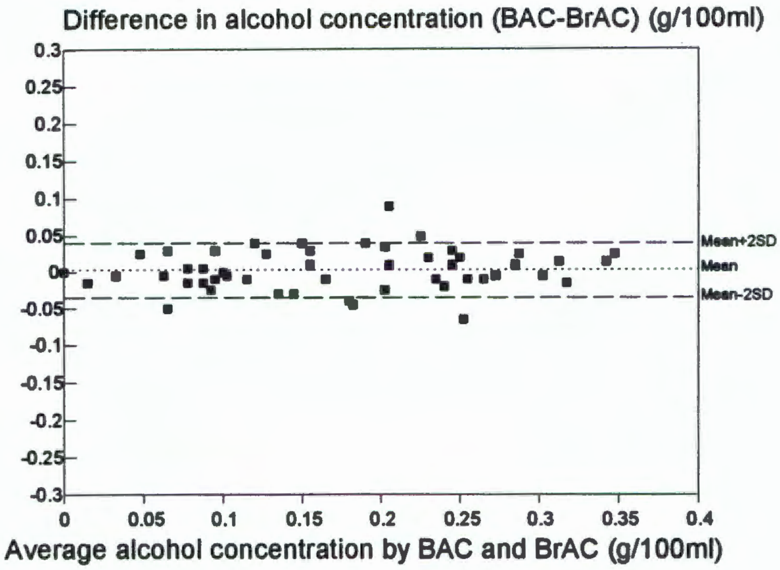


Mean difference = 0.025;	95% CI = 0.019 to 0.033
Upper limit = 0.126;	95% CI = 0.114 to 0.138
Lower limit = -0.074;	95% CI = -0.062 to -0.086

Figure 11.10 : Difference against mean for alcohol data in all pedestrians (n=196)

Again there were distinct differences with regard to how co-operative the patients were when the breath alcohol sample was obtained.

When the statistical and graphical procedures were applied to the co-operative patients only, a very good agreement was attained. The limits of agreement were narrow (±0.036) and only 3.8% of the differences fell outside of these boundaries (Figure 11.11).



Mean difference	= 0.003;	95% CI = 0.000 to 0.006
Upper limit	= 0.039;	95% CI = 0.034 to 0.044
Lower limit	= -0.033;	95% CI = -0.028 to -0.038

Figure 11.11: Difference against mean for alcohol data in co-operative pedestrians only (n=130)

The agreement for patients who were unco-operative or ventilated was very poor. Figures 11.12 and 11.13 indicate the great scatter of results and very wide limits of agreement - which would not be clinically acceptable. The figures also indicate the systematic bias the Alcolmeter produced in these patients, i.e. it almost always under-estimated the alcohol concentration.

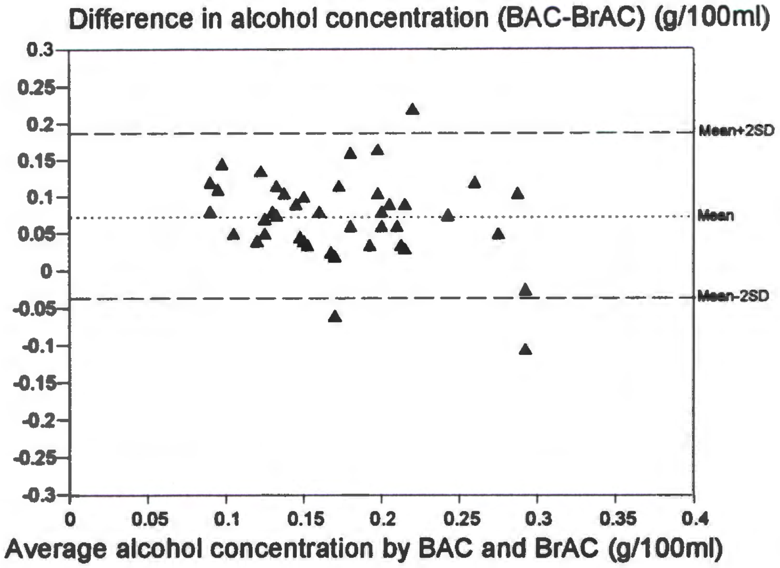


Figure 11.12 : Difference against mean for alcohol data in unco-operative pedestrians only (n=45)

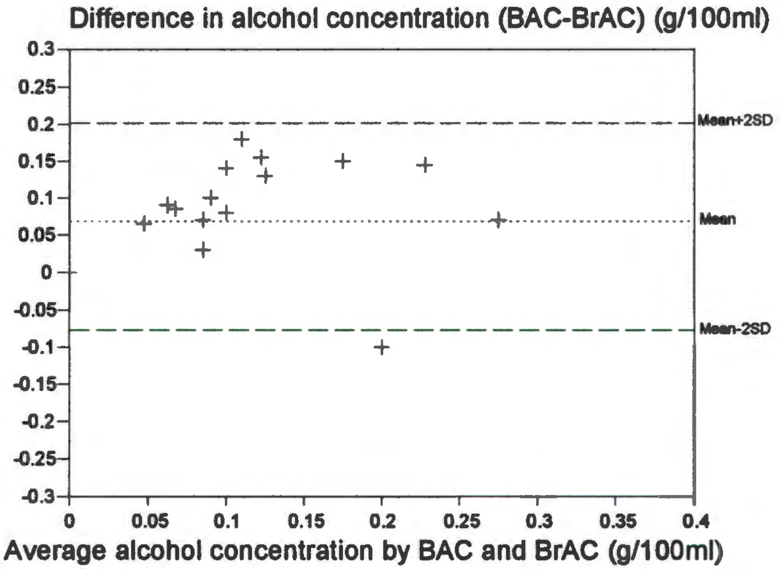


Figure 11.13 : Difference against mean for alcohol data in ventilated pedestrians only (n=21)

The lack of agreement between the two techniques (BrAC and BAC) in unco-operative and ventilated patients (but particularly the latter group) is probably an indication of the inferior method utilised to capture breath specimens in these patients.

11.6 BREATH ANALYSIS IN A LEGAL SETTING

The previous sections have suggested that breath analysis is sufficiently accurate and in agreement with BAC for it to be used in the place of the latter in injured patients. Since the results obtained in injured patients are only used to assist in diagnostic and management issues it is not particularly important if false positives occur, since initiatives taken on BrAC results are unlikely to harm the patient. It is, however, essential that there be few (or no) false positives if the instrument is used at road side sobriety check points.

In order to assess how the instrument performed in this study, the results obtained by patients who could co-operate with the test were analysed. Only this group of patients was assessed since they most closely resemble the majority of people stopped at sobriety check points, i.e. it is presumed that these latter people would co-operate with the test.

The instrument was found to be 100% sensitive and 100% specific using zero as the cut-off point, i.e. if the breathalyser registered zero then the blood alcohol result would also be zero.

