FORENSIC EPIDEMIOLOGY - THE INTERFACE BETWEEN FORENSIC SCIENCE AND PUBLIC HEALTH

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by

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DECLARATION

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INTRODUCTION

"Medicine is a social science, ..." - Rudolph Virchow

In the industrialised world, injury accounts for an increasingly large proportion of the burden upon curative and rehabilitative services. This is only partially due to an apparent increase in the rates of both intentional and unintentional injury. It more accurately reflects the success of improved quality of life and public health in reducing morbidity and mortality due to disease. This growing burden of injury and violence on the health care system is also to some extent reflected in the limited information from the developing world, where control of infectious disease has resulted in an increase in the proportion of disability and mortality due to injury. In South Africa, violence and injury is presently a leading cause of death and morbidity, leaving permanent physical and emotional scars in all sectors of society. This is of concern, when considering the prospect that demographic changes associated with greater urbanisation are likely to be associated with rising levels of interpersonal violence and unintentional injury.

It is against this backdrop that a selection of published works is presented, designed to focus on the role of the forensic pathologist in improving community safety. The aim is to transcend the purely legalistic framework within which the forensic pathologist is portrayed and highlight a broad range of areas where a contribution can be made to the creation of a safe and healthy society.

1.

LERER LB, VOLPE M.

TRAUMATIC TRANSECTION - AN UNUSUAL

FATAL PEDESTRIAN INJURY.

AMERICAN JOURNAL OF FORENSIC MEDICINE AND PATHOLOGY

The American Journal of Forensic Medicine and Pathology 13(3):243–247, 1992.

Traumatic Transection

An Unusual Fatal Pedestrian Injury

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Speed, alcohol, and pedestrian injuries constitute disturbing components of the spectrum of trauma in the developing world. The complete fatal transection of a pedestrian, at the level of the lower abdomen, by an oncoming automobile traveling at high speed is described. The upper torso was found inside the vehicle, whereas the lower torso was projected some distance ahead, onto the highway. An accident analysis, in order to ascertain the speed of the automobile, is demonstrated and the biodynamic mechanisms of this injury are discussed. The nature of this injury is compared with that of traumatic hemipelvectomy following which survival has been reported.

Key Words: Pedestrian—Accident analysis—Traumatic transection—Traumatic hemipelvectomy—Automobile crash investigation—Alcohol—Trauma biomechanics.

Pedestrian injuries are a disturbing feature of trauma epidemiology in the developing world (1–3). In 1986, 46% of all traffic fatalities in South Africa were pedestrians and mortality in this single largest group of road users remains a source of severe economic and emotional hardship (4). The presence of unfenced and poorly lit highways close to densely populated areas and the lack of adequate sidewalk facilities in areas of high traffic density exacerbate the problem. The fatality described occurred on an expressway where 99 accidents were reported in 1989 (5).

ACCIDENT DESCRIPTION

On a Saturday at approximately 21:00 hours, an automobile struck a pedestrian on Vanguard Drive, a lit double-laned tarred highway in Cape Town. The weather was good and the road was dry. Parallel skid marks were present before the point of impact and, after hitting the pedestrian, the vehicle crossed a grass-and-sand island embankment and proceeded across the oncoming double-laned highway, striking a steel traffic barrier. The lower torso of the pedestrian was found some distance ahead of the point of impact. The upper torso was found in the vehicle on the front passenger side. The vehicle, a white, four-door, 1982 Ford Cortina XR6, appeared to have been in good condition prior to the accident. It was found against the steel traffic barrier with extensive damage to its front, which included crushing and backward buckling of the structures in the engine compartment. The bodywork was buckled backward, mainly on the driver's side. The windshield was broken and there was some damage to the roof. There was severe damage to the steering mechanism and suspension. The front wheels were damaged and the right front tire was deflated. Bloodstains were observed in the engine compartment and on the roof (Fig. 1).

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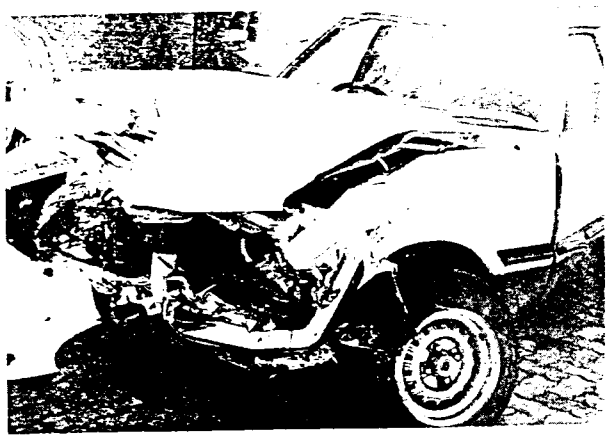

FIG. 1. Passenger-side view of the automobile. Shattered windscreen and buckled front bodywork with damage to the engine compartment. It is suggested that most of the damage to the driver's side of the automobile was due to the collision with the steel traffic barrier.

POSTMORTEM FINDINGS

The body was presented for autopsy examination in two parts, having been transected at the level of the third and fourth lumbar vertebrae. The body length, after approximation of the two portions, was 165 cm and the mass was 65 kg. The face, arms, hands, thighs, knees, and legs had multiple abrasions and lacerations. The left lower tibia and fibula had compound fractures. Examination of the intracranial contents revealed subarachnoid hemorrhage of both occipital poles. The lower cervical and upper thoracic vertebrae were fractured. The thoracic cage had multiple rib fractures and the diaphragm was ruptured. The lungs were extensively lacerated. The liver, attached to the upper torso, was intact. The intestines and mesentery were extensively lacerated. The aorta and the left kidney were lacerated (Figs. 2–4). The postmortem blood alcohol level was 0.25 g per 100 ml.

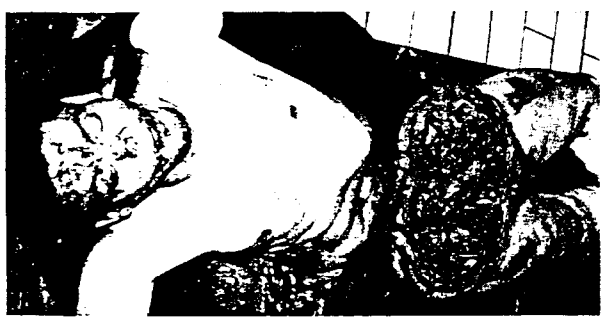

FIG. 2. The transected body with approximation of the upper and lower torso. The facial injuries are illustrated.

ACCIDENT ANALYSIS

The combination of careful evaluation of the findings at the scene of the accident, the vehicle, and the postmortem examination can provide a basis for understanding the mechanisms of injury (6,7). In this case, it can be reasonably assumed that the vehicle struck the pedestrian with considerable force and in such a manner as to cause a traumatic transection and projection of the lower torso. The brakes were continually applied from point A until the vehicle struck the island embankment at point B (Fig. 5). The pedestrian was struck some unknown distance before the vehicle hit the island embankment. It is likely that the lower leg was caught and temporarily fixed and at the same time the lower torso was in relatively prolonged contact with the front of the vehicle. An area of shearing force occurred between the relatively fixed lower and mobile upper torso. The lower torso was projected from the vehicle and landed at point C (Fig. 5). The vehicle containing the upper torso continued to move at an angle to the road and came to rest at a point D (Fig. 5) after striking the traffic barrier. It is difficult to determine the extent that the vehicle was slowed by its collision with the island embankment. We have attempted to calculate the speed of the vehicle at the moment of impact. The following data were used in the accident analysis:

The gravitational acceleration $g = 9.8\ \text{ms}^{-2}$. Coefficient of friction between tar and rubber $\mu = 0.8$. Mass of lower torso $m_l = 35$ kg. Mass of upper torso $m_t = 30$ kg. Mass of vehicle $m_c = 1200$ kg. Horizontal projected distance of lower torso $s_{bc} = 99$ m. Distance of brake application $s = 1 + 46 = 47$ m. Distance traveled following the collision $s_{bd} = 126$ m. An assessment of the extent of damage to the front of the vehicle indicated that the velocity of impact with the barrier was $v_c = 11$–$14\ \text{ms}^{-1}$. We can also assume that the pedestrian was stationary with respect to the motion of the vehicle prior to the collision.

The trajectory equation provides the vertical distance y of the body at any horizontal distance x:

$$y = x \tan \alpha - \frac{gx^2}{2u_l^2}(1 + \tan^2 \alpha)$$

where α is the initial angle of projection and u_l is the velocity of the lower torso immediately after the collision. At the distance $x = s_{bc}$ the vertical distance y is zero and hence

$$\frac{gs_{bc}^2}{2u_l^2} \tan^2 \alpha - s_{bc} \tan \alpha + \frac{gs_{bc}^2}{2u_l^2} = 0 \qquad (1)$$

We were unable to calculate the exact initial veloc-

ity u_l of the lower torso as the angle of projection was unknown. We, however, calculated the minimal initial velocity at which the lower body was projected by noting that for optimal projection $\alpha = 45°$, substitution of this value into Eq. 1 gives

$$s_{bc}^2 - \frac{g^2 s_{bc}^4}{u_l^4} \geq 0$$

$$\Rightarrow \quad u_l \geq \sqrt{g s_{bc}} \qquad (2)$$

$$= \sqrt{9.8 \times 99} = 31 \text{ ms}^{-1}$$

Hence the speed of the lower body immediately after the collision was >112 kmh^{-1}.

From the equations of motion for constant acceleration, velocity u_c of the vehicle immediately after the collision is given by

$$v_c^2 = u_c^2 - 2ds_{bd} \qquad (3)$$

$$\Rightarrow \quad u_c = \sqrt{v_c^2 + 2ds_{bd}}$$

where $d > 0$ is the deceleration of the vehicle (due to rolling resistance, braking, and so on).

By conservation of momentum, we have

$$\begin{matrix}\text{momentum} \\ \text{before collision}\end{matrix} = \text{momentum after collision} \qquad (4)$$

$$\Rightarrow \quad m_c v \cos 13° = m_l u_l \cos 28° + (m_c + m_t) u_c$$

$$\Rightarrow \quad v = \frac{m_l u_l \cos 28° + (m_c + m_t) u_c}{m_c \cos 13°}$$

where v is the velocity of the vehicle immediately prior to the collision.

From the equations of motion for constant acceleration, the velocity u of the vehicle immediately prior to brake application is given by

$$v^2 = u^2 - 2as_{ab} \qquad (5)$$

$$\Rightarrow \quad u = \sqrt{v^2 + 2as_{ab}} \qquad \text{where} \quad \alpha > 0$$

FIG. 3. The transected lower torso indicating the lacerated viscera and the anterior thoracic cage with minimal evidence of external injury.

FIG. 4. The transected lower torso with evidence of the fracture of the right femur and the left tibula and fibula. Multiple abrasions and lacerations are present.

The deceleration α caused by the resistive force of the brakes can be calculated using the second law of Newton:

$$m_c a = \mu \times \text{weight of vehicle}$$

$$= \mu m_c g \qquad (6)$$

$$\Rightarrow \quad a = \mu g = 7.9 \text{ ms}^{-2}$$

Substitution of Eqs. 3 and 4 into Eq. 5 gives

$$u = \left(\frac{(m_l u_l \cos 28° + (m_c + m_t)\sqrt{v_c^2 + 2ds_{bd}})^2}{m_c^2 \cos^2 13°} + 2as_{ab} \right)^{1/2}$$

and, hence, from Eqs. 3 and 6,

$$u \geq \left(\frac{(958 + 1230\sqrt{v_c^2 + 252d})^2}{1367132} + 737 \right)^{1/2} \text{ ms}^{-1}$$

The velocity u of the vehicle before braking depends on the values chosen for the barrier impact velocity v_c and the deceleration d. A realistic value for the deceleration would be $d = 2$ ms^{-2}. Using this value with the range of the barrier impact velocity given in the initial data, the speed of the vehicle before brake application was estimated to be 138–141 kmh^{-1}.

DISCUSSION

Traumatic transection is an injury involving the application of substantial force to the body. A case had been described of transection by a highway sign stanchion in vehicular suicide (8). The basis of the injury is a shearing strain that occurs when opposing forces act across a tissue and exceed its limit of resistance (9). In the case of brain and viscera, the differential in motion causes a shear strain and injury at the interface between the different tissue densities. As a general principle, the body's tolerance to a shear strain has an inverse relationship to the force applied (10). Factors affecting the body's dynamic tolerance include the length of time of ex-

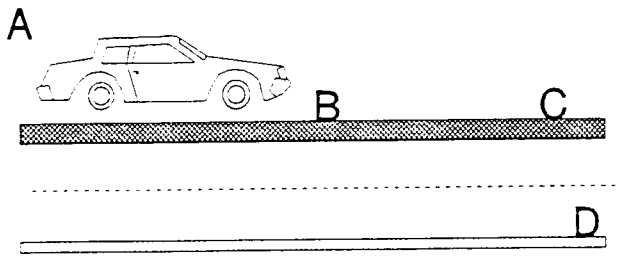

FIG. 5. Schematic illustration of the accident. **A** represents the point where the vehicle began to apply its brakes. **B** represents the point of collision with the pedestrian. **C** represents the point where the lower torso was found. **D** represents where the vehicle, containing the upper torso, struck the steel traffic barrier.

posure to a force, the nature and duration of the force, the direction in which the force is applied, the nature of the surface in contact with the body, and the dynamics of the body at the time of impact (11).

Multiple injuries are a common finding in pedestrian fatalities. The combination of head, chest, pelvic, and lower limb injuries are consistent with the mechanism of injury. Pelvic injuries occur mainly in the severely injured pedestrian and are generally associated with a poor outcome (12,13). Multiplicity of injuries in itself is not the major factor in early pedestrian deaths and survival is related to rapid access to specialized trauma care and, in the case of the severely injured pedestrian, aggressive resuscitation and prehospital stabilization increase the probability of survival (14,15).

A number of cases have been reported of traumatic hemipelvectomy involving pedestrians struck at high speed by oncoming motor vehicles (16–22). The shearing avulsion of a limb and its hemipelvis appears to have a similar mechanism to the injuries we have described. In some cases the avulsed segment was located a distance from the victim. Postulated mechanisms of traumatic hemipelvectomy include entanglement and literal tearing off of the limb and hemipelvis from a stationary victim. This includes pedestrians caught in the wheel of an oncoming vehicle and in agricultural or industrial accidents. The second mechanism is associated mainly with motorcyclists and bicyclists and involves abduction and external rotation of the limb with disruption of the pelvic joints (21). The third mechanism constitutes a crush injury with disruption of the pelvis. These cases occur when the victim is trapped beneath a heavy object or machinery (16,23). A similar mechanism of injury to that of the traumatic transection has been demonstrated when a high-speed shearing hemipelvectomy occurs due to contact with a relatively sharp surface (22). Traumatic hemipelvectomy remains a complex and rare injury often associated with major trauma (19,20). Patients are in a state of profound shock due to hemorrhage from the major pelvic vessels. This hemorrhage often stops spontaneously, but the injury requires rapid specialized trauma care. Treatment includes vigorous resuscitation, staged surgical repair, and attempts to restore the integrity of the colon, genitourinary system, and anorectum. Large-scale reconstructive surgery is required. Rehabilitation and the psychological trauma of a devastating injury complicate the recovery period. A number of cases of successful rehabilitation have been recorded (16,17).

Alcohol affects human impact tolerance and this is reflected in the correlation between injury severity and blood alcohol levels (24,25). The blood alcohol found in the victim would have been associated with a moderate to heavy degree of intoxication at the time of the accident. The effects would include poor judgment, slowed reaction time, and a loss of dexterity. Alcohol alters hemodynamic responses to trauma and its potentiating effect at the central nervous system level may in itself contribute to increased injury severity (26–28).

CONCLUSION

This case demonstrates the destructive power of the motor vehicle and the dangers of high speed and alcohol. Insight into the circumstances and mechanisms of injury may provide some basis for attention to preventable aspects. Although changes in the design of vehicle bumpers may reduce the severity of pedestrian trauma, the main factor in injury dynamics would appear to be the speed of the vehicle and the physical difference between a motor vehicle and a pedestrian (29,30). Reduction of the speed limit has been associated with a decrease in the severity and frequency of traffic accidents and speed remains an important determinant of outcome (31–33). The role of alcohol in traffic accidents and the vulnerability of pedestrians with high blood alcohol levels has been documented (34,35).

In attempting to address the problem of speed and alcohol, strict law enforcement and severe punishment play an equivocal role (36). Real prevention involves a deep-seated awareness that trauma is a major source of morbidity and mortality and an unnecessary drain on already overburdened health and social resources. Perhaps the most important factor lies in the education of a new generation of drivers so that a healthy society avoids the excesses of alcohol and speed on the road. □

REFERENCES

1. Fosseus CG. Injuries sustained in transport accidents. *S Afr J Contin Med Educ* 1986;4:61–5.
2. Knobel GJ, De Villiers JC, Parry CDH, Botha JL. The causes of non-natural deaths in children over a 15-year period in greater Cape Town. *S Afr Med J* 1984;66:795–801.
3. Kibel SM, Joubert G, Bradshaw D. Injury-related mortality in South African children, 1981–1986. *S Afr Med J* 1990;78:398–403.
4. Department of National Health and Population Development. Motor vehicle accidents in South Africa, 1976–1986. *Epidemiol Comments* 1989;16:1–25.
5. City's crash 'black spots.' *Cape Times* 1990 Nov 15, Section A, p. 7, col. 1.
6. Collins JC. *Accident reconstruction.* Springfield, IL: Charles C Thomas, 1979.
7. Lau IV, Viano DC, Gamero F. Invalidity of speculated injury mechanism in autopsy reports. *Injury* 1989;20:16–21.
8. Boglioli LR, Taff ML, Green AS, Lukash LI, Lane R. A bizarre case of vehicular suicide. *Am J Forensic Med Pathol* 1988;9:169–78.
9. Viano DC, King AI, Melvin JW, Weber K. Injury biomechanics research: an essential element in the prevention of trauma. *J Biomech* 1989;22:403–17.
10. Viano DC, Lau IV. A viscous tolerance criterion for soft tissue injury assessment. *J Biomech* 1988;21:387–99.
11. Besson A, Saegesser F. Deceleration and crush injury of the chest. In: Besson A, Saegesser F, eds. *A colour atlas of chest trauma and associated injuries;* vol 1. London: Wolfe Medical, 1982:93–104.
12. Sevitt S. Fatal road accidents: injuries, complications, and causes of death in 250 subjects. *Br J Surg* 1968;55:481–505.
13. Perry JF, McClellan RJ. Autopsy findings in 127 patients following fatal traffic accidents. *Surg Gynecol Obstet* 1964;119:586–90.
14. Sevitt S. Fatal road accidents in Birmingham: times to death and their causes. *Injury* 1972;4:281–93.
15. Anderson ID, Woodford M, de Dombal FT, Irving M. Retrospective study of 1000 deaths from injury in England and Wales. *Br Med J* 1988;296:1305–8.
16. Beal SL, Blaisdell FW. Traumatic hemipelvectomy: a catastrophic injury. *J Trauma* 1989;29:1346–51.
17. Sham AR, Spencer RF. Traumatic hemipelvectomy: a case report. *S Afr J Surg* 1988;26:79–81.
18. Moore WM, Brown JJ, Haynes JL, Viamontes L. Traumatic hemipelvectomy. *J Trauma* 1987;27:570–2.
19. Oppenheim WL, Tricker J, Smith RB. Traumatic hemipelvectomy—the tenth survivor: a case report and a review of the literature. *Injury* 1975;9:307–12.
20. Evans RN, Foss FE. Traumatic hemipelvectomy in combination with traumatic amputation of an upper extremity. *J Trauma* 1984;24:342–5.
21. Rodriguez-Morales G, Phillips T, Conn AK, Cox EF. Traumatic hemipelvectomy: report of two survivors and review. *J Trauma* 1983;23:615–20.
22. Meester GL, Myerley WH. Traumatic hemipelvectomy: case report and literature review. *J Trauma* 1975;15:541–5.
23. Ganapathy DH. A report of traumatic hindquarter amputation. *Injury* 1973;5:51–3.
24. Gilroy D. Deaths (144) from road traffic accidents occurring before arrival at hospital. *Injury* 1985;16:241–2.
25. Waller PF, Stewart JR, Hansen AR, Stutts JC, Popkin CL, Rodgman EA. The potentiating effects of alcohol on driver injury. *JAMA* 1986;256:1461–6.
26. Blomqvist S, Thörne J, Elmer O, Jönsson B, Strand S, Lindahl SGE. Early post-traumatic changes in hemodynamics and pulmonary ventilation in alcohol-pretreated pigs. *J Trauma* 1987;27:40–4.
27. Flamm ES, Demopoulos HB, Seligman ML, Tomasula JJ, DeCrescito V, Ransohoff J. Ethanol potentiation of central nervous system trauma. *J Neurosurg* 1977;46:328–35.
28. Smith LS. Alcohol and driving. In: Cooper WE, Schwär TG, Smith LS, eds. *Alcohol, drugs and road traffic.* Cape Town: Juta, 1978:312–39.
29. Ashton SJ, Mackay GM. Pedestrian injuries and death. In: Mason JK, ed. *The pathology of violent injury.* London: Edward Arnold, 1978:38–55.
30. Fisher AJ, Hall RR. The influence of car frontal design on pedestrian accident trauma. *Accid Anal Prev* 1972;4:47–58.
31. De Villiers RA, De Villiers JC. The relationship between speed restrictions and head injury admissions to Groote Schuur Hospital: an interim report. *S Afr Med J* 1974;48:2546–8.
32. Rose-Innes AP, Le Roux CJG. Influence of road speed restrictions on the incidence and severity of head injuries. *S Afr Med J* 1974;48:2548–51.
33. McCoy GF, Johnstone RA, Nelson IW, Duthie RB. A review of fatal road accidents in Oxfordshire over a 2-year period. *Injury* 1989;20:65–8.
34. Myers RAM, Taljaard JJF, Penman KM. Alcohol and road traffic injury. *S Afr Med J* 1977;52:328–30.
35. Hossack DW. Investigation of 400 people killed in road accidents with special reference to blood alcohol levels. *Med J Aust* 1972;2:255–8.
36. Trunkey DD. Trauma. *Sci Am* 1983;249:20–7.