When a cut-off point of 0.08 g/100ml was used (the current legal driving limit) the tool produced very high sensitivities and specificities (Table 11.8). In fact, only two people would have been accused of being over 0.08 g/100ml when in fact they were not. This, however, may be a problem in litigation.

Table 11.8 : Sensitivity and specificity of breath analysis using 0.08 g/100ml as the cut-off point

		BAC		
		≤0.07 g/100ml	0.08+ g/100ml	TOTAL
BrAC	≤0.07 g/100ml	73	3	76
	0.08+ g/100ml	2	52	54
	TOTAL	75	55	130

Sensitivity = 97% (95%CI = 91 - 100) Specificity = 95% (95%CI = 85 - 99)

An ideal solution to this problem would be to stipulate a 'grey area' within which all BrAC levels should be confirmed by BAC results.

Regression analysis on the results obtained from the 130 co-operative patients in this study (Table 11.9) produced a predictive BAC linear model of:

$$Y = a + bX \text{ where } a = 0.0014 \text{ and } b = +1.0$$

In other words if a BrAC of 0.08 g/100ml was obtained from a co-operative person the predicted BAC level would be 0.082 g/100ml (SE=0.019 g/100ml).

As with all other measurements, including BAC, one has to make allowances for a margin of error or variability. The 95% confidence intervals for the estimated BAC results would therefore be ±0.037 g/100ml (1.96 X standard error of the estimate). This means that for a breath result of 0.08 g/100ml, the predicted BAC would be 0.082 g/100ml and the corresponding 95% confidence intervals would be 0.045 g/100ml and 0.119 g/100ml (Table 11.9).

Table 11.9 : Linear regression analysis in co-operative patients (n=130)

Dependent variable = BAC			Independent variable = BrAC		
Parameter	**Df**	**Parameter Estimate**	**Standard Error**	**T**	**P**
Intercept	1	0.0014	0.0021	0.649	0.5173
Slope	1	1.0099	0.0158	63.740	0.0001

Standard error of estimate = 0.0188 Model : P < 0.0001

These results may be presented graphically so that the predicted BAC and the corresponding 95% confidence intervals may be read off (Figure 11.14).

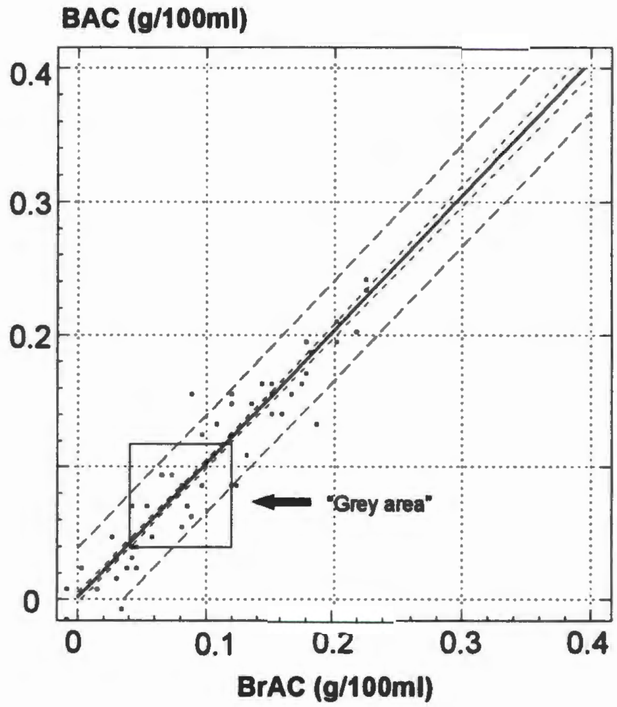


Figure 11.14: Obtaining a BAC level from a BrAC result

Considering these 95% confidence intervals, it is therefore suggested that if a breath alcohol level of 0.04 g/100ml to 0.12 g/100ml is obtained (the 'grey area' indicated in Figure 11.14) then the motorist should immediately be taken to a District Surgeon for blood alcohol analysis in order to validate this result. If a result below 0.04 g/100ml is obtained it can be taken that the motorist is well below the legal limit of 0.08 g/100ml; conversely, if a breath result of 0.12 g/100ml or above is obtained it clearly indicates that the person is well above the legal limit.

11.7 DISCUSSION

The primary aim of this section of the thesis was to assess the accuracy and validity of the modified Lion Alcolmeter S-D2 in injured pedestrians with the view to recommending that this screening tool be used on all injured patients as an adjunct to clinical assessment. As a secondary aim the study attempted to assess how accurate and useful breath analysis would be in a legal setting.

11.7.1 ALCOHOL ASSESSMENT IN A CLINICAL SETTING

Three methods of assessing alcohol intoxication in a clinical setting were compared, viz. self-evaluation, clinical assessment and the modified Lion Alcolmeter S-D2. Although the 'gold standard', i.e. blood alcohol, is the most accurate and specific test for assessing alcohol levels in trauma populations (Salaspuro, 1994) it is expensive to conduct and therefore not practical in a developing country such as South Africa. It also takes too long to get the results for it to be useful in clinical practice. A suitable alternative, which is quick and easy to use but accurate and reliable, is required so that clinicians can use it as an adjunct to clinical assessment.

11.7.1.1 Self-evaluation

The patients interviewed in this study were very forthcoming with regard to whether or not they had consumed alcohol, possibly because they felt that this information could assist with their management, as has been found in other studies (Cherpitel et al., 1992). However, they had a tendency to under-report the amount of alcohol they had consumed and thus, although this measure is cheap and easy to use, it is not particularly accurate at quantifying the amount of alcohol consumed.

It was interesting to note that some pedestrians spontaneously volunteered information on their simultaneous use of illicit drugs, such as cannabis, suggesting that in Cape Town these two substances may often be abused together, as in other countries (Mercer & Jeffery, 1995; Orsay, Doan-Wiggins, Lewis et al., 1994; Soderstrom, Dailey & Kerns, 1994b). This hypothesis would, however, require further research to establish the extent of the problem in order to suggest some interventions.

11.7.1.2 Clinical assessment

As has been found in other studies (Holt et al., 1979; Rutherford, 1977; Sobell et al., 1979) clinical assessment was found to be inaccurate. Clinical assessment of patients enabled the author to judge which patients had consumed alcohol and which patients had not, but the six clinical parameters chosen to assist with this assessment were of no further benefit. Clinical assessment was based largely on the smell of alcohol on a patient's breath, which has previously been proven to be a poor indicator since the congeners in alcohol may persist for some time after a patient has consumed alcohol or may be present on his/her clothing (L.S.

Smith, 1979c). Lateral nystagmus was found to be the best single test for assessing alcohol intoxication in injured patients although this test is best used to identify people who have BACs in excess of 0.15 g/100ml (Cooper et al., 1979). Although the author attempted to categorise the amount of alcohol which the patients had consumed, this assessment was inaccurate and is therefore not presented in this thesis.