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WOMEN, HOMICIDE AND ALCOHOL IN CAPE TOWN, SOUTH AFRICA.

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WOMEN, HOMICIDE AND ALCOHOL IN CAPE TOWN, SOUTH AFRICA

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Summary

Little is known about the complex circumstances culminating in the homicidal death of a woman. The records of 248 female homicides and suicides admitted to the Salt River State Mortuary between January 1990 and July 1991 were reviewed with specific attention to mode of death and blood alcohol concentration (BAC). Female homicide levels reflected the intensity of violence in specific residential areas. White females were far more likely to die a suicidal, as opposed to homicidal, death (Odds Ratio = 31.94; 95% Confidence Interval, 11.63 – 90.24). Blunt homicide predominated amongst White females, who were substantially older than the Coloured and African subjects. A BAC greater than 0.1 g per 100 ml was found in 56% of all female homicides studied. An association was found between increasing BAC and sharp homicide amongst women. A high BAC may represent a self-destructive element in a risk-taking situation amongst female homicide victims.

Key words: Female homicide; Alcohol; Self-destructive behaviour; Alcohol and violence

Introduction

Homicide rates have been increasing in the United States since the early 1980s [1]. Inadequacies in mortality reporting, lack of accurate population statistics and misclassification of cause of death has hampered the investigation of this form of non-natural mortality in the developing world [2]. The hypothesis of a suicidal component in the behaviour of homicide victims remains difficult to validate and alcohol features constantly in the violent interactions culminating in homicide [3,4]. The role of alcohol as a central nervous system depressant, its disinhibitory effect and the socio-cultural aspect of alcohol-related violence complicate research in this area [5 – 7]. Alcohol-related violence, concentrated in areas of overcrowding and disadvantage, overloads emergency facilities [8]. Women in the rapidly urbanising developing world and inner-city America share similar multiple burdens of racial, social and sexual oppression [9,10].

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The ignoble reputation of Cape Town as a 'crime capital of the world' has deep roots in the massive resettlement of established Coloured communities to the wastelands of the Cape Flats and African migration to informal settlements on the urban periphery [11]. Pervasive and interminable violence is regarded as an omnipresent part of South African life. This phenomenon is described by Malan as 'a third category of resonant killing for which I had no theory at all' [12].

This paper attempts to describe female homicide in Cape Town, its relationship with sex, race, age, female suicide and blood alcohol concentration.

Subjects and Methods

The population of metropolitan Cape Town is expected to exceed three million by the mid-1990s. Despite reported improvements in law enforcement, almost all of the at least 1500 homicides in 1990 occurred in Coloured and African areas [13]. A statutory requirement exists for all non-natural deaths (including suicides and homicides) to be subjected to a medico-legal postmortem examination [14]. Deaths which require autopsies are admitted to the Salt River State Mortuary which processes over 90% of the non-natural deaths in metropolitan Cape Town. Femoral vein blood removed at autopsy from all adults, excluding those who have a prolonged hospital admission, is analysed at the State Chemical Laboratories for blood alcohol concentration (BAC). This result is recorded in grams per 100 ml of blood (g/100 ml).

The records of all homicides and suicides over the age of 15 years, occurring in 1990, were extracted from the Death Register of the Salt River State Mortuary. This was done in order to provide comparative data by race and sex for a 1-year period. An in-depth analysis of female homicide was then undertaken for an 18-month period commencing January 1st, 1990 using the Death Register, post mortem and blood alcohol.

All women over the age of 15 years regarded as victims of homicidal violence or suicide in the police reports were included in the study. The method of homicide or suicide was ascertained from the police and autopsy record. Whilst specific suicidal methods were described, the homicides were divided into sharp, blunt and firearm groups. Sharp homicide included death due to stabbing or cutting, blunt homicide described death due to the application of blunt force (including beating or strangulation) and firearm homicide included death due to handguns, rifles or shotguns. The Death Register provided race and age information. Where possible, this data included confirmation from the identification document of the deceased. A single unidentified decomposed female homicide was excluded from the study.

Summary statistics were calculated for homicide and suicide admissions of both sexes for 1990. Female homicides and suicides were then described in further detail for the study period (January 1st, 1990 to June 30th, 1991). It is perhaps inappropriate to study the disturbing differences in the non-natural death rates of the various population groups without in-depth review of the role of various forces in the structure of violence in South Africa. Statistical analysis was undertaken using Epi-Info (Version 5) and the SAS statistical package

TABLE 1

HOMICIDES AND SUICIDES ADMITTED TO THE SALT RIVER MORTUARY BY RACE AND SEX, 1990

	Homicide				*Suicide*			
	Male	*Female*	*Total*	*Female (%)*	*Male*	*Female*	*Total*	*Female (%)*
White	18	8	26	31	92	13	105	12
Coloured	523	107	630	17	28	4	32	13
African	607	57	664	9	12	1	13	8
Total	1148	172	1320	13	132	18	150	12

[15,16]. An Odds Ratio (OR) and 95% confidence interval (CI) were used to assess the relationship between race, homicidal or suicidal death and type of homicide. The median ages of the homicide and suicide groups were calculated and races were compared using non-parametric statistics. Stratification was done for race, homicide type or suicide, conditioned on a BAC. A Chi-Square statistic for trend was used to provide a summary measure of association between BAC and homicide type (sharp or blunt).

Results

African and Coloured homicides constituted 98% (1294 out of 1320) of the 1990 sample, whereas Whites formed 70% (105 out of 150) of all suicides for the same period. Whilst female homicide and suicide constituted only a small proportion of the 1990 total (13% and 12%, respectively), White women formed almost a third (31%) of the homicidal deaths in this population group (Table 1).

During the 18-month study period, 72% (23 out of 32) of female suicides were White. White women (as compared to Coloured and African women combined) were more likely to die a suicidal, as opposed to homicidal, death (OR = 31.94;

TABLE 2

FEMALE HOMICIDES AND SUICIDES ADMITTED TO THE SALT RIVER MORTUARY BY RACE AND TYPE OF DEATH, JANUARY 1st, 1990 – JUNE 30th, 1991

	Sharp homicide	*Blunt homicide*	*Firearm homicide*	*Suicide*
White	2	12	2	23
Coloured	64	59	4	7
African	40	20	13	2
Total	106	91	19	32

TABLE 3

FEMALE SUICIDES BY METHOD AND RACE, JANUARY 1st, 1990 - JUNE 30th, 1991

	White	*Coloured*	*African*
Firearm	5	1	
Hanging	2	1	1
Drug overdose	8	3	
Gassing	3		
Drowning		1	
Jumping	3		
Cutting	1		
Burning		1	1
Total	23	7	2

95% CI, 11.63 - 90.24). Differences in female homicide types included a large number of firearm deaths in the African group and an increased likelihood of blunt homicidal death amongst White females (all female homicides excluding firearms, OR = 7.9; 95% CI, 1.61 - 52.69) (Table 2).

Median ages of the female homicides were 29.5 years for Africans, 35 for Coloureds and 63 for Whites. A significant difference in median age of suicidal death existed between the White and combined Coloured and African groups with the median age of Whites being 59 years compared to 29.5 years for Coloureds and Africans (Wilcoxon, Chi-Square = 3.95, $P < 0.05$).

Drug overdose was the method of choice in 34% (11 out of 32) of the suicides. Firearms were used in 22% (5 out of 23) of the White suicides (Table 3).

It was possible to obtain BAC in 214 cases and these levels are presented in Table 4. An elevated BAC (>0.00 g/100 ml) was present in 76% (76 out of 100) of the sharp homicides and 56% (40 out of 72) of the blunt homicides. Only 12% (3 out of 25) of the suicides had an elevated BAC. Stratification by BAC showed an increased risk of a sharp as compared to blunt homicidal death with rising BAC (Chi-Square = 16.66, $P = 0.02$).

TABLE 4

FEMALE HOMICIDES AND SUICIDES BY RECORDED BLOOD ALCOHOL CONCENTRATION (BAC) AND TYPE OF DEATH, JANUARY 1st, 1990 - JUNE 30th, 1991.

S, sharp homicide; B, blunt homicide; F, firearm homicide; SU, suicide.

BAC (g/100 ml)	*White*				*Coloured*				*African*			
	S	*B*	*F*	*SU*	*S*	*B*	*F*	*SU*	*S*	*B*	*F*	*SU*
0.00	1	10	2	19	8	17	3	2	15	5	10	1
0.01 - 0.09	0	1	0	1	7	1	1	0	2	0	0	0
0.10 - 0.19	0	0	0	0	12	12	0	0	2	5	1	0
0.20 - 0.29	1	0	0	1	30	10	0	1	11	4	0	0
>0.30	0	0	0	0	7	6	0	0	4	1	0	0

Discussion

This paper provides some perspective on the characteristics of female homicide in Cape Town. The magnitude of violence in the Coloured and African populations should be a source of concern and although this paper is mainly descriptive in nature findings of this nature should at least precipitate consideration of intervention measures at a community level. This study is limited to fatal cases of violence and suicide. This represents a small proportion of a spectrum of minor to life-threatening injuries. Butchart's study of non-fatal trauma in Johannesburg showed that over 50% of injuries were as a result of inter-personal violence and often, in the case of women, at the hands of spouses and lovers [17].

Traditional distinctions between various types of homicide appear to be difficult to confirm in Cape Town. High levels of penetrating incised wound (sharp violence) would appear to be unusual in the context of domestic violence where blunt force (spouse or lover 'battering') would be expected to predominate [10,18]. Reasons for high levels of sharp homicide, especially in the Coloured population, could include Zimring's theory of the effect of instrumentality as explained by Barlow and Barlow [19]. Knives are easily accessible and constitute a large component of inter-personal violence in areas of overcrowding and poverty. Death may not be the intended outcome of a knife assault and may be potentially avoidable. Access to firearms in the African community has led to increased homicides due to gunshot wounds. Whilst a finding of this nature should be viewed with the utmost circumspection in the light of reported political and factional violence, some anecdotal reports indicate that many of the deaths recorded in this study were as a result of inter-personal disputes or domestic violence [20]. Increasing firearm homicide and suicidal use of firearms should provide a firm basis for the advocacy of strict gun control legislation as sufficient evidence exists as to the efficacy of this strategy in the District of Columbia in the United States [21].

Perhaps the most disturbing aspect of this study is the finding that over three-quarters of the female sharp and over half the female blunt homicides had an elevated BAC. It is unlikely that this is an artefactual finding relating to decomposition, as the vast majority of the BAC levels recorded were greater than 0.1 g/100 ml. Little appears to have changed since le Roux and Smith's 1962 description of high BAC levels in the Cape Peninsula's homicide victims [22]. Elevated BAC levels in sharp homicide victims has been previously documented [4].

Evidence exists from police records and interviews with offenders that alcohol may play an important role in the precipitation of a homicidal attack due to the behaviour of both an intoxicated victim and assailant [23]. A substantial proportion of female sharp and blunt homicide victims (44%) were heavily intoxicated (BAC greater than 0.2 g/100 ml) at the time of death.

The extent to which the high BAC of a female in a dangerous environment represents self-destructive behaviour is controversial. A victim precipitated homicidal attack may, to varying extents, represent the suicidal desires of the particular victim [3,7]. A broader analysis would concentrate on incidents of this nature representing destructive components of society as a whole.

Acute alcohol intoxication does not appear to play a major role in suicide amongst women in Cape Town. A distinct limitation of this study is the absence of data on alcohol abuse amongst the suicides studied. The corresponding substantial difference between the age at death of White, as compared to African and Coloured homicides and suicides, should perhaps be studied further. White homicides are usually elderly robbery victims who die as a result of assault or strangulation. The two White firearm homicides were associated with a family murder and the subsequent suicide of a husband. The social circumstances surrounding a homicidal attack may explain the difference in ages between the groups.

Very little is known about women's perceptions of violence and study in this area could form the basis for preventive strategies. Examination of qualitative narrative data (Butchart and Terre Blanche, Lerer and Butchart — unpublished data) reveals substantial differences between descriptions of imaginary attacks and the realities of fatal and non-fatal violence. Alcohol and inter-personal violence did not feature strongly in the narratives studied, whereas many of the women interviewed reflected commuter-related anxiety and fear of robbery. Data from this study seems to indicate that female homicide often occurs at the hands of assailants known to the victim. The violent death of a woman may represent entrapment by circumstance and the 'social lottery' which results in potentially self destructive behaviour, often involving alcohol and a dangerous environment [24].

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References

1 P.C. Holinger, *Violent Deaths in the United States: An Epidemiologic Study of Suicide, Homicide and Accidents*. Guilford Press, New York, 1987.
2 A.P. Polednak, Accidents, Injuries, Homicide and Suicide. In *Racial and Ethnic Differences in Disease*, Oxford University Press, New York, 1989, pp. 273–276.
3 E. Ferreira de Castro, F. Pimenta and I. Martins, Who kills whom in Portugal. *Acta Psychiatr. Scand.*, 83 (1991) 92–98.
4 R.A. Goodman, J.A. Mercy, F. Loya et al., Alcohol use and interpersonal violence: Alcohol detected in homicide victims. *Am. J. Publ. Health*, 76 (1986) 144–149.
5 Goodman and Gilman's, *The Pharmacological Basis of Therapeutics*, 8th Edn., Maxwell Macmillan, New York, 1991, pp. 370–382.
6 Alcohol and Violence (Editorial), *Lancet*, 336 (1990) 1223–1224.
7 M. Wolfgang, *Patterns in Criminal Homicide*, John Wiley, New York, 1958.
8 J.W. van der Spuy, Alcohol-related trauma. *S. Afr. J. Contin. Med. Educ.*, 9 (1991) 859–868.
9 D. Cooper, W.M. Pick, J.E. Myers et al., Urbanisation and women's health in Khayelitsha. Part I. Demographic and socio-economic profile. *S. Afr. Med. J.*, 79 (1991) 423–427.
10 J.A. Grisso, A.R. Wishner, D.F. Schwarz, B.A. Weene, J.H. Holmes and R.L. Sutton, A population-based study of injuries in inner city women. *Am. J. Epidemiol.*, 134 (1991) 59–68.
11 Political Correspondent, Cape Town is the crime capital of the world. *Cape Times*, March 21, 1991.

12 R. Malan, *My Traitors Heart*, The Bodley Head, London, 1990, pp. 64 – 65.
13 Staff Reporter, Housebreaking city's fastest growing crime. *The Argus*, March 24, 1991.
14 Inquests Act (Act No. 58 of 1959 (as amended)).
15 A.D. Dean, J.A. Dean, J.H. Burton and R.C. Dicker, *Epi Info*, Version 5, Centers for Disease Control, Atlanta, GA.
16 Statistical Analyser Systems, *SAS/STAT User's Guide* (release 6.03), SAS Institute, Cary, NC, 1988.
17 A. Butchart, V. Nell, D. Yach, D.S.O. Brown, A. Anderson, B. Radebe and K. Johnson, Epidemiology of non-fatal injuries due to external causes in Johannesburg-Soweto. Part II. Incidence and determinants. *S. Afr. Med. J.*, 79 (1991) 472 – 479.
18 K. Tardiff, E.M. Gross and S.F. Messner, A study of homicides in Manhattan, 1981. *Am. J. Publ. Health*, 76 (1986) 139 – 143.
19 H.D. Barlow and L.S. Barlow, More on the role of weapons in homicidal violence. *Med. Law*, 7 (1988) 347 – 358.
20 F. Esterhuyse, 10 Violent deaths every day. *The Weekend Argus*, January 4, 1992.
21 C. Loftin, D. McDowall, B. Wiersma and T.J. Cottey, Effects of restrictive licensing of handguns on homicide and suicide in the District of Columbia. *N. Engl. J. Med.*, 325 (1991) 1615 – 1620.
22 L.C. le Roux and L.S. Smith, Violent deaths and alcoholic intoxication. *J. Forensic Med.*, 11 (1964) 131 – 147.
23 J.E. Muscat and M.S. Huncharek, Firearms and adult, domestic homicides. The role of alcohol and the victim. *Am. J. Forensic Med. Pathol.*, 12 (1991) 105 – 110.
24 E.H. Loewy, Communities, Self-causation and the natural lottery. *Soc. Sci. Med.*, 26 (1988) 1133 – 1139.

3.

LERER LB.

IMPROVING MORTALITY DATA IN SOUTH AFRICA:

REVIEW OF NEXT OF KIN

STATEMENTS TO DETERMINE CAUSE OF DEATH

IN POLICE CERTIFICATION.

JOURNAL OF EPIDEMIOLOGY AND COMMUNITY HEALTH

Improving mortality data in South Africa: review of next of kin statements to determine cause of death in police certification

Leonard B Lerer

Abstract

***Study objective*—The study aimed to improve mortality data by finding ways of reducing the large number of deaths certified as being from "ill-defined" causes (ICD 780–798) in South Africa. This problem is attributable to the absence of cause of death information in many cases where the police issue the death certificate.**

***Design and setting*—A total of 600 consecutive death certification records at the Salt River State Mortuary, Cape Town were reviewed.**

***Measurements and main results*—Altogether 347 (58%) deaths were from unnatural causes, 111 (18%) were certified by a doctor, 83 (14%) were certified as being the result of natural causes after a necropsy, and 59 (10%) were certified by the police as being from natural causes. Analysis of sworn statements obtained from the next of kin of all those certified dead by the police rather than a doctor provided a clear cause of death in 72·9%, and a history of recent contact with health services (less than one week previously) in 47·5%. All infants certified dead by the police had a history consistent with diarrhoeal disease.**

***Conclusions*—The method of death certification may be an indicator of access to health care and reviewing sworn statements to determine the cause of death should improve the quality of mortality data in the developing world.**

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Mortality statistics are an important indicator of health status[1] and their critical examination is vital for the development of an accurate information system—the foundation of essential national health research.[2] A substantial proportion of deaths in South Africa are classified as "ill-defined": this constituted the leading cause of death in the black African population in 1986.[3] The extent of under-registration and the poor quality of the data for most South Africans caused leading researchers to describe African mortality statistics as "a black hole".[4] Deaths as a result of uncertain causes are recorded as "ill-defined" (International Classification of Disease (ICD) 780–798)[5] by the Central Statistical Services (the government agency responsible for the production of national mortality statistics[3]) with consequent deleterious results. In Port Elizabeth, a study of deaths from ill-defined causes concluded that the root of the problem lay in the high proportion of deaths certified by a police officer instead of a doctor.[6]

A study was undertaken in metropolitan Cape Town to investigate further death certification by the police and to determine the utility of sworn statements obtained from the next of kin in providing information about access to health care and the cause of death.

Methods

Death certificates are usually issued by a medical practitioner. Where the deceased did not have a regular medical attendant or where it is impossible to issue a certificate stating that death was from natural causes, however, the body is transferred to a state mortuary where a necropsy may be performed. If the necropsy confirms a natural cause of death, an autopsy certificate is issued with a cause of death (where ascertainable) given. An investigating police officer may, however, issue a certificate stating that to the best of his knowledge and belief and based on a sworn statement from a relative of the deceased, the death was solely and exclusively the result of natural causes. In these cases, no necropsy is performed, death certificates contain no information on the medical history or cause of death, and the deaths are classified as being the result of "ill-defined" causes. In South Africa a death must be registered before documentation for burial or cremation can be obtained. Police death certification was introduced to reduce the hardship suffered by the deceased's family, who often had problems in obtaining medical practitioner death certificates, especially in rural areas.

The removal of established coloured communities to the Cape Flats, and the influx of African settlement to informal areas on the periphery of the city since the mid-1980s have been important events in the social history of metropolitan Cape Town.[7] Inequalities in access to health care are largely based on the system of apartheid,[8] and although there is now transition to a more equitable social structure, most black South Africans rely on overburdened and financially constrained state funded tertiary level and community based health care facilities.

This study was conducted at the Salt River State Mortuary which processes over 90% of deaths registered with the police in metropolitan Cape Town. Six hundred consecutive deaths registered from 1 January 1991 were examined. The types of death certified were grouped into:

(1) Deaths from unnatural causes, including murder, transport accident, suicide, and drowning;

(2) Deaths certified by a medical practitioner as being from natural causes;

(3) Deaths certified as being the result of natural causes after a necropsy;

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(4) Deaths certified by the police as being the result of natural causes, based on a sworn statement of a relative, and with no specific cause of death recorded on the certificate.

The age and race distribution of those who had died was examined. The study then focused on the police certified deaths and individual records were examined. Sworn statements obtained from the next of kin were studied to determine whether the deceased had visited a hospital, clinic, or private practitioner within one week of death and if it were possible for someone with a medical training in this case a medical practitioner) to ascertain a cause of death from the information provided.

The process of reading the sworn statements attempted to approximate to the standard international form of medical certificate of causes of death[9] by seeking the "disease or condition directly leading to death". A case was regarded as having a clear cause of death when an antecedent history, such as a hospital diagnosis of heart disease or cancer, was accompanied by a history of symptoms and signs consistent with the condition resulting in death. In cases where only one of the aforementioned criteria was satisfied, the cause of death was regarded as unclear. Infant deaths certified by the police were compared with those that had been certified after necropsy.

Results

Of the 600 deaths examined, 347 (58%) were the result of unnatural causes, 111 (18%) were certified by a medical practitioner, 83 (14%) were certified as being the result of natural causes after necropsy, and 59 (10%) were certified by the police as being due to natural causes. Table I gives the age and sex distribution of these deaths and shows that most violent and accidental deaths were in men. Deaths certified as the result of natural causes after a necropsy mainly occurred in infants and in those aged 25–64 years and the distribution of deaths certified by the police was similar. White South Africans constituted a relatively small proportion of all death categories (table II). This was particularly evident in cases of natural death. Of the 59 deaths certified by the police, just under half (47·5%) had a history of contact with medical care in the week before death. It was possible to ascertain a cause of death in almost three quarters (72·9%) of the cases, based on the sworn statement of next of kin (table III). Table IV gives the causes of death obtained from the sworn statements relating to the 30 adults certified dead by the police. Comparison between necropsy and police certified infant deaths (table V) showed substantial differences in the cause of death between the two groups.

Table I Percentage of deaths in age categories and ratio of male to female deaths by death certificate type

Type of death certificate	Age (y)					Male/female ratio
	1	1–4	5–24	25–64	65+	
Unnatural causes (n=347)	2·3	4	23	63	7·7	4·16
Natural causes after necropsy (n=83)	38·6	1·2	6·0	45·8	8·4	1·37
Certified by medical practitioner (n=111)	1·8	0·9	2·7	53·2	41·4	2·36
Certified by police (n=59)	22	3·4	1·7	47·5	25·4	2·05

Table II Percentage of deaths in relation to race and type of death certificate

Type of death certificate	African	Coloured	White
Unnatural causes (n=347)	37	48·9	14·1
Natural causes after necropsy (n=83)	44·6	45·8	9·6
Certified by medical practitioner (n=111)	31·5	62·2	6·3
Certified by police (n=59)	50·8	40·7	8·5

Table III Percentage of police certified deaths in relation to availability of cause of death information and recent medical attention (n=59)

Medical attention less than week before death	Cause of death from statement	
	Clear	Unclear
Yes	32·2	15·3
No	40·7	11·8

Table IV Ranking of the most frequent adult causes of death in police certified cases (n=30)

Ischaemic heart disease	15
Pulmonary tuberculosis	7
Cerebrovascular disease	3
Gastric carcinoma	2
Oesophageal carcinoma	1
Bronchial carcinoma	1
Haematological malignancy	1

Table V Percentage of deaths certified by the police or after necropsy in infants in relation to specific cause of death

Cause of death	Police certification (n=13)	Necropsy (n=32)
Diarrhoeal disease	100	31·3
Sudden infant death syndrome	—	37·4
Bronchopneumonia	—	12·5
Other	—	18·8

Discussion

The number of unnatural deaths found during the study periods reflects a pattern of mortality that constitutes a major health problem in South African men.[10,11] The high rate of police death certification and necropsy may reflect difficulties in obtaining death certificates from medical practitioners. The areas from which these subjects came are generally poorly served by private medical practitioners and most of the public health facilities are not open at night or over weekends.[12] It is also likely that the poor are forced to use police facilities to remove, transport, and store bodies, with consequent higher police certification and necropsy rates.

Occasionally, the statement of the next of kin would recount an attempt to obtain a death certificate from a hospital or clinic where the deceased had been treated. These attempts failed, either because of difficulties in obtaining the medical record or inability to find the medical practitioner who had treated the deceased and a general reluctance on the part of health care professionals to be involved in the issuing of death certificates. Contact with the health services within one week of death does not indicate that all these cases had problems in obtaining medical death certificates. It is possible that families did not realise that death certificates could be obtained from those involved in the recent medical care of the deceased, and were further constrained by the lack of transport and the prospect of long delays in obtaining the required documentation. Undertaking services are limited in

areas of informal settlement and this situation has been further exacerbated by conflicts between rival funeral organisations. It must be noted that many health care workers, burdened with high patient volumes, would obviously accord the provision of a death certificate low priority.

All those involved in health care must be trained in the importance of providing death certificates in order to minimalise hardship suffered by bereaved families. Also important is the upgrading of medical practitioner death certification, with emphasis on providing accurate medical cause of death information.[13] The importance of mortality statistics as a basis for health resource allocation decisions must be recognised more widely.[1]

This study illustrates that next of kin statements can provide valuable information on the cause of death where this is ill-defined. Conventional post mortem interviews rely on either open ended questions or structured questionnaires administered by trained medical or lay personnel. Recent studies have shown that post mortem interviews provide a high level of sensitivity and specificity in the diagnosis of fatal illnesses and are an important method of obtaining mortality information in the developing world.[14 15]

The system of police death certification is based on obtaining a sworn statement from the next of kin as to the circumstances surrounding the illness and final days of the deceased. This constitutes a narrative account with a minimum of additional questioning. The aim of this statement is not to ascertain a specific medical cause of death, but rather to exclude any unnatural cause of death that would require further investigation. In Cape Town, this statement is usually obtained by a police detective with no additional nosological training. This enables the investigating police officer to issue a death certificate. As this certificate contains no cause of death information, however, these deaths are recorded as "ill-defined". The exclusion of specific cause of death information from the certificate is based on the fact that when untrained police provided the cause of death, problems were encountered with inaccurate, and occasionally, bizarre information.[6]

The statements obtained by the investigating police officer were clear enough to allow a medical practitioner to ascertain a cause of death in almost three quarters of the cases. In most accounts, both the background circumstances and the immediate events surrounding the death concurred in providing a clear cause of death. The variety of accounts and causes of death make it unlikely that the police officer did indeed influence the narrative obtained. Most of the interviews were conducted in Afrikaans which is not the home language of the African next of kin and further research into the effect of language on the sensitivity of these statements is required. The "language of interview" may in itself be a good indicator of health status.[16]

The lack of association between contact with health care and next of kin knowledge of the cause of death may be a result of the fact that patients with clearly terminal conditions may not have visited hospitals or clinics regularly because of lack of mobility and financial constraints. A number of cases required police certification although the deceased had, according to the next of kin, been discharged recently from hospital "in order to die at home".

A major concern is the deleterious effect of high levels of "ill-defined" infant deaths on national diarrhoeal disease mortality statistics.[17] The predominance of diarrhoeal disease deaths in this study is attributable to the fact that it was conducted in the summer, and an active programme of infant mortality surveillance shows that acute respiratory infection[18] is an important cause of infant mortality in South Africa. One specific virtue of examining relatives' statements may be that it allows some understanding of the attitude and beliefs surrounding the event described. This could be of importance in understanding the socio-cultural complexities of infant mortality.[19]

The application of innovative nosological techniques such as the analysis of sworn statements associated with sentinel health events[20] could be used in conjunction with direct[21] and indirect[22 23] methods to improve the quality of mortality data in the developing world.

1 Ruzicka LT, Lopez AD. The use of cause-of-death statistics for health situation assessment: national and international experiences. *Wld Hlth Statis Quart* 1990; **43**: 249–57.
2 Evans JR. Essential national health research—a key to equity in development. *New Engl J Med* 1990; **323**: 913–5.
3 Kielkowski D, Steinberg M, Barron PM. Life after death—mortality statistics and the public health. *S Afr Med J* 1989; **76**: 672–5.
4 Botha JL, Bradshaw D. African vital statistics—a black hole? *S Afr Med J* 1985; **67**: 977–81.
5 World Health Organisation. *Manual of the international classification of diseases, injuries and causes of death* 9th Revision. Geneva: WHO, 1978.
6 van der Merwe S, Yach D, Metcalf CA. Peering into the black hole—the quality of black mortality data in Port Elizabeth and the rest of South Africa. *S Afr Med J* 1991; **79**: 419–22.
7 Dewar D, Watson V. An overview of development problems in the Cape Town metropolitan area. Cape Town: University of Cape Town, 1990. UPRU working paper no 40.
8 Botha JL, Bradshaw D, Gonin R, Yach D. The distribution of health needs and services in South Africa. *Soc Sci Med* 1988; **26**: 845–51.
9 World Health Organisation. *Medical certification of cause of death. Instructions for physicians on use of international form of medical certificate of cause of death.* Geneva: WHO; 1979.
10 Bradshaw D, Botha D, Joubert G, Pretorius JP, van Wyk R, Yach D. *Review of South African mortality*. Parow: South African Medical Research Council, 1987.
11 Fisher AJ, Joubert G, Yach D. Mortality from external causes in South African adolescents, 1984–1986. *S Afr Med J* 1992; **81**: 77–80.
12 Community Health Research Project. Access to health services in the greater Cape Town area. Cape Town: University of Cape Town, 1983. SALDRU working paper no 55.
13 Lindahl BIB, Glattre E, Lahti R, Magnusson G, Mosbech J. The WHO principles for registering causes of death: suggestions for improvement. *J Clin Epidemiol* 1990; **43**: 467–74.
14 Kalter HD, Gray RH, Black RE, Gultiano SA. Validation of post mortem interviews to ascertain selected causes of death in children. *Int J Epidemiol* 1990; **19**: 380–6.
15 Pacque-Margolis S, Pacque M, Dukuly Z, Boateng J, Taylor HR. Application of the verbal autopsy during a clinical trial. *Soc Sci Med* 1990; **31**: 585–91.
16 Kirkman-Liff B, Mondragon D. Language of interview: relevance for research of southwest Hispanics. *Am J Public Health* 1991; **81**: 1399–404.
17 Yach D, Strebel PM, Joubert G. The impact of diarrhoeal disease on childhood deaths in the RSA, 1968–1985. *S Afr Med J* 1989; **76**: 472–5.
18 von Schirnding YER, Yach D, Klein M. Acute respiratory infections as an important causes of childhood deaths in South Africa. *S Afr Med J* 1991; **80**: 79–82.
19 Scheper-Hughes N. Social indifference to child death. *Lancet* 1991; **337**: 1144–7.
20 Carr W, Szapiro N, Heisler T, Krasner MI. Sentinel health events as indicators of unmet needs. *Soc Sci Med* 1989; **29**: 705–14.
21 Koumans EHA. Infant and child mortality in the Elim district, northern Transvaal, 1976–1986, and a comparison of trends. *S Afr Med J* 1992; **81**: 202–5.
22 Brass W, Macrae S. Childhood mortality estimated from reports on previous births given by mothers at the time of maternity: I. Preceding births technique. *Asian and Pacific Census Forum* 1984; **11**: 1.
23 David P, Kawar S, Graham W. Estimating maternal mortality in Djibouti: an application of the sisterhood methods. *Int J Epidemiol* 1991; **20**: 551–7.

4.

LERER LB, HANSSON D.

SMOKING GUNS AND PUBLIC HEALTH.

SOUTH AFRICAN MEDICAL JOURNAL

Smoking guns and public health

It seems almost trite to state that contemporary South Africa is characterised by a pernicious 'culture of violence'.[1] Even more worrying, however, is the growing perception that violent death is somehow incomprehensible,[2] for this is a view that legitimates inaction. We cannot afford to adopt such a view if the level of violence in this country is to be reduced. It is the social and ethical responsibility of those who hold privileged professional positions, to help end the current spiral of violence and death.

A domestic arms race has been gathering momentum, particularly over the past decade. Each year growing numbers of civilians purchase guns to enhance their personal safety.[4] In 1988, gunshot wounds were the second largest cause of death in cases both of suicide and homicide[5,6] in South Africa and an increasing proportion of homicides in Cape Town have involved the use of firearms since the mid-1980s.[7]

Of course guns do not cause violence or lawbreaking. Nevertheless the use of a firearm increases the likelihood of a fatality fivefold,[8] even when death is not the intended outcome of an attack. In addition, firearms are by far the most lethal of 'household' weapons.[9,10]

Those who would decrease the level of extreme violence in society therefore argue that access to firearms should be curtailed significantly, as 'fewer guns would mean fewer deaths, even assuming that killers would choose alternative methods rather than abandon an attack'.[11] A body of research now exists in support of the claim that stringent restrictions on civilian gun ownership produce a reduction in both homicidal and suicidal fatalities.[12,13]

Empirical findings consistently show that gun ownership to enhance personal safety is a myth. Domestic firearms are far more likely to be used in a suicide or on a family member or friend, than on an intruder;[14,15] those most at risk of homicidal attack in the context of robbery,[16] such as elderly women, benefit little from gun ownership. Furthermore, it is now clear that the availability of guns in the home, irrespective of the type or method of storage, increases the risk of 'successful' adolescent suicide.[17,18]

Guns leave little option for reconsideration of an impulsive decision, be it homicidal or suicidal. It is therefore reasonable to expect that reduction of the accessibility of guns will decrease fatalities, especially those resulting from heat-of-the-moment confrontations such as domestic conflicts[19] and attacks on less vulnerable victims.[20]

Nevertheless, the pro-gun lobby continues to emphasise the numerous advantages of licensed domestic gun ownership including the myth of enhanced personal security and the less pragmatic pleasures associated with the possession of fine weapons and their recreational use. Internationally, the strongest opposition to the gun control lobby has come from law enforcement agencies, whose emotive cry has been that 'when guns are criminalised, only criminals will have guns'.[3] Some pro-gun lobbyists have expanded even further on this, claiming that licensed civilian gun ownership should be encouraged as a deterrent to lawbreaking. Potential lawbreakers they contend, will be more reluctant to confront people whom they know may be armed![3]

The demonstration of a significant and sustained reduction in the number of gun-related homicides and suicides in the District of Columbia following the introduction of restrictive gun control legislation[12] unleashed vehement attack from the North American pro-gun lobby, which chose to ignore the obvious association between their products and deadly outcomes and dismissed the research findings on the grounds that epidemiological studies do not prove a causal relationship, in the strictly statistical sense. This response simply elevated the debate to the level of mathematical hypothesis, far removed from the realities of life and death.

The reaction of the pro-gun lobby to research findings that support gun control is disturbingly reminiscent of the way in which the pro-smoking lobby responded to studies that indicated the damaging effects of smoking. The debates on guns and smoking have much in common, as both are vital public health issues that are entangled with political, factional and personal interests. It is this very enmeshment that has prevented a straightforward strategy of surveillance, containment and prevention being applied in the case of smoking or violence, as would have been done for any infectious disease. The armament industry and the tobacco trade originated in the 'developed' world and both have dealt with the shrinking demand for their products in this area by shifting marketing to economically oppressed countries.[21] Furthermore, just as developed countries have had to combat the pernicious effects of smoking, they are now having to deal with the destructive consequences of firearm ownership.[22] Economically oppressed countries will be forced to grapple with the destructive consequences of tobacco[23] and firearms long after the 'developed' world has managed to ameliorate their negative impact. There is already growing evidence that violence and the rising number of gun-related injuries are placing increasing pressure on South Africa's already overburdened medical facilities.[24-26]

Hopefully, we can learn from the smoking debate and recognise by analogy that 'the issue was not, as some misunderstood it, whether the available data proved that smoking caused lung cancer (since it never could). Rather the issue was (or should have been) whether the available data warranted action'.[27] It would be futile to impose more restrictive legislation on domestic gun ownership, as South Africa has already implemented such legal reforms. More importantly, these reforms have failed to limit either the illegal possession of guns, or the abuse of firearms by licensed and unlicensed users. Despite relatively strict laws, people use guns with little restraint. The only large-scale and up-to-date study of firearm use in South Africa[28] has clearly shown that the majority of a sample of civilians and law enforcement personnel who use their firearms to kill, violated the internationally accepted principles of minimum force and proportionality of force to threat. More disturbingly, these shooters did not face certain, or serious, legal sanction for using their firearms with little restraint and deadly effect. In essence, this study indicated that the South African legal system is failing to apply controls on the use of deadly force strictly and consistently when determining liability. This means that a high level of restraint is not required from those who use firearms to kill in order for their actions to be deemed lawful and consequently for such persons to avoid legal sanction. It would seem, then, that strategies aimed at reducing firearm violence should focus on a change in the application, rather than the letter, of the law.

Gun control strategies must, therefore, move beyond legal reforms aimed at restricting the range of people

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who are permitted to possess firearms. Ironically, such restrictions emphasise the value of gun ownership and so act as an incentive to lawbreaking by those who are denied access to firearms.[29] This is surely part of the reason for the increase in the illegal possession of guns in South Africa.