Although clinical assessment is quick and easy to conduct and provides some indication of whether or not a patient has consumed alcohol, this study could not validate its usefulness with regard to assessing the amount of alcohol consumed. It is possible that the clinical parameters chosen were inappropriate, or that the assessment was obscured by the patient's injury severity or the depressed level of consciousness as a result of head injury. Either way, the author concurs with Loftus (1957, cited in L.S. Smith, 1979c) who said that it is impractical to assess alcohol intoxication by clinical examination alone.

11.7.1.3 Breath alcohol analysis

The modified Lion Alcolmeter S-D2 was found to be sufficiently accurate for this tool to be used as a substitute for BAC analysis in injured patients.

The apparatus yielded readings which were found to correlate very well with BAC. This was particularly true of co-operative patients but it also performed well in unco-operative and ventilated patients. Similarly good correlations have been found in international studies (Falkensson et al., 1989; Gibb et al., 1984; Wenzel & McDermott, 1985) but none of these studies went on to assess the agreement of breath analysis with BAC readings.

When the breath analysis was assessed with regard to agreement with BAC, certain discrepancies became apparent. In unco-operative and ventilated patients the breathalyser constantly under-estimated the BAC and its limits of agreement were unacceptably wide. Unfortunately these results could not be compared with any similar studies since no such study could be found. However, the results could indicate a flaw in the technique of obtaining breath specimens in unco-operative and ventilated patients. It is possible that the poor results obtained from these patients was due to the inadequate 'seal' of the cup device or due to an insufficient breath sample being obtained. Lion Ltd have recently brought out a new breathalyser (Alcolmeter SD-400PA) which has a cup similar to that used in this study (personal communication, G. Strydom, Sales Consultant, Alcosafe, 12 December 1996). The company has tested this new breathalyser at roadside sobriety checkpoints but it would be interesting to see how it performs on injured patients.

The use of the apparatus in co-operative patients was, however, found to be accurate, reliable and in sufficient agreement with BAC for it to be used in place of the latter. An alternative to the cup device would need to be sought and retested in unco-operative and ventilated patients.

11.7.2 THE USE OF BREATH ANALYSIS IN A LEGAL SETTING

In early 1993 the use of a breathalyser at roadside sobriety checkpoints was legislated in South Africa. The substitution to the Road Traffic Act of 1989 read "no person shall on a public road drive a vehicle ... while the concentration of alcohol in any specimen of breath exhaled by such person is not less than 0.38 milligrams per 1 000 millilitres [≈0.08 g/100ml]" (Amendment of section 122 of Act 29 of 1989 by section 22 of Act 39 of 1993). However, objections came from various quarters with regard to the accuracy and validity of breath analysis and an amendment to this section of the Act was introduced later in 1993, before the previous amendment could be enforced. This latter amendment reads "Until the Minister in consultation with the Minister of Justice orders otherwise by notice in the *Gazette*, no breath specimen shall be taken unless a specimen of blood ... is taken together with the said breath specimen" (Amendment of Section 122 of Act 29 of 1989, as amended by section 22 of Act 39 of 1993 and by section 70 of Act 129 of 1993). As a result of these controversies, only BAC levels are presently admissible in court for the conviction of drunk drivers. It appears as though this situation will remain as it is until breath analysis has been found to be accurate and valid by means of objective research conducted in South Africa.

With this debate in mind, this study assessed the accuracy and validity of the Lion Alcolmeter S-D2 in the cohort of co-operative pedestrians. In order to maintain credibility in this regard, all blood specimens taken were drawn strictly according to legal protocol and were analysed by a forensic chemist. Only co-operative patients were assessed since they most closely resemble persons stopped at a road block.

The Lion Alcolmeter S-32 was found to have excellent sensitivity and specificity in the sub-group of co-operative pedestrians. In fact, when a cut-off point of zero was used the breathalyser was found to be 100% accurate, i.e. if the breathalyser registered a zero reading the BAC was zero in all cases. However, when a cut-off point of 0.08 g/100ml was used this study obtained two false positive results, i.e. two people out of 54 would have been falsely accused of being over the legal limit when in fact this was not the case on BAC analysis. A screening tool which produces any false positive results cannot be used in court because these results could then be contested by the defence lawyers and the evidence rejected forthright.

An ideal proposition therefore is that, instead of all breathalyser levels being backed up with a blood sample (as is proposed in the last amendment to the Act), a 'grey area' be stipulated. Results from this study indicated that this 'grey area' lies between 0.04 and 0.12 g/100ml. In other words, if a driver is stopped in a road block and has a breath alcohol level of between 0.04 and 0.12 g/100ml he/she should be taken to a District Surgeon immediately for a blood alcohol specimen. Drivers who have breath levels below 0.04 g/100ml could safely be said to be within the limits of the law while those with levels above 0.12 g/100ml are definitely above the limit and these results could be used as concrete evidence against them. This is the ideal situation, unfortunately it probably will not stand in court and so therefore practically all BrAC levels of 0.04 g/100ml and above should be backed up with a blood alcohol sample.

11.8 CHAPTER SUMMARY

This chapter assessed the accuracy of three different methods of assessing alcohol intoxication against the 'gold standard'. Breath alcohol analysis was found to be the cheapest, quickest and most accurate method and should therefore be used for clinical purposes on all injured patients as an adjunct to clinical assessment.

CHAPTER TWELVE

CONCLUSIONS AND RECOMMENDATIONS

"There are three elements to the equation of pedestrian traffic trauma: the motorist and the vehicle, the road and road conditions and then the pedestrian. Our problem will not be solved by concentrating on the first component, giving some attention to the second and ignoring the third" (Van der Spuy, 1993:2).

12.1 INTRODUCTION

This is the first comprehensive study of pedestrian morbidity and mortality in relation to alcohol intoxication conducted in sub-Saharan Africa and the subject has therefore been discussed in great detail. This chapter will draw together the most important findings and then go on to make some suggestions on how we could reduce our high pedestrian morbidity and mortality rates. It concludes by mentioning some of the general barriers encountered in injury prevention in South Africa as well as a few of the ways in which the data from this study has already been put into practice.

12.2 CONCLUSIONS

This study recorded a very high incidence of alcohol intoxication among injured pedestrians in Cape Town. Traffic trauma in the city also has a disconcertingly high pedestrian component and the situation is most suggestive of a causal link.

Pedestrian collisions most commonly involve young black males in the 20 - 29 year old age group but males aged 30 - 39 are the group most likely to be intoxicated at the time of collision. Unlike the situation in developed countries, Cape Town's pedestrian trauma does not have a large geriatric component but the number of teenage pedestrians injured while intoxicated raises concern.

Pedestrian collisions appear to be related to low socio-economic status and a high number of collisions occur in informal settlements on the outskirts of the metropole.

As would be expected, most pedestrians were injured by motorcars but there were a number who were injured while getting onto or off minibus taxis. There was a clear relationship between the severity of a patient's injuries and the size of the motor vehicle, the speed at which it was travelling and the patient's level of alcohol intoxication.