It would be futile to wait for the effects of political transition and socio-economic upliftment to reduce the endemic levels of violence in this country. We propose that the only way of reducing the use and abuse of firearms in the long term is to develop a culture of disarmament and anti-violence. This must include surveillance of and continued research into firearm-related violence in order to provide policy-makers with accurate information on the severity of this problem.[30] This would be part of a broader public health strategy aimed at improving the personal safety of all South Africans. One of the most obvious ways of changing public attitudes to the ownership and use of firearms is to modify the way in which guns are depicted in the mass media;[3] we need to be aware of the dangers of exposing our children to violence on television.[31] A less obvious, but perhaps more effective, approach would be 'to change the attitudes, values, and practices of the core ownership group — the police, other law enforcement personnel, and private security forces'.[29] Such changes will require active public lobbying for gun control in this country akin to that undertaken by pressure groups in many industrialised countries. This requires awareness of the extent of legal gun ownership in South Africa and concerted educational campaigns in order to promote a 'gun-free' society.

Health professionals can and indeed ought to play an active role in working toward domestic disarmament. We can, at the very least, ensure that we explain to our patients the dangers of having guns in the home and, more specifically, that we recommend the removal of firearms from the homes of those deemed suicidal. To view gun control as a public health issue is a tangible and vital response to violence in South Africa.

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1. Marks S, Andersson N. The epidemiology and culture of violence. In: Manganyi NC, Du Toit A, eds. *Political Violence and the Struggle in South Africa*. Halfway House: Southern Books, 1990: 29-70.
2. Malan R. *My Traitor's Heart*. London: Bodley Head, 1990: 64-65.
3. Church GJ. The other arms race. *Time* 1989; 6 Feb: 8-15.
4. One deadly day in May. *Time* 1989; 17 July: 28-32.
5. Central Statistical Service. *Deaths of Blacks* (Report 03-10-01). Pretoria: Government Printer, 1988.
6. Central Statistical Service. *Deaths of Whites, Coloureds and Asians* (Report 03-09-01). Pretoria: Government Printer, 1988.
7. MacDonald IL, Lerer LB. Measuring violence: the application of hidden markov models in the examination of homicide and suicide statistics. Paper presented at the 11th Conference of the Epidemiological Society of Southern Africa. Johannesburg, Aug 1992.
8. Neal D. God, guns and guts. *Criminology Australia* 1989; **1**: 18-20.
9. Chappell D, Grabosky P, Wilson P, Mukherjee S. Firearms and violence in Australia. *Trends and Issues in Crime and Criminal Justice* 1988; **10**: 1-4.
10. Zimring F, Hawkins G. *The Citizen's Guide to Gun Control*. New York: Macmillan, 1987: 197.
11. Kaplan J. Foreword. *Law and Contemporary Problems* 1986; **49**: 1-4.
12. Loftin C, McDowall D, Wiersema B, Cottey TJ. Effects of restrictive licensing of handguns on homicide and suicide in the district of Columbia. *N Engl J Med* 1991; **325**: 1615-1620.
13. McDowall D, Lizotte AJ, Wiersema B. General deterrence through civilian gun ownership. *Criminology* 1991; **29**: 541-549.
14. Kellerman AL, Rivara FP, Somes G, *et al*. Suicide in the home in relation to gun ownership. *N Engl J Med* 1992; **327**: 467–472.
15. Kellerman AL, Reay DT. Protection or peril? An analysis of firearm-related deaths in the home. *N Engl J Med* 1986; **314**: 1557-1560.
16. Lerer LB. Women, homicide and alcohol in Cape Town, South Africa. *Forensic Sci Int* 1992; **53**: 93-99.
17. Brent DA, Perper JA, Allman CJ, Moritz GM, Wartella ME, Zelenak JP. The presence and accessibility of firearms in the homes of adolescent suicides. A case-control study. *JAMA* 1991; **266**: 2989-2995.
18. Rosenberg ML, Mercy JA, Houk VN. Guns and adolescent suicides (Editorial). *JAMA* 1991; **266**: 3030.
19. Cook PJ. The role of firearms in violent crime. An interpretative review of the literature, with some new findings and suggestions for future research. In: Wolfgang M, Weiner N, eds. *Criminal Violence*. Beverly Hills, Calif.: Sage, 1982.
20. Zarb FG. Police liability for creating the need to use deadly force in self defence. *Michigan Law Review* 1986; **8**: 1982-2009.
21. Stansfield SK, Smith GS, McGreevey. Injury. In Jamison DT, Mosley WH, Bobadilla JL, Measham AR, eds. *Disease Control Priorities in Developing Countries*. New York: Oxford University Press, 1993.
22. Martin MJ, Hunt TK, Hulley SB. The cost of hospitalization for firearm injuries. *JAMA* 1988; **260**: 3048-3050.
23. Yach D. Tobacco-induced diseases in South Africa (Letter). *Int J Epidemiol* 1990; **19**: 1122-1123.
24. Linton DM. The impact of trauma on ICU facilities in South Africa (Letter). *S Afr Med J* 1992; **81**: 118-119.
25. Yach D. The impact of political violence on health and health services in Cape Town, South Africa, 1986: methodological problems and preliminary results. *Am J Public Health* 1988; **78**: 772-776.
26. Abdool Karim SS, Andelman R. Impact of the political violence in Natal on emergency surgical services of a tertiary hospital. *S Afr Med J* 1991; **80**: 134-138.
27. Greenland S. Re: 'Those who were wrong' (Letter). *Am J Epidemiol* 1990; **132**: 585-586.
28. Hansson DS. *Firearms Used with Deadly Effect: a Study of South African Law and Practice* (Research Report 1 - 90). Cape Town: University of Cape Town Institute of Criminology, 1990.
29. Jacobs JB. Exceptions to a general prohibition on handgun possession: do they swallow up the rule? *Law and Contemporary Problems* 1986; **49**: 5-34.
30. Teret SP, Wintemute GJ, Beilenson PL. The firearm fatality reporting system: a proposal. *JAMA* 1992; **267**: 3073-3074.
31. Centerwall BS. Television and violence: the scale of the problem and where to go from here. *JAMA* 1992; **267**: 3059-3063.

5.

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APPLICATION OF TWO SECONDARY DOCUMENTARY SOURCES TO IDENTIFY THE UNDERREPORTING OF FATAL OCCUPATIONAL INJURIES IN CAPE TOWN, SOUTH AFRICA.

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American Journal of Industrial Medicine 26:00–00 (1994)

Application of Two Secondary Documentary Sources to Identify the Underreporting of Fatal Occupational Injuries in Cape Town, South Africa

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We reviewed 8,502 deaths registered at the Salt River state mortuary, Cape Town (medical examiner records) for an 18-month period (1/1/90–6/30/91). When fatal occupational injuries located from this data source were matched with the records of the occupational safety inspectorate of the Department of Manpower, it was found that 28% had not been reported in terms of statutory regulations. Unreported deaths accounted for 25% of all fatal occupational injuries in the construction industry. None of the fatal occupational injuries in agriculture and fishing had been reported. Falls constituted 45% of the unreported fatalities. High levels of unreported fatal occupational injury indicate deficiencies in current occupational safety surveillance and enforcement in South Africa.

Key words: work-related fatalities, occupational injury, injury surveillance

INTRODUCTION

Complete reporting is important for the identification and prevention through surveillance of fatal occupational injuries [Robertson, 1992]. Whilst nonfatal industrial injury rates have declined in South Africa, a similar trend has not been reported in fatal occupational injuries [Leger and Macun, 1990]. South African accident statistics often represent events in organized industry which participates in a national occupational safety program and generally adheres to statutory reporting procedures. Wide disparities exist between the effectiveness of various documentary sources in identifying occupational fatalities. In the United States, death certificates and medical examiner records have been consistently noted to identify a greater proportion of the occupational fatality "pool" than Workmen's Compensation and governmental agencies [Cone et al., 1991; Stout and Bell, 1991; Fingar et al., 1992].

This study attempts to identify all occupational fatalities that occurred in metropolitan Cape Town, South Africa in an 18-month period, explore the relationship

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between those fatalities identified solely by medical examiner records (as represented by state mortuary data) and those reported to the occupational safety authorities, and describe the differences between reported and unreported deaths.

METHODS

Legal Requirements for the Reporting of Fatal Occupational Injury

In terms of existing legislation, all deaths in South Africa due to causes other than natural causes [Inquests Act, 1959] are subjected to forensic autopsy examination as part of a police investigation and subsequent inquest held in order to determine a cause of death. This would include mortality related to homicide, transportation, suicide, therapeutic misadventure, and "accidents." An inquest magistrate can decide whether a death was due to an act or omission on the part of any person and refer such cases for criminal investigation and charges.

The Machinery and Occupational Safety Act (MOSA) [MOSA, 1983] requires that any incident resulting in a fatality that is consequent upon the use of machinery, hazardous working conditions, or any accident at the workplace be reported to the occupational safety inspectorate of the Department of Manpower (DOM). A formal investigation takes place, the report of such an enquiry being submitted to the attorney general for possible prosecution of the employer. In certain cases, the inquest and inquiry may be held together, this usually being applicable for "high profile" industrial "accidents" in which multiple fatalities occurred. Almost all inquests relating to fatal occupational injuries are closed without further legal action against employers (Senior Public Prosecutor, Cape Town, personal communication).

Sources of Data

State mortuary records. The Salt River state mortuary admitted over 95% of all nonnatural deaths in metropolitan Cape Town during the study period. Demographic information was obtained from the death registers of the mortuary and accident details extracted from the police report submitted prior to autopsy examination.

DOM. The occupational safety inspectorate of the DOM maintains a register of all fatalities reported in its area of jurisdiction, which includes metropolitan Cape Town. When required, for the purposes of clarifying the exact name or place of injury of the deceased, the actual investigation dockets of the DOM were consulted.

Selection of Cases

The mortuary death registers were scanned in order to locate any recorded fatal occupational injury during an 18-month period between January 1, 1990 and June 30, 1991. All likely occupational fatalities were isolated using a range of nonspecific descriptors designed to locate deaths not described in the register as fatal occupational injuries. These descriptors included adult drownings, falls, freak accidents, undetermined causes, electrical injury, nondomestic burns, exposure to gasses or vapors, explosions, and nonmotor vehicle transportation fatalities. Using this procedure, 154 possible fatal occupational injuries were located out of a total of 8,502 deaths, whereafter the police reports were studied in order to exclude nonoccupational deaths. Fifty-four cases were confirmed as occupational deaths.

The registers of the occupational safety inspectorate of the DOM were reviewed

TABLE I. Fatalities by Industry, Cape Town, 1/1/90–6/30/91

	Reported (n = 29)		Unreported (n = 11)		Total (n = 40)	
Industry	No.	%	No.	%	No.	%
Construction	15	52	5	45	20	50
Manufacturing	13	45	2	18	15	38
Fishing	0	0	2	18	2	5
Agriculture	0	0	2	18	2	5
Transportation	1	3	0	0	1	2

for the study peroid, identifying 55 reported deaths, 43 of which were located in metropolitan Cape Town.

Calculating the Proportion Identified by Each Data Source

The percentage of the total pool of fatal occupational injuries identified (this would constitute a proportion) by each of the two secondary documentary sources (state mortuary and DOM) was calculated [Stout and Bell, 1991]. Using the death register data as a baseline, the proportion identified was first calculated for all cases and, thereafter, for cases qualifying under the MOSA regulations.

Main Variables and Analysis of Data

Occupational category and type of fatal injury were described and compared for the two data sources.

RESULTS

It was possible to identify 54 occupational fatalities from the police and autopsy records of the Salt River state mortuary. Of these cases, 43 were located in the records of the occupational safety inspectorate of the DOM, hence giving the DOM a capture of 80% of the total pool of occupational fatalities identified by the two data sources combined.

Fourteen fatalities located in both datasets were excluded, as they did not fall under the definition of the MOSA as occupational accidents. These included a homicide at work (1), an accidental drowning of an infant (1), and motor vehicle accidents (12). This exclusion resulted in a final capture of 72.5% (29/40) for the DOM.

The proportion of reported and unreported fatalities for various industries is shown in Table I. The construction industry accounted for most of the reported and unreported fatalities. Both of the fatalities in the fishing and agricultural sectors were unreported. Type of fatal injury, as shown in Table II, represents the nature of activity undertaken in the various industries with falls predominating in both the reported and unreported groups.

DISCUSSION

Although based upon limited data, a finding that over a fourth of fatal occupational injuries in metropolitan Cape Town were not investigated, in terms of stat-

TABLE II. Type of Fatal Occupational Injury, Cape Town, 1/1/90–6/30/91

	Reported (n = 29)		Unreported (n = 11)	
Category	No.	%	No.	%
Falls	13	45	5	45
Drowning	0	0	2	18
Struck by object	3	10	1	9
Machinery accident	3	10	1	9
Asphyxia/anoxia	0	0	1	9
Electrocution	1	4	1	9
Buried	3	10	0	0
Explosion	6	21	0	0

utory regulations, has somewhat disturbing implications, representing deficiencies in injury surveillance and control in South Africa. This supports recent reviews concerning the low priority given to occupational injury as a public health problem in many less developed countries [Smith and Barss, 1991; Stansfield et al., 1993]. The object of investigation in this study is mortality or the most severe and hence ascertainable and measurable health outcome. The implications for the wide spectrum of occupational health is even more disturbing, as it is easy to infer that the bulk of adverse work-related health outcomes is even less ascertainable. Occupational fatality is the tip of the iceberg, its base including morbidity and disability from injury and hazardous workplace exposures that goes unrecognized.

It was not possible to locate occupational fatalities that were not reported to the police. As the police act as Registrars of Deaths in South Africa, official documentation is required for burial or cremation, making nonreporting unlikely. It is possible that a number of deaths occurring in hospitals may not have been regarded as due to occupational injury, an example being the death of a head injured patient in a long-term chronic care facility being certified as due to a natural cause such as pneumonia.

The construction industry accounted for the largest proportion of the total pool of fatalities, providing some evidence of the health hazards and high risk of construction. Construction also had the highest percentage of unreported cases. Factors contributing to the difficulty of regulation include a significant informal sector, high labor turnover, and constant changes in location. This industry relies on unskilled labor and has traditionally been hostile to trade unions and currently has low unionization rates. Formal mechanisms such as safety representatives and safety committees for monitoring health and safety are difficult to implement. Safety practices and safety equipment that are routinely available in developed countries are seldom observed in construction operations in South Africa. As 90% of the fatalities in this industry were due to falls, urgent attention is required in areas such as safety inspections of scaffolding and the use of safety lines.

Prevention of injury is the province of the DOM. The successful operation of this department is dependent upon the availability of precise data and the capacity to turn this data into useful information for the management of occupational hazards. One source of such information is the Workmen's Compensation Commissioner (WCC) which forwards information on claims for fatal injury to the DOM for investigation. Reports to the WCC involve the incentive of remuneration for dependents of

TABLE III. Fatal Accident Claims, WCC, 1988–Selected Categories (National Statistics)*

Industry	No.	Percent of total fatalities (n = 1,018)	Percent of total workforce (n = 5,167,354)
Agriculture	246	24	15
Manufacturing	222	22	23
Transportation	154	15	4
Construction	122	12	7
Fishing	3	<1	<1

*Data from WCC [1988].

fatally injured workers and may well exceed the number of reports to the DOM. As the WCC plays no role in the enforcement of occupational safety legislation, the utility of reporting to the WCC for preventing occupational fatalities is seriously limited. WCC annual reports are often delayed by a number of years and do not represent employment levels in the growing informal sector. Examination of the most recent WCC report, that of 1988 (Table III), represents the distribution of fatal injury and employment levels for registered employers [Leger and Macun, 1990]. The fact that the DOM was not aware of many fatalities in industries such as construction, indicates that no claims were made from the WCC. This finding supports concerns about the utility of official published data. Any potential advantage accuring from incentives to report is lost as a result of insufficient coordination of information that should be routinely linked and utilized jointly. This inefficient state of affairs can only be remedied by the introduction of a unified reporting, investigation and compensation authority [Myers and Macun, 1991].

Although the MOSA specifically excludes the reporting of fatal or disabling injuries on public roads, a number of occupationally related motor vehicle accidents were present in the DOM records. Certain categories of road accidents are recognized for the purposes of compensation by the WCC, such as those involving worker transportation and where the job itself entails driving a vehicle on public roads. The inspectorate of the DOM has undertaken a de facto partial recognition of the fact that motor vehicle fatalities are an important occupational hazard [Loomis, 1991] by investigating a number of incidents; urgent amendment of the law is required to include work-related transportation injuries on public roads as reportable.

As the Cape Town office of the DOM covers the agricultural areas surrounding the city, it was found that the 12 deaths excluded (as they did not fall under the area of jurisdiction of the state mortuary) were related to farming activities. It seems plausible that underreporting of deaths in the rural areas may also be high and therefore a high occupational injury rate may be present in the farming areas. As agriculture is a hazardous occupation with limited worker access to health services and compensation, a need exists for further descriptive research in this area [Myers, 1990; Ciesielski et al., 1991; Chisholm et al., 1992].

Internationally, fishing is regarded as a dangerous occupation [Hopper and Dean, 1992]. In the case of Cape Town, examination of inquest data for a 5-year period indicated that most fatalities occurred whilst vessels were in the harbor and were due to falls overboard, associated with high blood alchol levels [Lerer LB—

unpublished data]. The WCC reported the highest frequency of nonfatal occupational injury in the fishing industry for 1988 [WCC, 1988]. Although the number of fatalities associated with fishing was small, we believe that an ongoing surveillance program is urgently required to ensure worker safety in this industry.

Legislative reform of occupational safety, while substantially increasing regulation in law, has coexisted with weak labor, few worker rights, racial discrimination in the workplace, unemployment, and economic stagnation. This has increasingly led to a state policy of industrial self-regulation with diminished governmental inspectoral and monitoring functions. This functional "de-regulation" is in line with other state policy which seeks to relax basic licensing and work condition legislation in order to promote small business and the informal sector [Myers and Macun, 1989; Zwi et al., 1988]. This study indicates that workers in sectors which are difficult to regulate may be in particular need of further effective protection as they are most likely to be exposed to dangerous working conditions. In the case of certain industires such as construction, even formal sector workers face substantial hazards.

Although there are geographical differences in occupational activities, it is likely that these patterns of unreported occupational fatalities represent many of the problems facing occupational health in South Africa. This research is being conducted over a longer time period in order to obtain more stable estimates of the unreported occupational mortality proportion and to investigate specific sectors which are a cause for concern.

REFERENCES

Chisholm CJ, Bottoms DJ, Dwyer MJ, Lines JA, Whyte RT (1992): Safety, health and hygiene in agriculture. Safety Sci 15:225–248.

Ciesielski S, Paige Hall S, Sweeney M (1991): Occupational injuries among North Carolina migrant farmworkers. Am J Public Health 81:926–927.

Cone JE, Daponte A, Makofsky D, Reiter R, Becker C, Harrison RJ, Balmes J (1991): Fatal injuries at work in California. J Occup Med 33:813–817.

Fingar AR, Hopkins RS, Nelson M (1992): Work-related injuries in Athens County 1982–1986. A comparison of emergency department and workmen's compensation data. J Occup Med 34:779–787.

Hopper AG, Dean AJ (1992): Safety in fishing—learning from experience. Safety Sci 15:249–271.

Inquests Act (1959): Act No. 58 of 1959, as amended: Republic of South Africa.

Leger JP, Macun I (1990): Safety in South African industry: An analysis of accident statistics. J Occup Accidents 13:197–220.

Loomis DP (1991): Occupation, industry, and fatal motor vehicle crashes in 20 states, 1986–1987. Am J Public Health 81:733–735.

MOSA: Machinery and Occupational Safety Act (1983): Act No. 6 of 1983: Republic of South Africa.

Myers JE (1990): Occupational health of farmworkers. S Afr Med J 78:562–563.

Myers JE, Macun I (1989): The sociologic context of occupational health in South Africa. Am J Public Health 79:216–224.

Myers JE, Macun I (1991): Policy and strategy for occupational health services in South Africa. S Afr Med J 80:504–507.

Robertson LS (1992): "Injury Epidemiology." New York:Oxford University Press, p 54.