Most pedestrians were injured while crossing a road away from a designated pedestrian crossing, usually at night or over the weekend. Pedestrians injured on Saturdays were virtually always drunk at the time and some patients' BAC levels were extremely high. The previously reported peak of collisions one hour after sunset was well demonstrated in this study. There was also an unexplained peak on Wednesdays.

Nearly all pedestrians sustained an injury to the lower limbs and almost half had a concomitant head injury. Patients injured on roads with heavy traffic flow, where the speed limits are ≥80 km/hr, invariably sustained polytrauma and many of these patients were intoxicated. Patients who sustained abdominal or thoracic injuries were often hit by heavy vehicles or vehicles with high front bumpers and these patients all had very high injury severity scores.

A particularly strong relationship was noted between alcohol intoxication and head injuries. In fact, BAC positive pedestrians were twice as likely to sustain a head injury than their sober counterparts. Furthermore, most of the pedestrians who died in the pre-hospital phase did so as a result of a head injury.

There was an obvious trend between the proportion of patients who were alcohol positive and the level of care which they required. Alcohol positive pedestrians were more likely to require admission to an ICU, need multiple interventions, stay longer in hospital and require more complex management. Also, they were often left with long-term or permanent disabilities. Consequently these BAC positive patients were more expensive to treat and ultimately cost the State more than their sober counterparts.

A high proportion of pedestrians died in the prehospital phase. This could be attributed to, among other factors, the delayed transportation of severely injured pedestrians to a suitable facility : unacceptably few pedestrians reached hospital within the 'golden hour'. However, once a patient had reached the hospital his/her risk of dying was slim. In fact, the trauma audit indicated that the care which these patients received at GSH was superior to that of comparable American hospitals.

This study also compared the old method of measuring injury severity with the new method currently being validated in the USA. It found that the NISS was superior to the ISS, particularly in patients with low injury severity scores or in those who had several separate lesions to the head or lower limbs.

With regard to assessing alcohol intoxication in injured pedestrians, this study showed that both self-evaluation and clinical assessment have limited value in a clinical setting. Both techniques were found to be reliable at deciding whether a patient had consumed alcohol but neither were accurate at judging just how much alcohol had been consumed. The use of clinical assessment was found to be highly subjective and based largely on the smell of alcohol on the patient's breath. Many patients could not be interviewed because they were too severely injured or too intoxicated to answer questions reliably. It was interesting to note that a small proportion of those who could be interviewed volunteered information on the simultaneous use of cannabis. This suggests that there is a high incidence of combined alcohol and drug abuse among pedestrians but further investigation would be required to validate this.

On the other hand breath analysis with a modified Lion Alcolmeter S-D2 was found to be exceptionally reliable and accurate in patients who could co-operate with the procedure but less accurate in those who could not co-operate. The cup modification made to the Alcolmeter is probably not adequate to capture breath samples accurately in unco-operative patients and needs to be improved. However, the results obtained by breath analysis were still more accurate overall than those obtained by self-evaluation or clinical assessment. It is therefore recommended that all trauma patients be subjected to breath analysis, as an adjunct to the clinical assessment, in order to optimise their management.

Finally, although this study did not set out to assess breath analysis with the Lion Alcolmeter from a legal standpoint, the results obtained provide positive support to the lobby for the implementation of breath alcohol analysis in South Africa. However, as with all measurements, including BAC analysis, there is inherent variability in the results and this must be taken into account.

12.3 RECOMMENDATIONS

12.3.1 INTRODUCTION

This study has shown that alcohol consumption and pedestrian collisions are almost inextricably linked. In making recommendations it would therefore be naïve to address only the pedestrian problem and not make any attempt to deal with the underlying problem of alcohol consumption in South Africa. However, the latter is a topic on its own and so only a few methods of reducing per capita consumption of alcohol will be discussed briefly. Specific measures relating to drunk pedestrians will, however, be discussed in depth.

12.3.2 ADDRESSING THE PEDESTRIAN CATASTROPHE IN SA

In terms of the 'Haddon matrix' there must be a shift in emphasis in South Africa from postcrash damage control to precrash prevention management by means of law enforcement, education and engineering (Figure 12.1). However, at the same time, this public health approach should not lose sight of the fact that community health cannot be divorced from curative medicine and that curative medicine should adapt itself to the community (Cox, 1992:665).

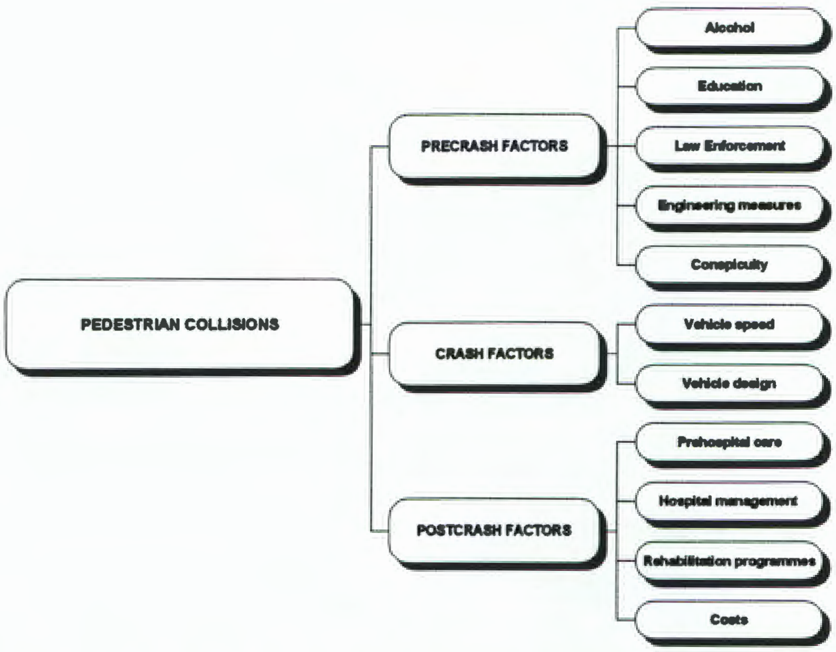


Figure 12.1 : Prevention of pedestrian collisions within the framework of the 'Haddon Matrix'

12.3.2.1 Precrash factors

The control of alcohol-related pedestrian collisions can probably best be discussed withing the framework of general deterrence (response to a fear of punishment) as well as general prevention measures which reduce alcohol consumption in a society (Berger, Snortum, Homel et al., 1990). Unfortunately, although alcohol is prevalent in pedestrian collisions in many countries, countermeasures have been difficult to find.

It is the author's view, however, that "there should be some degree of culpability on the part of pedestrians who cross the road in an intoxicated state" (Peden, Knottenbelt, Van der Spuy et al., 1996c:1105). Some road safety campaigns in South Africa should therefore be specifically targeted at pedestrians who drink, and the stigma associated with driving a vehicle while under the influence of alcohol should also be applied to drunk pedestrians.

Unfortunately, there is at present no law against crossing or walking on a roadway in an intoxicated state. There is, however, a jaywalking law as well as a public drunkenness law but neither of these laws are enforced by the traffic police in South Africa, possibly because of a lack of personnel. Law enforcement is also hampered by the fact that pedestrians are not required to carry identification documents and so they often give false names and addresses to the attending officer. A possible solution would be to legislate a BAC level at or beyond which it is an offence to walk on or cross a public road. This BAC level would have to be determined by means of further local research but international studies have shown that pedestrians with BAC levels above 0.1 g/100ml are usually accountable for their own collisions. It also appears as if a pedestrian is at the same risk of traffic collision at a BAC of 0.15 g/100ml as a driver at a level of 0.08 g/100ml (Cooper et al., 1979).

In Australia there are no drunk walking laws per sé but three states have legislation allowing the mandatory taking of blood samples for analysis from injured pedestrians who present to hospital (Holubowycz, 1995). In South Africa at present the breath alcohol levels done on injured pedestrians in hospital (and documented in their patient records) cannot be quoted in court (personal communication, Tessa Heunis, Attorney- General's Office, Western Cape, 6 December 1995). Even if they were, in the author's opinion, this would be 'closing the stable door after the horse had bolted'. What is required in South Africa is, firstly, legislation about drunk walking and then an extensive advertising campaign, backed up with vigorous enforcement similar to that which took place in New South Wales when random breath testing (RBT) for drivers was introduced in 1982 (Homel, 1993). In Australia the RBT law became "one of the best enforced and most widely publicised laws ever enacted" (Homel, 1994:20) and resulted in a dramatic drop in alcohol-related driver fatalities (Homel, 1990).

Road safety education, combined with law enforcement and legislation, should be ongoing in South Africa. Many pedestrians do not understand the rules of the road nor why they should conform to such rules (Nel, 1976) and this education should therefore be simple and explicit. The message put out should appeal to all people, including drivers, since all use the road in a pedestrian capacity at some time. Furthermore, good driver habits should be encouraged, such as giving way to people using a pedestrian crossing and not overtaking cars which have stopped to allow such people to cross the road. Pedestrians should also be made aware of the dangers of walking while drunk, not using pedestrian crossings, jaywalking, walking on highways and walking in the road if a footway exists.

Although the prevention of pedestrian collisions is a complex matter, research has repeatedly shown the importance of pedestrians making themselves conspicuous to oncoming drivers, especially at night (De Wet, 1992). Light clothing and reflective attire should therefore be promoted since it extends night-time conspicuity of pedestrians up to 230 metres (De Wet, 1993).

Road safety education and the fostering of correct attitudes "... must start at grassroots levels" (Ribbens, 1996:22) in South Africa. Community forums should be developed in order to involve ordinary people and thereby ensure public support for road safety programmes. This bottom-up approach will help ensure awareness of the key problems and provide opportunities for wider participation in decision-making but should be combined with a top-down approach. This is essential if "... road safety is to obtain an adequate share of resources" (Johnston, 1992:158).

Both the State and the private sector should be involved in pedestrian education. The Directorate of Traffic Safety in South Africa has been operative for some time and has recently adapted all its alcohol slogans to include pedestrians. These slogans now read "Don't drink and drive or walk" (Directorate of Traffic Safety, 1996a). The concept of 'Walk Alive' was also conceived and implemented by the National Pedestrian Committee, whose mission it is to identify deficiencies in the management and operation of pedestrian safety through monitoring and evaluation and to make recommendations to eliminate these deficiencies (National Pedestrian Safety Committee, 1994). The private sector is also beginning to make a concerted effect and show its willingness to accept responsibility with regard to traffic safety in the country. A new magazine, entitled "Traffic Safety Today", launched at the recent Traffic Safety campaign, is due for release in January 1997 (Directorate of Traffic Safety, 1996b).

The lack of proper road facilities for pedestrians has been identified as a major problem in South Africa but engineering measures tend to be very expensive, particularly when trying to make existing roads safer. Although some measure such as speed humps, road narrowing and chicanes can be incorporated into existing road structures, their impact on the road system should be researched before doing so. There are, however, other lower cost measures such as correct road markings and signs, reducing the speed at which vehicles travel, segregating pedestrians and vehicles, improved street lighting and access control to residential and shopping streets which have been found to be of benefit in other developing countries (Downing, 1991). It is encouraging to note that the Department of Transport has recently issued a 'Pedestrian Facility Manual' to all road authorities in the country in an attempt to standardise and upgrade pedestrian facilities.

12.3.2.2 Crash factors

The two most important vehicular crash factors which warrant assessment in South Africa are vehicle speed and vehicle design.

The faster a vehicle is travelling the longer the distance it needs in order to stop and the less time and chance the driver has to take evasive action. Vehicle speed also affects the angle of vision of the driver. At high speeds a driver's attention is narrowly focussed on the road ahead, while at lower speeds he/she can better take into account what is happening around him/her. A moderate decrease in speed would therefore achieve marked reductions in injuries and deaths on our roads (Van der Spuy, 1996a).

Other, more expensive, options include the fitting of anti-lock braking systems (ABS) to vehicles which allow them to stop in a shorter distance under difficult conditions. ABS also allows for a better combination of avoidance manoeuvres through the simultaneous use of swerving and braking. If more vehicles were fitted with ABS this could result in a reduction in impacts with pedestrians (Fraine, 1995). However, what is probably more realistic in South Africa would be to require vehicle owners to subject their cars to a road-worthy test on a periodic basis so that, amongst other things, the braking system can be checked. This could not only reduce pedestrian collisions but all types of road traffic trauma in South Africa.

In the long-term, manufacturers of motor vehicles should begin to design 'pedestrian friendly' vehicles. In order to minimise injuries to the pelvis, abdominal and thoracic regions, the bumper height should be lowered on vehicles. There should also be a smooth transition at the top of the bumper bar and around the leading top edge of the bonnet. Also a clearance space of at least 50 mm under the bonnet should be incorporated to allow it to 'give' before hitting the engine (Roads & Traffic Authority, 1994). Such vehicle modifications would spread the impact load during a crash and also increase the likelihood that a pedestrian will be thrown up onto the bonnet of the car rather than being run over, the former being less dangerous. In the short-term, the fitting of bull bars to the front of vehicles should be discouraged since, although they protect the car's occupants, they contradict the principles of pedestrian injury mitigation.

12.3.2.3 Postcrash factors

There are three major postcrash factors which warrant attention. The first is the prehospital care which pedestrians receive, the second is the management of injured pedestrians and the third is the fiscal impact of injured pedestrians on the economy.

At present the ambulance service (METRO) in the Cape metropolitan area is undergoing major changes and rationalisation. New management and initiatives are being put into place and it is reassuring to note that since the beginning of 1995 all ambulance staff have been trained according to ATLS standards. However, there remains a problem with communication systems and it appears as though most of the time wasted is a result of the general population's ignorance about who to contact and what information to give. Extensive public education and community involvement is essential in order to address this problem.