Smith GS, Barss P (1991): Unintentional injuries in developing countries: The epidemiology of a neglected problem. Epidemiol Rev 13:228–244.

Stansfield SK, Smith GS, McGreevey (1993): Health sectors priority review: Injury. In Jamison DT, Mosley WH (eds): "Disease Control Priorities in Developing Countries." New York: Oxford University Press for the World Bank (in press).

Stout N, Bell C (1991): Effectiveness of source documents for identifying fatal occupational injuries: A synthesis of studies. Am J Public Health 81:725–728.

WCC: Workmen's Compensation Commissioner (1988): Workmen's Compensation Act: 1941—Report on the 1988 statistics, Pretoria.

Zwi A, Fonn S, Steinberg M (1988): Occupational health and safety in South Africa: The perspective of capital, state and unions. Soc Sci Med 27:691–702.

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HOMICIDE ASSOCIATED BURNING IN

CAPE TOWN, SOUTH AFRICA.

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Homicide-Associated Burning in Cape Town, South Africa

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To describe the features of homicide-associated burnings (HAB) and examine factors that distinguish between intentional and accidental fatal burn injury, we undertook a review of all burn cases admitted to the Salt River State Mortuary, Cape Town, South Africa, between January 1, 1991, and December 31, 1992. Of 358 burn-related deaths, 35 (10%) were homicides; five (14%) of these were described as "necklacings." No significant difference existed in age, sex, residential status, or extent of burn injury between the HAB and adult residential fire victims (ARFV). Of the HAB, 44% had soot in the trachea and main bronchi, whereas soot was present in 83% of the ARFV ($p = 0.001$). The median blood carbon monoxide saturation was 12% in the HAB and 30% in the ARFV ($p = 0.001$). Of the HAB, 48% had a blood alcohol concentration > 0.1 g/100 ml, whereas this concentration was noted in 70% of ARFV ($p = 0.02$). Evidence of either gunshot, stabbing, or blunt force injury was seen in 82% of the HAB. Although some significant autopsy parameters characterize HAB, we conclude that the forensic pathologist should diligently seek evidence of homicidal injury in all fatal burn cases.

Key Words: Homicide—Burns—Carbon monoxide—Alcohol—"Necklacing".

Although burns are among the leading causes of nonnatural death in the developing world, little attention has been paid to intentional injury with the use of fire or hot liquids (1,2). Therefore, we set out to describe the features of homicide-associated burning and compare the demographic, postmortem, and laboratory parameters of its victims with those of accidental residential fire victims in order to provide baseline information to assist the forensic pathologist in the examination of such cases.

METHODS

Study Population and Data Sources

In South Africa, all deaths due to accident, suicide, or homicide are required by law to be subjected to postmortem examination (3). The study site, Salt River State Mortuary, Cape Town, admitted >90% of these victims in metropolitan Cape Town during the study period, January 1, 1991 to December 31, 1992. Burning deaths were defined as all deaths due to thermal injury or exposure to fire residues and gases. Information was extracted from death registers, police and autopsy reports, and medical and laboratory records.

All bodies were subjected to a full autopsy examination; radiographic screening was also done in suspected homicides. Blood alcohol (BAC) concentrations were obtained using gas chromatography and recorded in g per 100 ml of blood (g/100 ml). Blood carbon monoxide (CO) was calculated as the percentage saturation of the total hemoglobin and measured using a computerized spectrophotometer.

Homicide-associated Burnings (HAB)

Cases in which the police records described an incident where it was alleged that the deceased was assaulted or killed prior to being burnt or where the deceased was deliberately set alight were regarded as homicide-associated burnings (HAB). A single

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TABLE 1. *Major groups of fatal burn injury, January 1, 1991 – December 31, 1992 (n = 358)*

Type	No.	(%)
Residential fire (accident)	250	(70)
Residential fire (arson)	10	(3)
Homicide-associated burning (HAB)	35	(10)
Suicide	4	(1)
Domestic accident	46	(12)
Occupational	9	(3)
Gases/residues	4	(1)

case where a neonate was allegedly strangled and thereafter burnt by its mother was excluded.

Adult Residential Fire Victims (ARFV)

This group included all those >18 years of age who died when the residences they were occupying burnt down. Victims of alleged arson (n = 10) were excluded from this group.

Statistical Methods

Bivariate statistics were used to compare demographic, autopsy, and laboratory parameters of HAB and ARFV. BAC and CO levels were not available for hospitalized cases. Analysis was undertaken using the Epi-Info and SAS statistical packages (4,5).

RESULTS

HAB constituted 10% of the fatal burn injuries admitted to the Salt River State Mortuary during the study period; this was <2% of the total homicides in metropolitan Cape Town. The majority of burn deaths (70%) in this city were due to residential fires (Table 1).

TABLE 2. *Demographic characteristics of HAB (n = 34) and ARFV (n = 193), January 1, 1991–December 31, 1992*

	HAB		ARFV		
Factor	no	(%)	no	(%)	p value
Age (yr)					
18–24	4	(12)	24	(12)	
25–34	16	(47)	77	(40)	
35–54	13	(38)	81	(42)	
55–75	1	(3)	9	(5)	
>75	0	(0)	2	(1)	
					0.53[a]
Sex					
Male	29	(85)	143	(74)	
Female	5	(15)	50	(26)	
					0.15[b]
Residential Status					
City	0	(0)	2	(1)	
Suburban	6	(18)	21	(11)	
Squatter/informal area	28	(82)	170	(88)	
					0.43[b]

HAB = homicide-associated burnings; ARFV = adult residential fire victims.
[a]Wilcoxon two-sample test.
[b]Based on chi-square.

TABLE 3. *Extent of burn injury and presence of soot in airways for HAB (n = 34) and ARFV (n = 193), January 1, 1991–December 31, 1992*

	HAB		ARFV		
Factor	No.	(%)	No.	(%)	p value
% Burns of Total Body Surface					
<25	1	(3)	4	(2)	
25–50	0	(0)	4	(2)	
51–75	4	(12)	15	(8)	
>75	29	(85)	170	(88)	
					0.77[a]
Soot in Trachea and Main Bronchi					
Present	15	(44)	161	(83)	
Absent	19	(56)	32	(17)	
					0.0001[b]

HAB = homicide-associated burnings; ARFV = adult residential fire victims.
[a]Wilcoxon two-sample test.
[b]Based on chi-square.

More than half of the HAB victims and ARFV were between 18 and 34 years of age. Men were more likely to be victims of HAB and ARFV, although women constituted 26% of the latter group. Over 80% of both the HAB and ARFV were from informal settlement or squatter areas on the urban periphery (Table 2). Most of the HAB and ARFV were extensively burnt (>75% of total body surface area), and soot was present in the trachea and main bronchi of 44% of the HAB and 83% of the ARFV (p = 0.0001) (Table 3).

The median blood carbon monoxide saturation was 30% in the ARFV and 12% in the HAB (p = 0.001). Of the HAB, 48% had a blood alcohol concentration >0.1 g/100 ml, whereas the same level was found in 70% of ARFV (p = 0.02) (Table 4). Evidence of antemortem injury was found in 28 of 34 (82%) HAB; blunt force injury was seen in 40% of the cases (Table 5). Wire or rope was found around the limbs of seven of the 34 (21%) HAB. Of the five necklacings, two showed evidence of tire residues, including burnt rubber and the metal carcass of the tire.

DISCUSSION

Burning has been described in the context of folk medicine. It has also been reported during robbery and as punishment in Nigeria (6). In India, homicidal bride burning related to dowry and family problems contributes to the high level of female burn deaths (7). Murderers sometimes burn their

TABLE 4. *Percentage distribution of blood carbon monoxide saturation and alcohol level for HAB and ARFV, January 1, 1991–December 31, 1992*

Blood concentrations	HAB		ARFV		p value
Carbon Monoxide (%)	(n = 28)		(n = 160)		
	No.	(%)	No.	(%)	
<5	11	(39)	11	(7)	
5–10	3	(11)	18	(11)	
11–20	4	(14)	32	(20)	
21–30	2	(6)	19	(12)	
31–40	3	(11)	28	(18)	
41–50	1	(4)	20	(12)	
51–60	3	(11)	10	(6)	
>60	1	(4)	22	(14)	
					0.001*
Blood Alcohol (g/100 ml)	(n = 27)		(n = 160)		
	No.	(%)	No.	(%)	
0.00	9	(33)	35	(22)	
0.01–0.09	4	(15)	15	(9)	
0.10–0.19	8	(30)	40	(25)	
0.20–0.29	6	(22)	59	(37)	
0.30–0.40	0	(0)	10	(6)	
>0.40	0	(0)	1	(1)	
					0.001*

HAB = homicide-associated burnings; ARF = adult residential fire victims.
*Wilcoxon two-sample test.

victims in order to prevent their identification or to make the death look like an accident (8). In South Africa, a modality of homicidal burning known as "necklacing" has received extensive media coverage since first reported in 1984. Necklacing involves placing a car tire around the neck of the victim, dousing the tire with petrol, and setting the victim alight (9). Statistics on this method of killing are difficult to compile, but it has been estimated that about half of the homicidal burnings in South Africa between 1984 and 1986 were necklacings (10).

Although a relatively small component of homicides in this study were burn related, these cases are nevertheless important in light of the volume of homicidal deaths (>1000 per year) in Cape Town. The high levels of residential fire and domestic accident deaths are due to the lack of electrification as well as the flammable construction of informal settlement areas on the urban periphery, where candles, open fires, and paraffin are used for lighting and cooking, often with disastrous consequences. The major burns of the ARFV suggest the catastrophic nature of these fires. The HAB were also extensively burnt and charred due to the flammable materials used. Very little comparative information is available on the time period required for charring of bodies (11), although it is evident from this study that exposure to tires and petrol results in extensive superficial tissue charring.

TABLE 5. *Antemortem injury found at postmortem examination of HAB (n = 34), January 1, 1991–December 31, 1992*

Injury	No.	(%)
Blunt force	14	(40)
Penetrating incised wound	8	(24)
Gunshot wound	6	(18)
No wounds found	6	(18)

HAB = homicide-associated burnings.

The presence of soot in the trachea and main bronchi appears to be a good, but nonspecific, sign that the decedent was indeed breathing at the time of the fatal fire. Problems associated with this postmortem sign include the finding of soot in the presence of charring away of the face, neck, and thoracic wall and its presence in cases with severe antemortem injury.

The difference in the blood carbon monoxide saturation between the HAB and ARFV was substantial. The relatively low CO levels in the ARFV may indicate the rapidity of fire death in mainly wooden and paper-lined shelters. None of the HAB with CO saturations of <10% had soot in the trachea and main bronchi, indicating the utility of these parameters in determining whether the victim was indeed alive at the time of the burning. (It should be noted that inhalation of smoke can cause soot in the trachea without burning of the body.)

Reliance on traditionally quoted CO levels for incapacitation and death may not be appropriate in the presence of toxic products of combustion (12,13); hence, the measurement of other substances has been proposed. These include measuring blood cyanide, which has been associated with rapid death even in the presence of low CO levels (14). Blood cyanide requires rapid collection, which is not always possible in the autopsy situation, and it may diffuse into the body following postmortem burning (15). The measurement of blood hydrocarbon levels has also been suggested as an indicator of whether the deceased was alive prior to the burning (16).

The lower BAC in the HAB may represent the circumstances under which such killings occur, such as factional or criminal violence. The high BAC in the case of ARFV is a source of concern because children were often victims of the same fire. Assessment of the role of alcohol must be undertaken with caution in light of its association with smoking, a commonly recognized cause of residential fires (17).

The finding that 82% of the HAB had evidence of antemortem injury indicates that attempts at burning were not successful in disguising the na-

ture of the fatal injury. Blunt force is a common feature of necklacing murders, where a crowd will often beat and stone the victim prior to the burning (9). It was in many cases possible to identify the features of penetrating incised wounds or perforating gunshot wounds, even in extensively cooked or burnt organs. In some of the HAB, it is possible that burning took place in order to hamper identification of the deceased; this aspect of the medicolegal examination of the charred remains represents a major challenge to the forensic team (8). Forensic odontological identification is the mainstay of the approach to identifying HAB, no matter how badly charred the remains are (18).

The validity of comparison between HAB and ARFV would be called into question if greater levels of survival were found following residential fires. Even though residential fires in informal and squatter settlements are catastrophic, with high mortality, as evidenced in this study, only 16% of the ARFV were hospitalized, as compared to 20% of the HAB. Furthermore, no differences in survival rates were found between the alleged residential arson victims and the ARFV.

It is often impossible to distinguish whether injuries were inflicted prior to or after the burning and whether these injuries were of sufficient severity to cause death. The forensic pathologist therefore has to combine a detailed and accurate history in all burnings with a high index of suspicion. It is perhaps the wisest policy to subject all burning victims to radiographic examination and a complete autopsy protocol.

REFERENCES

1. Smith GS, Barss P. Unintentional injuries in developing countries: the epidemiology of a neglected problem. *Epidemiol Revs* 1991;13:228–66.
2. Stansfield SK, Smith GS, McGreevey W. Health sectors priority review: injury. In: Jamison DT, Mosley WH, eds. *Disease control priorities in developing countries*. New York: Oxford Univ. Press for the World Bank, 1993: 180–208.
3. Republic of South Africa. Inquests Act [Act No. 58 of 1959 (as amended)].
4. Dean AD, Dean JA, Burton JH, Dicker RC. Epi-Info; version 5. Atlanta: Centers for Disease Control.
5. Statistical Analyser Systems. SAS/STAT Users' Guide (release 6.03). Cary, NC: SAS Institute, 1988.
6. Datubo-Brown DD. Deliberate burns in Nigerians. *Trop Doct* 1989;19:137–40.
7. Gupta RK, Srivastava AK. Study of fatal burns in Kanpur (India). *Forensic Sci Int* 1988;37:81–9.
8. Eckert WG, James S, Katchis S. Investigation of cremations and severely burned bodies. *Am J Forensic Med Pathol* 1988;9:188–200.
9. Duflou JALC, Lamont DL, Knobel GJ. Homicide in Cape Town, South Africa. *Am J Forensic Med Pathol* 1988;9: 290–4.
10. Scharf W, Ngcokoto B. Images of punishment in the people's courts of Cape Town 1985–7: from prefigurative justice to populist violence. In: Chabani Mangyani N, du Toit A, eds. Political violence and the struggle in South Africa. Halfway House: Southern Book Publishers, 1990:341–71.
11. Madea B. Duration of the fire and degree of charring of a burned cadaver. *Arch Kriminol* 1992;189:39–47.
12. Hill IR. Incapacitation and fires. *Am J Forensic Med Pathol* 1989;10:49–53.
13. Beritio T. The challenge of fire effluents. *Br Med J* 1990; 300:696–698.
14. Baud FJ, Barriot P, Toffis V, et al. Elevated blood cyanide concentrations in victims of smoke inhalation. *N Engl J Med* 1991;325:171–6.
15. Karhunen PJ, Lukkari I, Vuori E. High cyanide levels in a homicide victim burned after death: evidence of postmortem diffusion. *Forensic Sci Int* 1991;49:179–83.
16. Kojima T, Yashiki M, Chikasue F, Miyazaki T. Analysis of inflammable substances to determine whether death has occurred before or after burning. *Z Rechtsmed* 1990;103: 613–9.
17. Ballard JE, Koepsell TD, Rivara F. Association of smoking and alcohol drinking with residential fire injuries. *Am J Epidemiol* 1992;135:26–34.
18. Phillips VM, Lang IR. The identification of a "necklace" murder victim. *J Forensic Odontostomatol* 1988;6:55–66.

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PREVENTABLE MORTALITY FOLLOWING

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PREVENTABLE MORTALITY FOLLOWING SHARP PENETRATING CHEST TRAUMA

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We examined the determinants of outcome following sharp penetrating chest trauma (SPCT) in Cape Town, South Africa. During a 6-month period, 248 nonsurvivors (comprising 231 prehospital and 17 in-hospital deaths) and 474 survivors admitted to the Groote Schuur Hospital Trauma Unit were located. Most (77%) of the deaths resulted from cardiac or great vessel injuries. An unexpected finding was that in 47 (19%) of the prehospital deaths, the only injury at autopsy was a unilateral lung wound. There were no deaths in the 442 patients with this injury admitted to the hospital. The survival rate following equivalent injuries was unexpectedly better in patients from poorer socioeconomic areas, possibly because of increased use of private transport to reach the hospital. The key to improved outcome after survivable SPCT lies in rapid transportation to adequate emergency care by the quickest available means.

SHARP penetrating chest trauma (SPCT) accounts for the majority of serious injuries caused by interpersonal violence in countries such as South Africa.[1,2] Stab wounds to the chest, which are treated in the hospital, are reported to have a relatively low mortality rate, ranging between 1% and 8%.[3–7] It has been suggested that this favorable outcome is a result of a select population reaching the hospital, with the more seriously injured patients dying in the prehospital phase.[8] The present study was undertaken to provide, through the inclusion of both nonsurvivors and survivors, a community-based perspective on the true outcome after SPCT, and, where possible, to make recommendations for appropriate interventions to reduce mortality following SPCT.

MATERIALS AND METHODS

Definition and Selection of SPCT Nonsurvivors and Survivors

A victim of SPCT (whether dying or surviving) was defined as any person over the age of 12 years who sustained a primary injury with a knife or sharp object to the chest of sufficient severity to result in death or hospital admission during the study period, July 1, 1991 through December 31, 1991. The registers of the local state mortuary, which processed more than 95% of all homicides in metropolitan Cape Town during the study period, were used to identify 356 SPCT deaths, 20 of which had occurred in Groote Schuur Hospital (GSH). There were 494 SPCT patients treated at the GSH Trauma Unit during the study period. The study area was defined as that normally covered by the ambulance services serving GSH. In order to ensure comparability of the study base,[9] 104 (31%) of the prehospital deaths, three (15%) of the in-hospital deaths, and 34 (7%) of the survivors were excluded. This left 248 nonsurvivors (231 prehospital and 17 in hospital) and 474 survivors in the study.

Data Collection

Demographic information on prehospital deaths was obtained from police reports and autopsy data were extracted from the records of the Department of Forensic Medicine of the University of Cape Town. Autopsy records of all patients who died were located. All autopsies followed a specific and detailed protocol and blood was taken for gas chromatographic analysis of alcohol levels. Data extracted from the records of in-hospital nonsurvivors and survivors included demographic, diagnostic, and treatment information available from patient records.

Variables

Age, sex, and suburb of residence were the demographic variables used. Suburb of residence corresponded with actual suburb where the episode of SPCT occurred in 92% of the nonsurvivors and 94% of the survivors. Reported suburbs of residence (62 in all) were stratified into three levels using a composite socioeconomic status scale based on education, housing, income, and employment (Mr. K. Smith: Personal communication, Cape Town City Council, Urban Studies Department). The highest socioeconomic level (level 1) consisted of middle-class and upper-class suburbs, with the middle level (level 2) being mainly poorer but well established areas. The lowest socioeconomic level (level 3) included areas with overcrowding and informal housing. All suburbs were within a 25-km radius of the GSH Trauma Unit.

The primary intrathoracic injury was categorized using the

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Abbreviated Injury Scale (AIS—90) as a guide for anatomic characterization and measurement of injury severity.[10] A secondary intrathoracic injury was regarded as any injury with a lower AIS score than the primary intrathoracic injury. Sharp penetrating injuries at extrathoracic sites were documented if their AIS score was 2 or greater.

Statistical Methods

Bivariate statistical analysis was undertaken to compare characteristics of the nonsurvivors and the survivors. Multivariate logistic regression analysis was then used to calculate adjusted odds ratios (ORs) for selected explanatory variables, and regression diagnostics was performed.[11] Analysis was carried out using the SAS Statistical System (Release 6.07).