Although it appears that the clinical care which injured pedestrians receive is in keeping with the best standards in most developed countries, the routine assessment of patients for alcohol intoxication is not undertaken. Knowledge of a patient's alcohol status would improve the management and possibly also reduce the number of unnecessary and costly tests and investigations which some patients are subjected to. All hospitals should therefore be supplied with breath analysis apparatus so that this quick, cheap and accurate method of assessing alcohol can be used as an adjunct to clinical assessment.

According to Van der Spuy (1996b) there will be approximately 70 million people living in South Africa by the year 2015 and the urbanised portion will have risen to beyond 70%. Unless something dramatic is done to curb violence and traffic collisions in South Africa "... the escalating trauma case-loads [will] pose a serious threat to health care delivery" (ibid:11). Since many pedestrians require State funded tertiary care the "... redirection of funding to primary health care will have no effect on expenditure on trauma in South Africa." (Linton, 1992;119). Cutting the budget to tertiary institutions would therefore have a detrimental effect on those people who need expert care most.

A concerted effort should be made to curtail expenditure in the already over-stretched tertiary facilities. This would involve the investment of large sums of money in traffic safety by the State but this would be money well spent. Half-hearted attempts or meagre financial budgets will do more harm than good. According to an Australian Traffic Chief "if you are only going to put R6 million into a traffic safety programme, you might as well pile the money in a heap and burn it for all the good it will do" (Du Plessis, 1996:11).

12.3.3 ADDRESSING PER CAPITA ALCOHOL CONSUMPTION IN SA

It has been estimated that in 1994 South Africans consumed roughly 4 billion litres of alcohol containing beverages, the majority of which was beer. Taken literally, this means that every person over the age of 15 years annually consumed about 10 litres of absolute alcohol (Parry, 1995). This is considerably higher than many other countries and is probably due to a combination of factors, including individual, environmental and biological considerations.

But the debate on how to reduce per capita alcohol consumption is multifaceted and cuts across politics and economics as well as religious and public health considerations. A number of models have been put forward by sociologists in an attempt to address alcohol-related damage in societies (Rush & Gliksman, 1986) but these need to be 'tailored' to South African conditions. Increasing the price of alcohol in South Africa could, for instance, only serve to reduce the alcohol intake of moderate consumers while causing those who abuse alcohol to spend even more of their hard-earned cash on alcohol (Yach, May & Pretorius, 1994). A price hike could even result in the smuggling of cheap alcohol across local borders, the hijacking of liquor company vehicles or increased production of home-made alcoholic beverages sold from unlicensed and untaxed outlets. Instead of applying such international preventive measure to South Africa we should first examine the social, cultural and economic circumstances thoroughly and arrive at our own combination of preventive strategies in the light of our history and political composition (Osterberg, 1991, cited in May, 1994).

12.4 OVERCOMING BARRIERS TO INJURY PREVENTION IN SA

Research is an integral part of injury prevention. Without adequate data the problems and solutions can only be matters for speculation. Although trauma ranks as the fourth overall 'killer' in South Africa, it is number one in some regions like Kwa-Zulu Natal (personal communication, J. Van der Spuy, 28 December 1996) and among the black population of the Western Cape (Cape Town Metropolitan Non-natural Mortality Study Group, 1995). Unfortunately there are a number of general barriers which need to be overcome before injury prevention and research in South Africa will begin to produce implementable data and show results.

No national injury data are available. Some areas such as Johannesburg and Cape Town, and Durban to some extent, have reasonably accurate morbidity and mortality data on injury. The calculation of precise incidence and prevalence rates is hampered by the fact that there are no accurate census data for South Africa. This could be rectified to some degree by the 1996 Census, although strategies will have to be put in place to do regular community surveys, since such data will rapidly become outdated because of the highly mobile nature of South African people (Butchart, Peden, Bass et al., 1996). At present a National Health Information System is also being developed on which rational planning may be based.

Another major barrier to injury prevention and control in South Africa is the cultural view that injuries are 'accidents' and thus not amenable to intervention. With the introduction of public education this view could slowly change but this is a long-term consideration and the problem is only beginning to be rectified in some developed countries.

Probably the greatest obstacle to the development of effective control strategies has been the lack of financial resources for injury research. In 1991-1992 South Africa spent R2.8 billion on research, but only 7% of this was allocated to health research in comparison to 34% for engineering and 14% for agriculture. It is not clear exactly how much of the health allocation injury research obtained, but the fact that the National Trauma Research Programme of the Medical Research Council received less that R1 million in 1993-1994 is a clear indication that injury research is not yet regarded as important.

Until these barriers are addressed there needs to be a co-ordinated effort between everyone involved in injury prevention so that duplication does not occur and so that the public at large can benefit.

However, there has already been a positive response to the findings of this study. The data has been presented both locally and abroad and has been well-received (Appendix E & F). It has also been peer reviewed in journals, both indexed (Peden et al., 1996c) and non-indexed (Peden & Van der Spuy, 1996d). It has been presented to stakeholders in the injury prevention arena in "executive summary" format in the NTRP's *Trauma Review* (Peden, 1993) and has received extensive coverage in the national, regional and local press (Baleta, 1996) as well as on radio and television. The data has been requested by the Provincial Administration of the Western Cape, the Attorney-General's office in the Western Cape and the National Department of Health. It has also been used by the Directorate of Traffic Safety for the development of pedestrian awareness programmes and mass media campaigns.

12.5 FINAL REMARKS

Traffic-related collisions and trauma in general are a threat to public health in every country. These injuries and deaths are largely preventable and yet they continue to increase. Control requires international co-operation, a global policy and, most importantly, actions based on sound research. "This action must come from strong commitment - commitment of minds and commitment of resources - to further reduce the needless death and suffering caused by injuries all over the world" (exert from the Melbourne Declaration, drawn up by delegates to the Third International Conference on Injury Prevention and Control, Melbourne, 22 February 1996).