RESULTS

Demographic and Injury Descriptors

Victims of SPCT were predominantly young, male, and from the poorer suburbs (Table 1). The injury sites and severity characteristics for nonsurvivors and survivors following SPCT are shown in Table 2. Cardiac or major vessel wounds were the primary intrathoracic injuries in 77% of the nonsurvivors and 6% of the survivors. Lung injuries (unilateral or bilateral hemo/pneumothorax) were present in 94% of the survivors and 23% of the nonsurvivors. The median AIS score of the primary injury for nonsurvivors was 4, higher than that of survivors, whose median AIS score was 3 ($p < 0.001$). A secondary intrathoracic injury was found in 45% of the nonsurvivors compared with 5% of the survivors. Sharp penetrating trauma at an extrathoracic site occurred in 8% of the nonsurvivors and 2% of the survivors.

Cardiac and great vessel injuries accounted for 15 (88%) of the in-hospital deaths, with six (47%) of these cases having a secondary intrathoracic injury. Table 3 shows the percentage mortality for the primary injury groups treated in the hospital. Heart and major vessel injuries had a mortality rate of 36%, whereas there were no deaths from unilateral lung injury.

Table 4 gives the blood alcohol concentrations (BACs), which were available for 94% of the prehospital and 71% of the in-hospital deaths. Of the prehospital nonsurvivors 79% had a BAC greater than 100 mg/dL compared with 42% of the in-hospital nonsurvivors. Comparison between the groups, however, is not meaningful, because of the varying periods of time spent by the latter group in the hospital and vigorous fluid resuscitation, both of which could have influenced measured BAC.

Multivariate Analysis of Demographic and Injury Descriptors

A multivariate logistic regression model was constructed using the demographic and injury variables (Table 5). The dependent variable was death or survival, with in-hospital deaths being included in the death group. Quartile-based age strata were used and residential socioeconomic status stratified into the three levels described above. Primary intrathoracic injuries were divided into the three major categories by collapsing the various subcategories in Table 2, allow-

Table 1
Comparison of demographic characteristics for nonsurvivors and survivors following SPCT

Factor	Nonsurvivors (n = 248)		Survivors (n = 474)	
	Number	(%)	Number	(%)
Age distribution (years)				
16	1	(0.5)	3	(1)
17–24	78	(32)	193	(41)
25–34	105	(42)	205	(43)
35–54	63	(25)	70	(14)
54	1	(0.5)	3	(1)
Median age	28		27	
Sex				
Male	233	(94)	426	(90)
Female	15	(6)	48	(10)
Socioeconomic status				
Level 1	24	(10)	27	(6)
Level 2	56	(23)	116	(24)
Level 3	168	(67)	331	(70)

Table 2
Comparison of injury site and severity characteristics for nonsurvivors and survivors following SPCT

Factor	Nonsurvivors (n = 248)		Survivors (n = 474)	
	Number	(%)	Number	(%)
Primary intrathoracic injury				
Heart and great vessels				
Cardiac	98	(40)	25	(5)
Aorta and major arteries	56	(23)	1	(<1)
Vena cava and major veins	16	(6)	0	(0)
Pulmonary vessels	20	(8)	1	(<1)
Lung				
Single	47	(19)	442	(93)
Bilateral	11	(4)	5	(1)
		$p < 0.001$*		
Median Abbreviated Injury Scale score	4		3	
		$p < 0.001$†		
Secondary intrathoracic injury	112	(45)	23	(5)
		$p < 0.001$*		

* Based on Chi-square test.
† Wilcoxon two-sample test.

Table 3
Primary intrathoracic injury for hospitalized SPCT patients

Injury Site	Total (n = 491)	Number of Deaths (n = 17)	(%)
Cardiac	35	10	(29)
Major vessel	7	5	(71)
Bilateral lung injury	7	2	(29)
Unilateral lung injury	442	0	(0)

Table 4
Blood alcohol concentration for prehospital and in-hospital deaths following SPCT

Blood Alcohol Concentration (BAC)	Prehospital Deaths (n = 229)		In-hospital Deaths (n = 12)	
	Number	(%)	Number	(%)
BAC (mg/dL)				
0	35	(15)	5	(40)
01–100	13	(6)	2	(17)
101–200	74	(32)	3	(25)
201–300	99	(43)	2	(17)
>300	8	(4)	0	(0)
Median BAC	200		90	

Table 5
Multivariate logistic regression for selected demographic and injury characteristics as predictors of risk of death following SPCT

Variables	Adjusted OR*	95% CI
Residential socioeconomic status†		
Level 1†	1	
Level 2	0.19	0.09–0.37
Level 3	0.11	0.05–0.24
Primary intrathoracic injury		
Single lung†	1	
Bilateral lung	16.9	5.6–51.3
Cardiac or great vessel	51.9	31.7–85.5
Other sharp penetrating injuries		
Absent†	1	
Present	3.4	1.3–8.9

* OR = odds ratio, 95% CI = 95% confidence interval.
† Reference category.

ing classification as single lung, bilateral lung, and cardiac/great vessel injuries. Other extrathoracic sharp penetrating chest injury was treated as a dichotomous variable.

As expected, the strongest determinant of death was a cardiac or great vessel injury (OR = 51.9; 95% CI, 31.7–85.5) followed by bilateral chest injury (OR = 16.9; 95% CI, 5.6–51.3) and the presence of another injury at an extrathoracic site (OR = 3.4; 95% CI, 1.3–8.9). Poorest residential socioeconomic level was unexpectedly associated with improved survival (level 3 OR = 0.11; 95% CI, 0.05–0.24). Regression diagnostics resulted in only minimal improvement of model-fit estimates.

Hospitalization and Physiologic Indices

Most of the in-hospital deaths (76%) occurred within 6 hours of admission. Table 6 summarizes the treatment given to those admitted. Of the survivors, 14% required a surgical procedure under general anesthesia and 3% were admitted to the ICU. All the in-hospital nonsurvivors had either an emergency room thoracotomy (ERT) or a formal thoracotomy: ERT was successful on 52% of the occasions it was performed.

Table 6
Treatment characteristics of in-hospital nonsurvivors and survivors following SPCT

Treatment	In-hospital Nonsurvivors (n = 17)		Survivors (n = 474)	
	Number	(%)	Number	(%)
Thoracostomy	8	(47)	380	(80)
Emergency room thoracotomy	10	(59)	11	(2)
Formal thoracotomy	7	(41)	31	(7)
Neck exploration	2	(12)	4	(1)
Laparotomy	1	(6)	19	(4)

Severely depressed physiologic indices on admission predominated in the in-hospital death group, with ten patients having cardiac arrests in the prehospital phase.

DISCUSSION

Sharp penetrating chest trauma mainly affects young males from poorer suburbs, although there is a documented incidence in all groups and areas. The present study shows that the true seriousness of SPCT within a community is only made apparent when all serious morbidity and mortality are located; the percentage mortality in hospitalized patients was only 3.5%, compared with 34.4% when prehospital deaths were included.

The autopsy findings suggest that many of the prehospital deaths resulting from cardiac or great vessel injuries were unavoidable, even with more rapid emergency transportation. Prevention of SPCT is probably the only way to significantly reduce the mortality from these major wounds.[12] A fair proportion of SPCT victims, however, had injuries that should be survivable with timely management in a tertiary hospital. Extensive on-site resuscitation by emergency personnel would not be expected to substantially improve survival in patients with these major vessel and cardiac wounds and should perhaps include only procedures that do not increase prehospital time such as airway support.[13,14] Where primary level facilities receive SPCT patients, clinical features can be used to triage those likely to need special care.[15] The unexpectedly improved survival of patients from poorer suburbs with these injuries might have been a result of the ready use of private transport in areas poorly served by emergency services. Further support for the success of rapid transportation lies in the successful outcome of ERT on 52% of the occasions it was performed, indicating that if SPCT patients can be brought to the hospital with vital signs, the chances of survival improve substantially.[16]

The group within the prehospital nonsurvivors (19%) who sustained only a single lung wound is a major

source of concern, since there were no deaths in the in-hospital group with such injuries. Apart from unusual cases of air embolism from a traumatic bronchovenous fistula,[17,18] the remainder should survive with early adequate management by the emergency services followed by hospital care even at a primary level institution. Eminently treatable conditions include tension pneumothorax and hemorrhage from the lung vasculature; unfortunately we were unable to determine their incidence in our nonsurvivors because of difficulties in diagnosing these conditions at autopsy.[19] Although unequivocally associated with traumatic death, the role of alcohol in determining injury severity and outcome remains controversial.[20] The fact that the majority of SPCT nonsurvivors (and probably most survivors) were intoxicated at the time of injury may give some indication as to the circumstances surrounding the injury that could possibly result in delays in obtaining emergency care, as a result of the attacker and witnesses underestimating the consequences of a chest wound or being incapable of rendering assistance. Since no alcohol levels were available for survivors at the time of admission, it was not possible to examine whether an elevated alcohol level had any physiologically protective or deleterious effect on SPCT patients. It has, however, been our experience that for a given level of shock, intoxicated patients respond far more rapidly to intravenous fluids than their sober counterparts, perhaps on the basis of alcohol-induced arteriolar and venous vasodilation causing hypotension from lesser blood volume deficits. It is possible that some of the single lung injury deaths resulted from the deleterious hemodynamic and ventilatory effects of the combination of blood loss and alcohol.[21] Other specific survival-related factors such as physical fitness, preexisting illness, drug ingestion, and prehospital fluid therapy were not controlled for in this analysis, but it is acknowledged that all may have had an influence on outcome.

In conclusion, this study supports the viewpoint that in order to improve patient management, we need data about the consequences of trauma along the continuum of events relating to prehospital and hospital care.[22] Autopsy information is a vital component of a multidisciplinary approach to avoidable mortality.[23] It is reasonable to assume that most of the SPCT deaths resulting from unilateral lung injury and a smaller proportion of the other deaths in this study could be regarded as preventable. In areas with overburdened or inadequate emergency services, improved survival following SPCT can probably be achieved by rapid transportation to the hospital using whatever means are readily available.

REFERENCES

1. Butchart A, Brown DSO: Non-fatal injuries due to interpersonal violence in Johannesburg--Soweto: Incidence, determinants and consequences. *Forensic Sci Int* 52:35, 1991
2. Lerer LB: Women, homicide and alcohol in Cape Town, South Africa. *Forensic Sci Int* 55:93, 1992
3. Beall AC Jr., Bricker DL, Crawford HW, et al: Considerations in the management of penetrating thoracic trauma. *J Trauma* 8:408, 1968
4. Hegarty MM: A conservative approach to penetrating injuries of the chest: Experience with 131 successive cases. *Injury* 8:53, 1976
5. Sukul DM, de Zeeuw GR, Brummelkamp WH: Sharp thoracic injury. *Injury* 20:22, 1989
6. Demetriades D, Rabinowitz B, Markides N: Indications for thoracotomy in stab injuries of the chest: A prospective study of 543 patients. *Br J Surg* 73:888, 1986
7. van der Spuy JW, Knottenbelt JD: Subpulmonary haemothorax: 387 cases. *Injury* 22:385, 1991
8. Moar JJ: Homicidal penetrating incised wounds of the thorax: An autopsy study of 52 cases. *S Afr Med J* 65:385, 1984
9. Wacholder S, McLaughlin JK, Silverman DT, et al: Selection of controls in case-control Studies. *Am J Epidemiol* 135:1019, 1992
10. Association for the Advancement of Automotive Medicine: The Abbreviated Injury Scale, 1990 Revision. Des Plaines, Illinois, 1990
11. Hosmer DW, Taber S, Lemeshow S: The importance of assessing the fit of logistic regression models: A case study. *Am J Public Health* 81:1630, 1991
12. Morrissey TB, Byrd CR, Deitch EA: The incidence of recurrent penetrating trauma in an urban trauma center. *J Trauma* 31:1536, 1991
13. Ivatury RR, Nallathambi MN, Roberge RJ, et al: Penetrating thoracic injuries: In-field stabilization vs. prompt transport. *J Trauma* 27:1066, 1987
14. Durham LA, Richardson RJ, Wall MJ, et al: Emergency center thoracotomy: Impact of prehospital resuscitation. *J Trauma* 32:775, 1992
15. Wormald PJ, Knottenbelt JD, Linegar AG: A triage system for stab wounds to the chest. *S Afr Med J* 76:211, 1989
16. Kulshrestha P, Iyer KS, Das B, et al: Chest injuries: A clinical and autopsy profile. *J Trauma* 28:844, 1988
17. Thomas AN, Stephens BG: Air embolism: A cause of morbidity and death after penetrating chest trauma. *J Trauma* 14:633, 1974
18. Yee ES, Verrier ED, Thomas AN: Management of air embolism in blunt and penetrating thoracic trauma. *J Thorac Cardiovasc Surg* 85:661, 1983
19. Shapiro HA: The significance of blood in the pleural cavity observed after death. In Gordon I (ed): *Medico-legal Mythology and Other Forensic Contributions*. Johannesburg, Hugh Keartland Publishers, 1975, pp 90–93
20. Pories SE, Gamelli RL, Vacek P, et al: Intoxication and injury. *J Trauma* 32:60, 1992
21. Blomqvist S, Thörne J, Elmer O, et al: Early post-traumatic changes in hemodynamics and pulmonary ventilation in alcohol-pretreated pigs. *J Trauma* 27:40, 1987
22. Trunkey DD: What's wrong with trauma care? *Bull Am Coll Surg* 75:10, March 1990
23. Pollock DA, O'Neill JM, Parrish RG, et al: Temporal and geographic trends in the autopsy frequency of blunt and penetrating trauma deaths in the United States. *JAMA* 269:1525, 1993

8.

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A TIME-SERIES ANALYSIS OF TRENDS

IN FIREARM-RELATED HOMICIDE AND SUICIDE.

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MacDonald I L (Actuarial Science Section, Department of Business Science, University of Cape Town, Rondebosch 7700, South Africa) and Lerer L B. A time-series analysis of trends in firearm-related homicide and suicide. *International Journal of Epidemiology* 1994; **23**: 66–72.

In order to determine whether firearm use was an increasing component of the general pattern of homicide in Cape Town, South Africa, hidden Markov time-series models were used to examine a week-by-week count of firearm homicides, non-firearm homicides, firearm suicides and non-firearm suicides for the 6-year period from 1986 to 1991. Of several models fitted to the proportion of homicides that involved firearms, the one which incorporated a discrete upward shift in the middle of 1991 was the most successful. There was no evidence of a similar upward shift in the proportion of the suicides that involved firearms. The sharp increase in 1991 in the probability that a homicide involved the use of a firearm is consistent with a reported upsurge in violence related to the so-called 'taxi wars'. Hidden Markov models, as a general methodology for the analysis of discrete-valued time series, may be a useful and flexible means of identifying time trends or points of transition related to events or interventions in a wide range of public health contexts.

Increasing use of firearms may be reponsible for the rising homicide rate in the US.[1–3] In countries such as South Africa, deficiencies in demographic data and inaccurate cause-of-death information hamper the estimation of homicide and suicide rates.[4,5] In order to supplement the body of descriptive trauma epidemiology[6,7] and provide information for prevention programmes, it is important to develop innovative methods to monitor trends in violence mortality in the developing world.[8] The purpose of this study was to examine the proportions of homicides and suicides in Cape Town between 1986 and 1991 that involved firearms, and to identify any time trends or discrete shifts that may have occurred in these proportions during those years. The methodology used here, that of hidden Markov models, takes into account the discrete nature of mortality counts and is therefore more appropriate than the standard time-series methods, which assume that the observations are continuous.

MATERIAL AND METHODS

A statutory requirement exists in South Africa for all unnatural deaths to be subjected to a necropsy examination. Over 95% of the cases of unnatural death occurring in metropolitan Cape Town are admitted to the Salt River State Mortuary. (The remainder, admitted to a smaller mortuary, are thought not to differ materially in relevant respects.) The records of all homicides and suicides admitted to the Salt River mortuary were extracted for the period 1 January 1986–31 December 1991. Cause-of-death information was obtained from the accompanying police record and the homicides and suicides were divided into four categories (*International Classification of Diseases, 9th Revision, Clinical Modification*) (ICD-9-CM): firearm homicides (E965.0–E965.4); non-firearm homicides (E960–E964 or E965.5–E969); firearm suicides (E955.0–E955.4); and non-firearm suicides (E950–E954 and E955.5–E959). Necropsy examinations follow a detailed and complete protocol, making misclassification of actual medical cause of death unlikely. However, a possible source of bias may be the classification of a homicide as a suicide or as an accidental death. Deaths recorded as due to law enforcement action (2.4% of all homicides) were excluded, as were a very small number of cases in which a history was unavailable (e.g. decomposed bodies and skeletal remains). The data on individual cases were used to derive four separate 313-week time series of counts, of which those relating to firearm homicides and firearm suicides are displayed in Figures 1 and 2.

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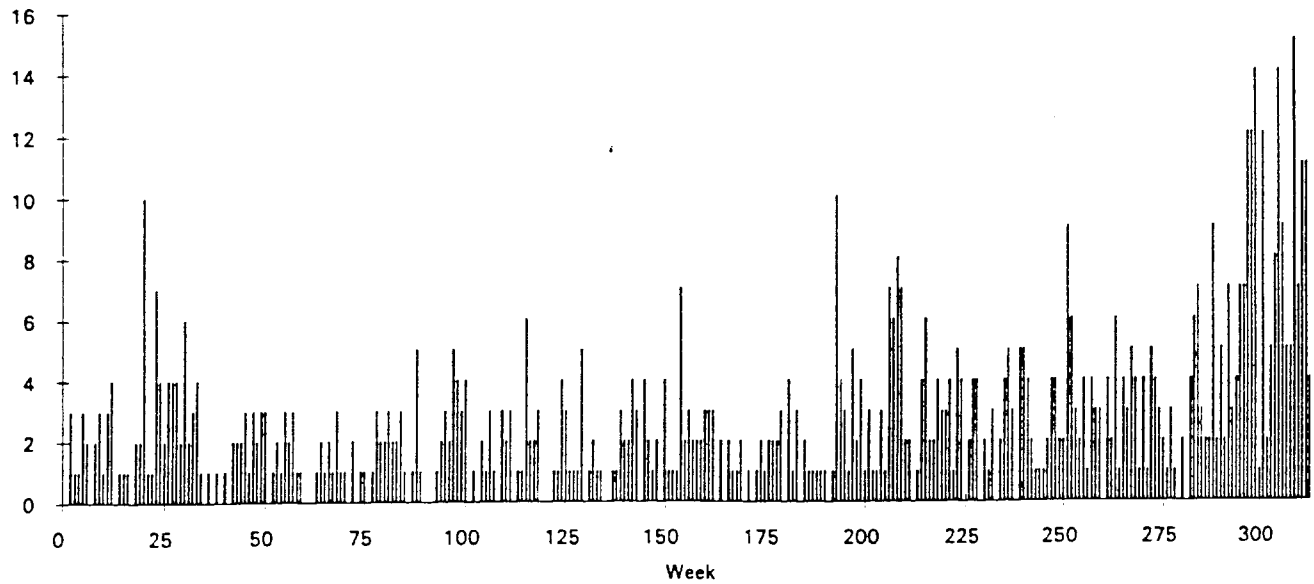

FIGURE 1 *Weekly counts of firearm homicides, 1986–1991. Week 1 begins on 1 January 1986 and week 313 ends on 31 December 1991*

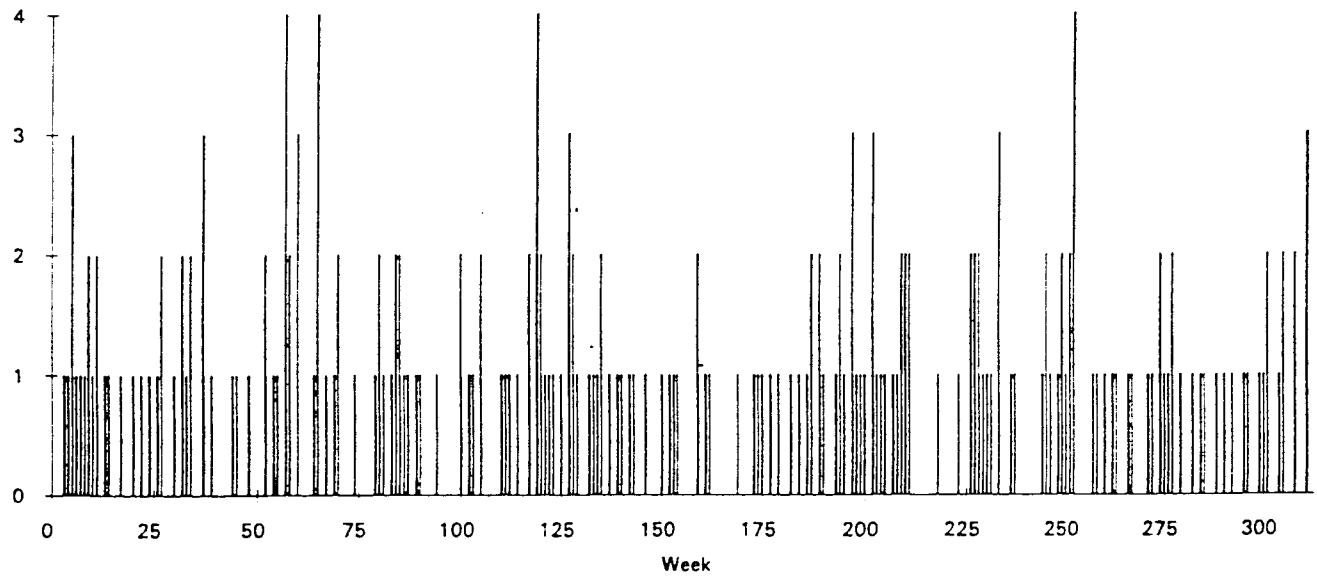

FIGURE 2 *Weekly counts of firearm suicides, 1986–1991*

Three characteristics of these data are worth noting. Firstly, they are in the form of time series, and it may therefore not be appropriate to apply the common statistical methods which rely on the assumption that the observations are independent. It may be necessary instead to use time-series models and methods, which allow for serial dependence in the observations. Secondly, the observations, being counts, are discrete-valued. Thirdly, many of the counts of firearm homicides and firearm suicides are very small. All of these characteristics are relevant to our choice of models for the quantities of interest, namely the proportions of homicides and suicides that involved firearms. Before describing the models chosen, however, we present some background information on time-series methods, especially as they apply to discrete data such as those under discussion here.

Most of the applications of time-series methodology that have appeared in the medical literature are based on 'autoregressive moving average models' and the techniques commonly associated with the names of Box and Jenkins, described very fully by those authors in their textbook.[9] For a useful discussion of such methods in the context of epidemiology, see Helfenstein,[10] and for some applications see Helfenstein *et al.*,[11] Haines *et al.*[12] and the references appearing in Helfenstein.[10] An example of this approach in the field of firearm-related violence is to be found in the work of Loftin *et al.*[13] describing the benefits of restrictive gun control legislation in the District of Columbia.

One criticism to which this 'Box-Jenkins' approach is open is that the models, being based on a *continuous* probability distribution—the normal—are not entirely appropriate to discrete data. Sometimes this distinction between discrete and continuous is unimportant, because the counts are large enough to justify treating them as if they were continuous quantities. When one is dealing with small counts, however, it is advisable to use models and techniques which are designed specifically for discrete observations. An example of such work, relating to monthly numbers of cases of poliomyelitis in the US in the years 1970–1983, is due to Zeger.[14] Furthermore there are applications in which, although the counts are large and can for certain purposes be treated as continuous, there are important questions of interest which cannot be answered by the standard 'normal-theory' techniques. An application of this kind, to monthly counts of births at Edendale Hospital in South Africa, has been described by MacDonald.[15]

A class of models that seem to be very useful as general purpose models for discrete-valued time series is the 'hidden Markov' models. These have been used for some time in automatic speech recognition applications,[16] and more recently have been applied (*inter alia*) to daily rainfall data,[17] time series of epileptic seizure counts[18] and the movements of a lamb in utero.[19] As a class of practical statistical models their great advantage is their flexibility and usefulness for a wide range of types of discrete-valued time-series data: unbounded counts, bounded counts, categorical data, univariate and multivariate observations and data displaying trend or seasonality can all be represented by hidden Markov models. A detailed discussion of these and other time-series models for discrete data will appear in a forthcoming book.[20]

A simple example of a hidden Markov model useful in the present context is as follows. Suppose that there are n_t homicides in week t. Suppose that the number of firearm homicides in that week is distributed as a binomial random variable with parameters n_t and p_1 if some underlying process is in state 1, and parameters n_t and p_2 if that process is in state 2. The underlying two-state process, which is assumed to be unobserved, is taken to be a Markov chain. (A Markov chain may be described informally as a discrete-valued random process such that, conditional on the present, the past and future are independent. For a discussion of Markov chains, see for instance Grimmett and Stirzaker.[21]) This Markov chain is the link between the successive observations, in the sense that it introduces serial dependence in the observation sequence. In some applications of hidden Markov models the states of the underlying Markov chain may have, or may turn out to have, a useful substantive interpretation. That is, they may have a definite interpretation in terms of the subject matter of the application concerned. Even if the models are not substantive ones, however, they may nevertheless be very useful as empirical ones not based on any specific subject matter considerations. This is true, for instance, of the standard autoregressive moving average models commonly used for continuous-valued time series: they are most often used as empirical models, but are no less valuable for that. (We use the terms 'empirical model' and 'substantive model' in the sense used by Cox.[22])

It is also possible to build a time trend or change point into such a model, simply by allowing the probabilities p_1 and p_2 to depend on the time parameter t. For instance, a smooth logistic-linear time trend in the probabilities p_t is represented by

$$\text{logit } {}_tp_t = a_t + bt.$$

More precisely, this allows for the same trend in the two states, whereas the following assumption allows the trend parameter b to differ between states:

$$\text{logit } {}_tp_t = a_t + b_t t.$$

If on the other hand it is suspected that the probabilities p_1 and p_2 undergo a discrete shift at some time point, one can set p_1 equal to one value before that change point and a different value afterward, and similarly p_2.

Models can be fitted (i.e. parameters estimated) fairly routinely by maximum likelihood provided that suitable optimization software is available, but it is not feasible to do the computations by hand. Given competing hidden Markov (or other) models, model selection may be performed by minimizing Akaike's information criterion (AIC)[23] or the Bayesian information criterion (BIC) of Schwarz.[24] Some mathematical details of the models used are presented in an Appendix.

RESULTS

The methodology described above was applied to modelling the number of firearm homicides as a proportion of all homicides, and similarly the number of firearm suicides as a proportion of all suicides. Time-series plots of these two proportions are displayed in Figures 3 and 4. Since in some weeks there were no suicides at all, there are observations missing from the latter series. Fortunately it is straightforward to allow for missing data in fitting hidden Markov models, and this aspect of the data therefore caused no difficulty.

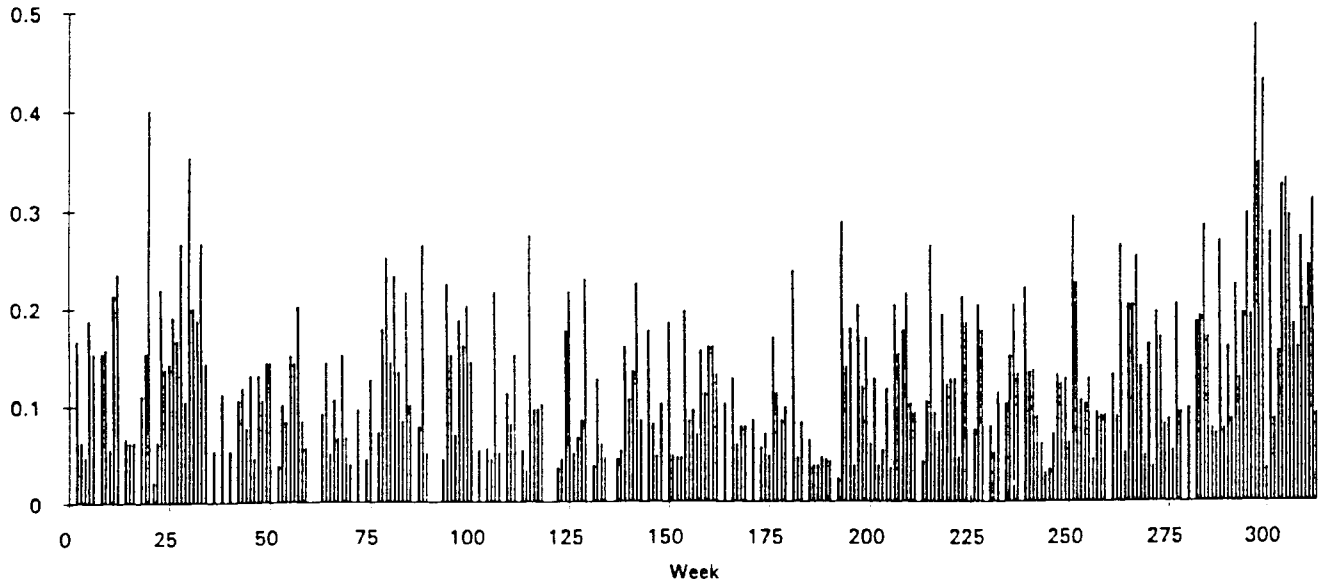

FIGURE 3 *Firearm homicides as a proportion of all homicides, 1986–1991. The week ending on 2 July 1991 is week 287*

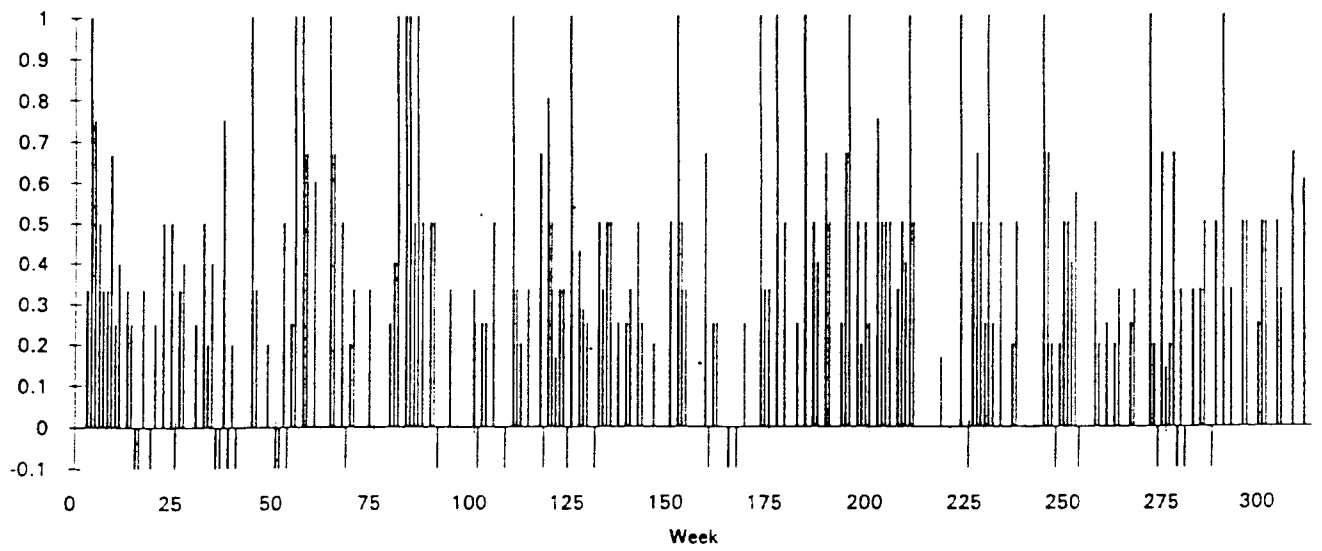

FIGURE 4 *Firearm suicides as a proportion of all suicides, 1986–1991. (Negative values indicate no suicides in that week)*

Four types of two-state hidden Markov model were fitted in each case: a model with constant probabilities p_1 and p_2 of death being due to a firearm, a model with a linear time trend (the same for the two states) in the logits of those probabilities, a model allowing the time-trend parameter to differ between states, and finally a model which assumes that the probabilities p_1 and p_2 are piecewise constant, with a change point at the end of week 287, i.e. on 2 July 1991. The time of the change point was chosen because of the known upsurge of violence in metropolitan Cape Town during the second half of 1991. The models were compared on the basis of AIC and BIC. The results are shown in Tables 1 and 2, with l denoting the maximized log likelihood.

In the case of the homicides the conclusion from BIC is that a single (upward) time trend is better than either no trend or two trend parameters, but that the model with a change point is the best of the four. The conclusion in respect of the suicides is that the model with constant p_1 and p_2 is best. The hidden Markov models chosen for the two proportions are in detail as follows. For the firearm homicides the Markov chain has transition probability matrix

$$\begin{pmatrix} 0.695 & 0.305 \\ 0.283 & 0.717 \end{pmatrix}$$

and stationary distribution (0.481 0.519). The probabilities p_1 and p_2 are given by (0.060 0.140) up to 2 July

TABLE 1 *Comparison of various hidden Markov models for firearm homicides as a proportion of all homicides*

Model with:	No. parameters	$-l$	AIC	BIC
p_1 and p_2 constant	4	590.75	1189.5	1204.5
one time-trend parameter	5	585.59	1181.2	1199.9
two trend parameters	6	583.98	1180.0	1202.4
change-point at 2 July 1991	6	575.04	1162.1	1184.6

TABLE 2 *Comparison of various hidden Markov models for firearm suicides as a proportion of all suicides*

Model with:	No. parameters	$-l$	AIC	BIC
p_1 and p_2 constant	4	289.93	587.86	602.84
one time-trend parameter	5	289.22	588.45	607.18
two trend parameters	6	288.30	588.61	611.09
change-point at 2 July 1991	6	289.21	590.42	612.90

TABLE 3 *Comparison of various 'independence' models for firearm homicides as a proportion of all homicides*

Model with:	No. parameters	$-l$	AIC	BIC
p constant	1	637.46	1276.9	1280.7
time-trend in p	2	617.80	1239.6	1247.1
change-point at 2 July 1991	2	590.60	1185.2	1192.7

TABLE 4 *Comparison of various 'independence' models for firearm suicides as a proportion of all suicides*

Model with:	No. parameters	$-l$	AIC	BIC
p constant	1	291.17	584.33	588.08
time-trend in p	2	290.28	584.55	592.04
change-point at 2 July 1991	2	291.04	586.09	593.58

1991, and by (0.143 0.283) thereafter. The unconditional probability that a homicide involved the use of a firearm is therefore 0.102 before the change point, and 0.216 thereafter. For the firearm suicides, the transition probability matrix is

$$\begin{pmatrix} 0.854 & 0.146 \\ 0.117 & 0.883 \end{pmatrix}$$

and the stationary distribution is (0.446 0.554). The probabilities p_1 and p_2 are given by (0.186 0.333), and the unconditional probability that a suicide involves a firearm is 0.267.

A question not considered above, however, is whether time-series models are needed at all. Is it not perhaps sufficient to fit a model which assumes stochastic independence of the consecutive observations, but is otherwise identical to one of the time-series models described above? More explicitly, such a model consists of a sequence of *independent* binomial random variables with known number(n_t) of trials at time t and 'success probability' p which either is constant with respect to t, or has a logistic-linear time trend, or has a change point at 2 July 1991. Models of this type were therefore fitted by maximum likelihood both to the firearm homicides as a proportion of all homicides, and to the firearm suicides as a proportion of all suicides. The comparison of models was performed, as before, on the basis of the criteria AIC and BIC. The results are presented in Tables 3 and 4, in which the parameter p represents the probability that a death involves a firearm.

The conclusions that may be drawn from these models are as follows. For the homicides, the models based on independence are without exception clearly inferior to the corresponding hidden Markov time series models. There is sufficient serial dependence present in the proportion of the homicides involving a firearm to render inappropriate any analysis based on an assumption of independence. For the suicides the situation is reversed: the models based on independence are in general superior. There is in this case no evidence of serial dependence, and time-series models do not appear to be necessary. The 'best' model based on independence assigns a constant value (0.268) to the probability that a suicide involves the use of a firearm. This is quite consistent with the conclusion about this probability which was drawn from the chosen hidden Markov model.

To summarize, therefore, we may say that the proportion of homicides that involve firearms does indeed seem to be at a higher level after June 1991, but that there is no evidence of a similar upward shift (or trend) in respect of the proportion of the suicides that involve firearms. There is evidence of serial dependence in the proportion of homicides that involve firearms, but not in the corresponding proportion of suicides.

DISCUSSION

The finding of serial dependence in the proportion of homicides (but not suicides) that involve firearms suggests that in the case of the homicides there are underlying factors, such as factional conflict, that

cause persistence in violence involving firearms. It seems unlikely that there would be similar tendencies resulting in persistence in the level of firearm suicides, and this is borne out by the apparent absence of serial dependence in that case.

Increased legal and illegal availability of firearms contributes to higher levels of homicides, as the case-fatality rate substantially exceeds that of other modalities of interpersonal violence.[25,26] During 1991 a bitter struggle occurred between rival taxi organizations for control of lucrative transport routes from the townships of metropolitan Cape Town. Extensive use of illegal weapons, including sub-machine guns and high-velocity rifles, was responsible for numerous deaths.[27,28] The lack of an increase in the proportion of suicides due to firearms is interesting in view of studies which suggest that suicide rates among white South Africans have remained stable.[29] As almost all legal individual gun ownership is concentrated in the white population, this group accounts for almost all the firearm suicides, and these findings should be seen in the light of the controversy concerning the effects of a prolonged economic recession and political turmoil on homicide and suicide rates.[30]

We believe the potential usefulness of the time-series models exemplified here extends far beyond the present application, to a variety of epidemiological time series. Many such series are by their very nature discrete, e.g. daily counts of epileptic seizures in a single patient, or weekly disease notifications. Hidden Markov models provide a unified approach to the analysis of such discrete-valued series that may be appropriate when the standard normal-theory time-series methods are entirely inappropriate—as is the case when one is dealing with very small counts. Furthermore, the ease with which time trends or change points can be incorporated into a hidden Markov model adds to the utility of these models in a public health context: trends in observations may be identified, and the effects of interventions assessed.

Hidden Markov models may be of fairly general use in the study of firearm-related violence, a problem which is causing growing international concern. In the US, a system of continued surveillance has been proposed in order to provide policy makers with accurate information on the increasing use of firearms.[31] In less developed countries such as South Africa the difficulties of maintaining national information systems make it necessary to use sentinel surveillance sites.[32] In this context the methods we have described here seem particularly applicable because of the occurrence of small counts and the importance of assessing the effects of interventions.

It will not always be possible to place a useful substantive interpretation on the states of the Markov chain in a hidden Markov model, but this does not detract in any way from the value of such models as empirical models. However, there may well be applications where a useful interpretation emerges from the modelling process, and thereby contributes to our fundamental understanding of the process generating the data.