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Appendix A : Research questionnaire for Hospital Pedestrians

GSH TRAUMA UNIT/MRC MVA-PEDESTRIAN STUDY
1993

STUDY ID NUMBER GSHMRC ____________

DEMOGRAPHIC DATA

PATIENT STICKER

RESIDENTIAL SUBURB	____________				
OCCUPATION	EMPLOYED	UNEMPLOYE	SCHOLAR	PENSION	UNKNOWN
INCOME PER MONTH	____________				
PLACE OF INJURY	____________				
WEATHER CONDITION	FINE	RAIN	WIND	MIST	OTHER
VEHICLE INVOLVED	CAR	BAKKIE	MINITAXI	BUS	TRUCK
	M/BIKE	OTHER	UNKNOWN		

TIME OF INJURY ____________ DATE OF INJURY ____________

TIME OF ATTENDANCE ____________ DATE OF ATTENDANCE ____________

SELF ASSESSMENT OF ALCOHOLIC STATE

HAVE YOU BEEN DRINKING?			YES	NO	NOT ASS
QUANTITY CONSUMED		LITTLE	MODERATE	LOT	NONE
TYPE OF DRINK	BEER	WINE	SPIRITS	METHS	OTHER

CLINICAL ASSESSMENT

SMELL OF ALCOHOL			YES	NO	NOT ASS
SLURRING OF SPEECH			YES	NO	NOT ASS
INAPPROPRIATE BEHAVIOUR			YES	NO	NOT ASS
INTOXICATION LEVEL		MILD	MODERATE	SEVERE	NONE
NYSTAGMUS ON LATERAL GAZE			YES	NO	NOT ASS
PUPIL SIZE (IN MM)			LEFT	RIGHT	NOT ASS
PUPIL REACTION TO LIGHT			LEFT	RIGHT	NOT ASS
INTOXICATION LEVEL		MILD	MODERATE	SEVERE	NONE
BREATHALYSER LEVEL		____________	CO-OPER	UNCO-OP	VENT
BLOOD ALCOHOL LEVEL		____________			

PRIMARY EXAMINATION

PULSE ________ BP ________

RESP RATE ________ HB ________

SKIN [NORMAL] [COLD] [SWEATY] [HOT] [DRY]

G.C.S. [ ] R.T.S. [ ]

		AIS
HEAD/NECK	________	[ ]
FACE	________	[ ]
CHEST	________	[ ]
ABDOMEN	________	[ ]
SKIN/GENERAL	________	[ ]
LIMBS/PELVIS	________	[ ]
SPINE	________	[ ]

I.S.S. [ ] TRISS [ ]

PROGRESS AND OUTCOME

PLACEMENT AFTER PRIMARY RESUSCITATION

[DISCHARGED] [THEATRE] [WARD] [ICU] [DEAD] [ABSCONDED]

LOCATION TWO WEEKS AFTER INJURY

[DISCHARGED] [WARD] [CONV HOSP] [ICU] [DEAD] [ABSCONDED]

DISCHARGE DATE ________

DAYS IN WARD ________ DAYS IN ICU ________ TOTAL DAYS ________

IN THE FIRST TWO WEEKS AFTER INJURY HOW MANY

UNITS OF BLOOD DID THE PATIENT RECEIVE? ________

X-RAY EXAMINATIONS DID THE PATIENT HAVE? (REGIONS) ________

HOURS DID THE PATIENT SPEND IN THEATRE? ________

ESTIMATED PHYSICAL IMPAIRMENT PERIOD

[NONE] [SHORT TERM (< 8 WKS)] [LONG TERM (> 8 WKS] [PERMANENT]

ESTIMATED FUNCTIONAL DISABILITY PERIOD

[NONE] [SHORT TERM (< 8 WKS)] [LONG TERM (> 8 WKS] [PERMANENT]

FIELDWORKER ________

Appendix B : Research questionnaire for Mortuary Pedestrians

GSH TRAUMA UNIT/MRC MVA-PEDESTRIAN STUDY
MORTUARY PATIENTS 1993

STUDY ID NUMBER GSHMRC ____________ (M)

GENDER ________ RACE ________ D.O.B. ________

RESIDENTIAL SUBURB ____________________

OCCUPATION [EMPLOYED] [UNEMPLOY] [SCHOLAR] [PENSION] [UNKNOWN]

PLACE OF INJURY ____________________

VEHICLE INVOLVED [CAR] [BAKKIE] [MINITAXI] [BUS] [TRUCK]

[M/BIKE] [OTHER] [UNKNOWN]

TIME OF INJURY ________ DATE OF INJURY ________

BLOOD ALCOHOL LEVEL ________

POST MORTEM RESULTS

HEAD ____________________

____

NECK ____________________

FACE ____________________

CHEST ____________________

ABDO/PELVIC CONTENTS ____________________

UPPER LIMBS ____________________

LOWER LIMBS ____________________

____

SPINE ____________________

EXTERNAL ____________________

ISS [ ]

Appendix C : Guidelines for field workers

Dear Trauma Student

Thank you for consenting to help with this project.

The following are just a few points I would like to emphasise in order to get the most accurate data for this study.

STUDY

What we are attempting to do is to assess the alcohol levels of approximately 200 consecutively admitted pedestrians who have been involved in motor vehicle accidents.

Each pedestrian, as he comes in, will be given a GSHMRC number ranging from 001 to 200 (see top of questionnaire). This number will be used on the blood tube in order to maintain anonymity. One of the patient's stickers will be attached to the questionnaire so that I will be able to identify the patient in order to get follow-up information. Another sticker must be placed on the follow-up schedule.

CONSENT

Before getting any of the data requested, please briefly explain to the patient what the study is about. Please stress that the blood that will be taken will not have the patient's name on the tube. Nobody will be able to identify whose blood it is and so therefore no action can be taken against the patient for being drunk. All results will be kept confidential and no names will be published. The ultimate goal is to make the public aware of the consequences of drinking and walking.

DEMOGRAPHIC DATA

Residential suburb : I think that this information is quite straight forward, e.g. Guguletu, Athlone, etc (you can get this information from the folder).

Occupation : Please put a cross in the appropriate box.

Income : An estimate of the patient's income - either from the patient or from the inside of the folder. If unknown, leave this space blank. If the patient is unemployed - write "none".

Place of injury : Here we are looking for the road where the collision took place as well as the suburb, e.g. Koeberg Road, Milnerton or N2 near airport. If there are 2 roads involved, put them both down. This information can be found on the ambulance slip, or if the patient was brought in by an escort - ask them. If unknown - write unknown.

Weather conditions : Raining, misty, windy, fine, etc. just tick the correct box. NB. This is at the place where the collision took place, not the weather at GSH. (Ask the ambulance men).

Vehicle involved : What type of vehicle was involved, e.g. car, minibus taxi, 'bakkie', etc. Just tick the correct box. If unknown, just tick unknown.

Time and date of injury : This information will not be reliable from the patient. Check the ambulance slip (time of call to scene is the closest time) or ask the ambulance driver, family, etc. An estimated time is acceptable.

Time and date of attendance : When he arrived in Trauma Unit.

SELF-EVALUATION OF ALCOHOLIC STATE

We know that people who drink are very hesitant to give any information about how much they drink, or tend to underestimate. The questions regarding their self-evaluation should therefore be approached in the most tactful manner possible.

As far as the question concerning **"how much have you drunk today"**: what we are trying to find out is whether the patient has drunk less than his usual amount, about the same, or more than usual, or not at all (the questionnaire reflects "a little", "moderate" or "a lot").

The question on **what they were drinking** may have more than one of the options ticked, i.e. he may have drunk beer and brandy. If he has not been drinking one of the options, then please tick other and specify what he has been drinking. Please note brandy, whiskey, etc all fall into the category of spirits. If you are unsure rather mark the "other" category.

If the patient is unconscious/ventilated, then these questions cannot be answered. Tick not assessed in the first box.

CLINICAL ASSESSMENT

Smell of alcohol - if you are unsure, rather tick N/A. If the patient is being ventilated and you are unable to assess the patient then also put N/A (but you can usually smell it even if they are ventilated).

Slurring of speech - easy to detect if the patient is talking. Tick N/A if not talking.

Inappropriate behaviour - if the patient exhibits any inappropriate behaviour, please mark yes. Do not try to work out whether this inappropriate behaviour is due to pain or alcohol. If he is unconscious/ventilated mark N/A.

Nystagmus on lateral gaze - ask the patient to follow your finger from the centre to the right, and from the centre to the left. If there is any "flicking" of the eyes, the patient has nystagmus. This tends to be difficult to assess because the patients are not particularly co-operative, but please try. You cannot assess this in the unconscious/ventilated patient.

Pupil size - please just make sure that you do not have a bright light shining into the patient's face when you try to assess pupil size. The size in mm must be assessed **before** you shine your torch light into the pupil. If the patient has a swollen eye(s), indicate this by means of a C, do not force their eyes open.

Pupil reaction to light - brisk, sluggish, fixed. Please use a penlight torch and not one of the big torches because they tend to disperse the light and therefore make the result inaccurate. The ones on the wall in Trauma Unit are ideal.

The two questions on what you would say the patient's **intoxication level** was, are your gut feeling, considering what you have found on examination. **DO NOT DO BREATH ANALYSIS BEFORE THE CLINICAL ASSESSMENT!** otherwise you will be influenced by the result.

Breath analysis : The alcometer is kept in the sister's office. Should it require more batteries, these are kept locked in Mrs Scheepers' office. Please make sure that it has been properly "purged" before using it. Ask the patient to breathe into the cup so that it mists up, then push "read". Repeat if necessary. If the patient is ventilated, the alcometer should be held under the expiratory valve. Please indicate on the form whether the patient was co-operative, unco-operative or ventilated.

Blood alcohol level : Special blood tubes can be found in the fridge in "Child Assessment". Take 5 ml of venous blood. **PLEASE DO NOT USE A WEBCOL BEFORE TAKING THE SPECIMEN**, otherwise the blood sample may be contaminated with alcohol from the swab, and give a falsely high reading. Tubes should be labelled with the specially designed labels supplied. Only the GSHMRC patient number, date and time the blood was taken should be written on the label. Place the blood back into the fridge. I will collect the blood on a regular basis and take it to the State Chemical Laboratory. **Please use gloves when taking blood for your own protection.**

PRIMARY EXAMINATION

Please do not transcribe the Pulse, BP, Respiratory rate, Hb and skin condition from the patient's "pinkie" (admission form) - please do them yourself. Please note if the patient is reasonably stable one minute and then "crashes the next" - we want the worst observations. The Glasgow Coma Scale is very important; please do it carefully, even if the patient is wide awake. We need the result in order to do work out the Revised Trauma Score. **Leave the RTS space blank - I will work out the RTS on the computer.**

Under the Abbreviated Injury Scale headings please write down all the injures that the patient has sustained. Do not place anything in the AIS boxes: this will also be done later. Also the ISS/NISS and TRISS scores will be calculated later. **PLEASE REMEMBER TO INDICATE WHETHER THE INJURY IS ON THE LEFT OR RIGHT** of the body. This section takes time because you have to wait for the x-rays etc.

PROGRESS AND OUTCOME

All you need to do here is fill in the first question on placement after resuscitation. Please indicate if the patient is going to theatre and then to the ward or ICU. If possible (for easy follow-up) can you find out which ward the patient is going to be admitted to and write it on the follow-up schedule.

The rest of the follow-up questions will be done by me. Thank you.

Appendix D : Ethical consent

UNIVERSITY OF CAPE TOWN

ETHICS & RESEARCH COMMITTEE
DEAN'S OFFICE
MEDICAL SCHOOL

Faculty of Medicine

Observatory, 7925
Tel: (021) 406-6911
Fax No: (021) 47-8955

#406-6106

ERC REF NO: 060/93

14 May 1993

Professor J D Knottenbelt
Dept. of Trauma Unit
GROOTE SCHUUR HOSPITAL

Dear Professor Knottenbelt

"ALCOHOL LEVELS IN MVA PEDESTRIANS."

Thank you for the protocol of your proposed study and your letter dated 7 April 1993.

I have pleasure in informing you that there have been no objections on ethical grounds and it is therefore in order to proceed. Please note comments made by Professor D Knobel (Forensic Medicine):

> "Should the State Forensic Laboratory preform the alcohol determinations and be granted co-authorships for scientific input, no fees will be charged and any involvement and data required from Dept. of Forensic Medicine re: Autopsy reports will be delivered through Prof D Knobel, who will collate and prepare autopsy data as co-author."

Please note that formal approval can only be granted after the next meeting of the Ethics and Research Committee.

Yours sincerely

Signed

PROFESSOR J P de v VAN NIEKERK
CHAIRMAN : ETHICS AND RESEARCH COMMITTEE

JP/mg
ER930514-4

Appendix E : Bristol-Myers Squibb Award

Bristol-Myers Squibb (Pty) Limited

Head Office: AMR Park, 1 Concorde Road East, Bedfordview. P.O. Box 1408, Bedfordview 2008, South Africa
Tel: (011) 455-3271 Fax: 455-3388 Company Registration No. 56/01115/07

16 FEBRUARY 1994

Sister Margie Peden
Senior Research Technologist
Medical Research Council
P O Box 19070
TYGERBERG
7505

Dear Margie

Congratulations on receiving the 1994 Bristol-Myers Squibb Travel Award for your outstanding presentation on the 31/01/94. This award provides you with the airfare and accommodation for your attendance at the 1994 Critical Care Congress in May.

The accommodation details and air ticket will be forwarded to you closer to the time.

Kind regards

Yours sincerely

Signed

CARON ZWICKY
Associate Product Manager Anti-infectives

Appendix F : Letter of commendation from Dr Leonard Evans (General Motors, Michigan, USA)

GM

Research & Development Center

24 October 1995

Margaret M. Peden
Medical Research Council
National Trauma Research Program
OP Box 19070
Tygerberg, 7505
South Africa

Dear Margaret M. Peden:

I had hoped to run into you informally at the Association for the Advancement of Automotive Medicine meeting in Chicago and commend you in person on your excellent presentation. Alas, there seemed to be so much going on that this did not happen (I was the one who asked, in the question period after your talk, if there were any laws in SA against being drunk in public). I found you paper the most memorable of the meeting.

Your data brought to mind the comment from my book *Traffic Safety and the Driver* that one reviewer cited (see highlighted portion). In September I'm giving a public lecture in Dublin -- I'm not sure I want to dwell too much on this!

Enclosed is material that might be of interest to you.

I hope you will consider joining the Association for the Advancement of Automotive Medicine. Vancouver is a one of my favorite cities -- so hope you can make it to the next annual meeting there.

Very best wishes.

Sincerely,

Signed

Leonard Evans
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