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REFERENCES

1. Holinger P C. *Violent Deaths in the United States: An Epidemiologic Study of Suicide, Homicide and Accidents.* New York: Guilford Press, 1987.
2. Wintemute G J. Firearms as a cause of death in the United States, 1920–1982. *J Trauma* 1987; **27**: 532–36.
3. Reiethford J H. Homicide trends in New York State, 1980 to 1988. *Am J Public Health* 1991; **81**: 1677.
4. Poiednak A P. Accidents, injuries, homicide and suicide. In: *Racial and Ethnic Differences in Disease.* New York: Oxford University Press, 1989, pp. 273–76.
5. Bradshaw D, Dorrington R E, Sitas F. The level of mortality in South Africa in 1985—what does it tell us about health? *S Afr Med J* 1992; **82**: 237–40.
6. Butchart A, Brown D S O. Non-fatal injuries due to interpersonal violence in Johannesburg-Soweto: incidence, determinants and consequences. *Forensic Sci Int* 1991; **52**: 35–51.
7. Lerer L B. Women, homicide and alcohol in Cape Town, South Africa. *Forensic Sci Int* 1992; **55**: 93–99.
8. Stansfield S K, Smith G S, McGreevey W. Injury. In: Jamison D T, Mosley W H, Bobadilla J L and Measham A R. (eds). *Disease Control Priorities in Developing Countries.* New York: Oxford University Press, 1993.
9. Box G E P, Jenkins G M. *Time Series Analysis, Forecasting and Control.* Revised edition. Oakland, California: Holden-Day, 1976.
10. Helfenstein U. The use of transfer function models, intervention analysis and related time series methods in epidemiology. *Int J Epidemiol* 1991; **20**: 808–15.
11. Helfenstein U, Ackermann-Liebrich U, Braun-Fahrländer C, Wanner H U. The environmental accident at 'Schweizerhalle' and respiratory diseases in children: a time series analysis. *Stat Med* 1991; **10**: 1481–92.
12. Haines L M, Munoz W P, van Gelderen C J. ARIMA modelling of birth data. *J Appl Stat* 1989; **16**: 55–67.
13. Loftin C, McDowall D, Wiersema B, Cottey T J. Effects of restrictive licensing of handguns on homicide and suicide in the District of Columbia. *N Engl J Med* 1991; **325**: 1615–20.
14. Zeger S L. A regression model for time series of counts. *Biometrika* 1988; **75**: 621–29.
15. MacDonald I L. An application of two novel models for discrete-valued time series to births data. *S Afr Statist J* 1993; **27**: 87–102.

[16] Juang B H, Rabiner L R. Hidden Markov models for speech recognition. *Technometrics* 1991; **33**: 251–72.
[17] Zucchini W, Guttorp P. A hidden Markov model for space-time precipitation. *Water Resour Res* 1991; **27**: 1917–23.
[18] Albert P S. A two-state Markov mixture model for a time series of epileptic seizure counts. *Biometrics* 1991; **47**: 1371–81.
[19] Leroux B G, Puterman M L. Maximum-penalized-likelihood estimation for independent and Markov-dependent mixture models. *Biometrics* 1992; **48**: 545–58.
[20] MacDonald I L, Zucchini W. *Hidden Markov and Other Models for Discrete-valued Time Series*. London: Chapman and Hall, (In Press), 1993.
[21] Grimmett G R, Stirzaker D R. *Probability and Random Processes*. Second edition. Oxford: Oxford University Press, 1992, Ch.6.
[22] Cox D R. Role of models in statistical analysis. *Stat Sci* 1990; **5**: 169–74.
[23] Priestley M B. *Spectral Analysis and Time Series*. London: Academic Press, 1981, p. 372.
[24] Schwarz G. Estimating the dimension of a model *Ann Stat* 1978; **6**: 461–64.
[25] Saltzman L E, Mercy J A, O'Carroll P W, Rosenberg M Z, Rhodes P H. Weapon involvement and injury outcomes in family and intimate assault. *JAMA* 1992; **267**: 3043–47.
[26] Lee R K, Waxweiler R J, Dobbins J G, Paschetag T. Incidence rates of firearm injuries in Galveston, Texas. *Am J Epidemiol* 1991; **134**: 511–21.
[27] Davis G. Dissecting the malaise of the taxi war. *Weekly Mail*, 27 March 1992, p. 6.
[28] Davids B, Mabote R. Taxi killing: Cop arrested. *Cape Times*, 21 October 1991, p. 4.
[29] Levin A. Suicide patterns and trends in South Africa's population groups. In: Schlebusch L (ed.). *Suicidal Behaviour 2*. Proceedings of the 2nd Southern African Conference on Suicidology. Durban: University of Natal, 1992, pp. 6–11.
[30] Reinfurt D W, Stewart J R, Weaver N L. The economy as a factor in motor vehicle fatalities, suicides, and homicides. *Accid Anal Prev* 1991; **23**: 453–62.
[31] Teret S P, Wintemute G J, Beilenson P L. The Firearm Fatality Reporting System: a proposal. *JAMA* 1992; **267**: 3073–74.
[32] Smith G S. Development of rapid epidemiologic assessment methods to evaluate health status and delivery of health services. *Int J Epidemiol* 1989; **18(Suppl.2)**: S2–S15.
[33] Numerical Algorithms Group. *NAG Fortran Library (Mark 15)*. Oxford: Numerical Algorithms Group, 1992.

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APPENDIX

In this Appendix we present some mathematical details of the models and model selection criteria used, and describe the parameter estimation technique.

Let $\{C_t : t \in \mathbf{N}\}$ be a stationary homogeneous irreducible Markov chain on state-space $\{1,2, \ldots, m\}$, with transition probability matrix $\Gamma = (\gamma_{ij})$ and stationary distribution the row vector δ. We suppose that, conditional on $\{C_t\}$, the observations $\{S_t\}$ are mutually independent and, if $C_t = i$, the conditional distribution of S_t is binomial with parameters n_t (known) and p_i. Such a model $\{S_t\}$ has m^2 parameters: the m 'success probabilities' p_i, and m^2-m of the transition probabilities γ_{ij}, e.g. the off-diagonal elements of Γ.

With these assumptions it may be shown that the likelihood of a sequence of T consecutive observations $s_1, s_2, \ldots, s_T$ is given by the following expression:

$$L = \delta\lambda(s_1)\Gamma\lambda(s_2)\Gamma \ldots \Gamma\lambda(s_T)\mathbf{1}.$$

(Here $\mathbf{1}$ is a column vector of ones and $\lambda(s_t)$ is the $m \times m$ diagonal matrix with ith diagonal element the binomial probability $\binom{n_t}{s_t} p_i^{s_t}(1-p_i)^{n_t-s_t}$.) Direct numerical maximization of the likelihood with respect to the m^2 parameters (subject, if $m > 2$, to generalized upper bound constraints on the transition probabilities) yields estimates of the parameters. In this work the routine E04UCF in the NAG Fortran Library[33] was used to perform the optimizations.

Incorporation of a time trend or change point into the probabilities p_i is straightforward. If for instance one assumes that the same (logistic-linear) time-trend applies in all m states, the constant probability p_i is replaced by ${}_tp_i$, where $\text{logit } {}_tp_i = a_i + bt$. Otherwise the likelihood computation proceeds as before, and direct numerical maximization of the likelihood is again feasible as a means of parameter estimation.

The model selection criteria AIC and BIC are given by

$$\text{AIC} = -2l + 2k$$

and

$$\text{BIC} = -2l + k\log_e T,$$

where l is the maximized log likelihood, k is the number of parameters, and T is (as above) the number of observations. Except when $\log_e T < 2$, BIC will therefore select more parsimonious models than will AIC.

9.

BUTCHART A, LERER LB, TERRE BLANCHE M.

IMAGINARY CONSTRUCTIONS AND FORENSIC RECONSTRUCTIONS OF FATAL VIOLENCE AGAINST WOMEN: IMPLICATIONS FOR COMMUNITY VIOLENCE PREVENTION.

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Imaginary constructions and forensic reconstructions of fatal violence against women: Implications for community violence prevention

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Abstract

The almost exclusive media focus on political violence in South Africa has deflected attention from the high levels of interpersonal violence in areas of socioeconomic deprivation. In order to explore the tension between an at-risk community's perspective and the current reality of violence against women, imaginary constructions of their own violent death produced by 45 African female interview respondents were examined in conjunction with forensic data relating to 73 African female homicide victims in Cape Town, South Africa. The prototypical account of an imagined homicide involved a female commuter being approached by a group of men, taunted and assaulted, raped and then killed. The majority of actual homicides occurred at or in the vicinity of the residence of the victim, with the attacker being known to the deceased. Whilst only 1 of the imagined homicide narratives depicted the use of alcohol by the victim, over half the actual homicides had elevated postmortem blood alcohol levels. These and other disjunctions and convergencies between lay and forensic constructions of violent female death should be viewed in the wider context of enmeshment in social circumstance, and could provide some understanding of how at-risk communities perceive violence against women, thereby providing a foundation for appropriate prevention programmes.

Key words: Violence; Women; Homicide; Interpersonal violence; Alcohol; Discourse analysis

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1. Introduction

Increasing attention is being paid to interpersonal violence as a public health priority in the developing world [1]. In South Africa, seemingly interminable political and factional violence [2] should be viewed against the backdrop of unacceptable levels of premature death due to injury [3] and endemic interpersonal violence [4,5]. As this interpersonal violence is rooted in poverty and deprivation [6,7], the key to its attenuation may therefore lie in massive socioeconomic and political transformation. These, however, are long term objectives and public health professionals are faced in the short term with the need to provide appropriate interventions in particular at-risk populations [8]. These interventions should be designed for specific groups, such as women [9,10], where multiple burdens of racial, social and sexual oppression [5,11–13] trap victims, potential victims and perpetrators in a complex mix of structural and psychological dynamics that render such violence resistant to social and political change.

To design appropriate and acceptable interventions it may be important to take into account not only the existing body of descriptive epidemiological data [4,5,11–13] or population perspective on violence against women, but also individual perspectives. This has been described by Jeffery as providing 'a way to translate epidemiologic findings into terms that are salient to individuals' and is based on the public health utility of exploring the difference between population perspectives (based on epidemiological data) and individual perspectives (based on personal estimates of risk) of risk factors and 'unhealthy' behaviour [14]. A particular problem such as violence against women may from the population perspective be regarded as an urgent public health priority, whereas the individual woman may see the odds of her avoiding this problem as stacked in her favour — with or without behaviour change. The disjunctions between the two perspectives may cause information, which from the population perspective appears salient to prevention, to appear irrelevant from the individual perspective. It is this tension that requires articulation in the case of particular populations and this paper aims to contrast imaginary constructions of fatal violence against women (individual perspectives) with forensic data on actual homicides (population perspectives) in Cape Town, South Africa, and to explore the implications of this juxtaposition for violence prevention.

2. Subjects and methods

2.1 Imaginary constructions of female homicide (the individual perspective)

Fifty African[1] women (median age 27.7 years) were interviewed during February, 1992, at a major railway station in Cape Town. They were two female African medical students who had spent a period training in reflexive interviewing techniques. They were instructed to approach all African women waiting on the platform and

[1]Disparities in socioeconomic and health status in South Africa are strongly linked to legally defined racial categories. As (until recently) official terminology made use of the terms white, black, asian and coloured, we have used the term African in place of black for the purposes of clarity.

request an interview with the statement that they were doing research into what women thought about violence and that all responses would be totally anonymous. Interviewees who assented were then asked: 'Imagine you were to die violently at the hands of another person, can you tell me how it will happen?' The response, in the home language of the interviewee, was tape recorded and thereafter transcribed and translated into English. The interviews were conducted in the late afternoon with almost all the respondents being on their way home from work. Of 62 women approached, 50 agreed to be interviewed, with the majority of those refusing claiming that they did not have sufficient time for the interview. Five interviews were not included in the analysis due to technical problems relating to the quality of the tape recording.

The type of story elicited from respondents is illustrated by the following example:

> My boyfriend and I were coming from a New Year's eve festival in the morning. In the street three guys came and started quarrelling with my boyfriend. They stabbed him and took his money. Then they raped me on the side of the road before killing me too (Respondent 40).

To analyse and compare both the content and structure of the 45 narratives, the following procedure was adopted. Each individual narrative was read as a story composed of discreet but related elements through which the plot unfolds to construct a scenario of violent death. The example presented above commences by setting the scene through a description of the context in which the attack will occur — it is New Year's eve and the victim is with her boyfriend. This is the first element of the plot. Then, the narrator introduces an element of potential threat as 'three guys' approach — this is the second element. The third element consists of provocative verbal and physical actions — quarrelling followed by stabbing, robbery and rape — that confirm that this will be a violent episode and transform the 'three guys' from neutral strangers into aggressors. Finally, the fourth element consists of the homicide itself, in this case referred to simply as 'killing' by the narrator.

By analysing each story in this way, all these elements were extracted from the stories, grouped according to their positioning within the stories, and these groups were labelled with headings and sub-headings that capture the essence of their contribution to the plot[2]. This structured collection of narrative elements used by the respondents to construct their stories of imaginary death is known as a 'discursive repertoire', and is used in discourse analysis to identify the 'building blocks' available to individuals speaking or writing in particular domains about particular topics [15].

2.2 Forensic data from actual female homicides (the population perspective)

A sample of 73 African homicide victims (median age 29.5 years) was extracted from a detailed study of female homicide in metropolitan Cape Town between January 1990 and July 1991 [5]. The information obtained from the postmortem records was supplemented with a study of the police reports. This sample

[2]Software for the automation of parts of this process may be obtained by writing to the authors.

represented over 95% of the African female homicides that were investigated in metropolitan Cape Town during these 18 months and reflects the intensity of violence in specific residential areas. Blood alcohol concentrations (BACs) were available for 60 (82%) of the homicides and these are illustrated together with type of death in Table 1.

3. Results and discussion

'It was as if a female death could he entrusted only to words; that only words could see it through.' (Nicole Loraux) [16]

3.1 Imaginary constructions of female homicide

The repertoire of events produced through the extraction and labelling of the elements present in the 45 stories is presented in Table 2. Inspection of this table shows that it was possible to classify the elements under four main headings, each representing a distinct phase in the homicidal process.

The first phase was labelled 'Incipient Context' and consisted of scene-setting elements that suggest the type of incident which was to follow. Within the phase, elements suggesting that they would be 'mugged' (in particular while commuting to a legitimate destination such as work, the shops, or home) were just over twice as common as those suggesting that they would be killed in the course of domestic conflict, political or criminal violence, or 'mayhem'.

The second phase was labelled 'Becoming Conspicuous' as it consisted of elements whereby respondents portrayed processes through which the woman was singled out for attack or came to attention as a potential victim. Two sub-categories of elements were particularly prominent, being those where the victim is approached by a group, and those where she met an individual (usually a stranger). Scenarios where the victim came to prominence while witnessing a fight or robbery in progress were also quite common.

The third phase, labelled 'Provocation and Pacification', consisted of a clearly defined collection of verbal and non-verbal actions that impelled the encounter between victim and aggressor into a physically violent confrontation. Here, non-verbal and verbal provocation by the aggressor appeared most frequently. On the part of

Table 1
African female homicides by recorded blood alcohol concentration and type of death, January 1, 1990–June 30, 1991 [5]

BAC (g/100 ml)	Sharp homicide	Blunt homicide	Firearm homicide
0.00	15	5	10
0.01–0.09	2	0	0
0.10–0.19	2	5	1
0.20–0.29	11	4	0
>0.30	4	1	0

Table 2
The homicide repertoire, with frequency of element occurrence (in parentheses)

1. Incipient context[a]

Mugging (22)
Aa. Robbery (4)
Ab. Narrator journeying to legit. destin. (18)

Domestic tension (13)
Af. Sibling rivalry (3)
Ag. Lovers/spouses' tiff (3)
Ah. Sexual jealousy (6)
Ai. Family feud (1)

Mayhem (10)
Ac. Tranquil at home (5)
Ad. At club/shebeen (4)
Ae. At school (1)

Criminal/Political (9)
Aj. Gangland (4)
Ak. Taxi war (2)
Al. Assasination (1)
Am. Racial/political intolerance (2)

2. Becoming comspicuous

Approached by group (12)
Ba. On street (11)
Bb. Enter house (1)

Group loyalty/membership (3)
Bf. Ethnic affiliation question (1)
Bg. Group loyalty challenged (1)
Bh. Suspected informant (1)

Meet individual (13)
Bc. Meet stranger (8)
Bc. Meet ex-lover/rival (5)

Avoidance (1)
Bi. Avoid conflict (1)

Killer sees money (2)
Bj. Looks at victim's purse (2)

Narrator approaches (2)
Bk. Offers charity (1)
Bl. Drunkenly greets (1)

Narrator witnesses (8)
Bm. Quarrel/fight (7)
Bn. Break-in (1)

3. Provocation and pacification

Aggressor provocation (79)

Verbal (30)
Ca. Interrogatory questioning (4)
Cb. Lewd proposition (5)
Cc. Demand (5)
Cd. Threaten to kill unless... (3)
Ce. Accuse (9)
Cf. Abuse/demean (3)
Cg. Lure out (1)

Non-verbal (49)
Da. Rob victim (3)
Db. Reveal weapon (4)
Dc. Beat up (10)
Dd. Circle/follow (6)
De. Manhandle (8)
Df. Rape (9)
Dg. Forcibly enter victim's dwelling (5)
Dh. Abduct (4)

Narrator provocation (14)

Verbal (6)
Ga. Refuse to talk (3)
Gb. Fail to understand (1)
Gc. Intervene (2)

Non-verbal (8)
Ha. Identify attacker (3)
Hb. Struggle against (3)
Hc. Ignore (2)

Narrator pacification (18)

Verbal (12)
Ia. Answer (4)
Ib. Explain (3)
Ic. Cry for help (5)

Non-verbal (7)
Ja. Attempt escape (5)
Jb. Keep still (1)
Jc. Comply (1)

4. Killing

Narrator (45)
La. Stabbed (16)
Lb. Blunt force (5)
Lc. Shot (8)
Ld. 'Killed' (13)
Le. Petrol bombed (1)
Lf. Thrown from train (1)
Lg. Strangled (1)

Aggressor
---Empty---

[a]Elements in this category total 54, as nine of the stories began with phrases suggesting more than one incipient context.

victims, the most commonly imagined actions in this phase were verbal attempts to pacify the aggressor, although a number of provocative actions by the victim were also depicted.

The final phase, 'Killing', described the homicide itself, and in it stabbing was the most frequently imagined type of force resulting in death, followed by unspecified 'killing', shooting and blunt force.

To summarise these findings, the dominant scenario shaping womens' imaginary perspectives of violent death is displayed in the form of a 'narrative signature' composed by plotting the most common sequences between the phases of attack and groups of elements within each phase (Fig. 1).

Fig. 1 shows that the most commonly imagined scenario was one in which a woman on her way to or from a legitimate destination was either approached by a group or met an individual. Following this, the stories converge around clusters of provocatory and pacificatory actions, with verbal provocation by the attacker and verbal attempts at pacification on the victim's part preceding non-verbal aggressor and victim actions such as physical abuse and attempts to fight back that were immediate precursors to the killing.

3.1.1. Contrasting imaginary and real female homicide

In the absence of comprehensive information including the testimony of witnesses and suspected perpetrators, forensic data of actual homicide victims cannot reconstruct the homicidal process with anything approaching the rich detail produced through the analysis of imaginary accounts. However, in the present study, examination of 73 actual female homicide victims coupled with scrutiny of the largely impoverished police records available for each victim did yield some idea of the events preceding death. These data are now reported in tandem with a comparison between them and the imaginary accounts, which revealed the following divergences and convergencies.

In contrast to the dominant image in the imaginary accounts of a woman being raped and then killed while commuting, police data records the homicidal incidents in 86% of the actual cases as occurring at or in close proximity to the victims' homes. For over 50% of actual cases, the perpetrator was recorded as being someone intimately acquainted with or well known to the victim, while only 13 out of 45 (29%) of the imagined incidents depicted the aggressor as a spouse, lover or acquaintance.

A major disjunction was also seen with respect to the role of alcohol as a proximal cause of the events culminating in death. Of the 60 cases in the mortuary sample where BAC's were obtained, over 50% were elevated [5]. While this would lead one to expect alcohol being accorded a prominent role in imaginary accounts, this was not the case. Only a single respondent depicted her own consumption of alcohol as contributing to the generation of a homicidal context:

> It was the festive season and I was in a very happy mood, so I had gone down to the local shebeen (tavern) to enjoy myself and I had quite a lot to drink. I was sitting with this other guy who was my friend from another place. Then my boyfriend with whom I have a child, came there and didn't ask any questions. He assumed that it was my boyfriend that I was sitting with, so he grabbed me from there, he started hitting me with the handle of a pick axe, and then he damaged my brain and I died in hospital. (Respondent 19)

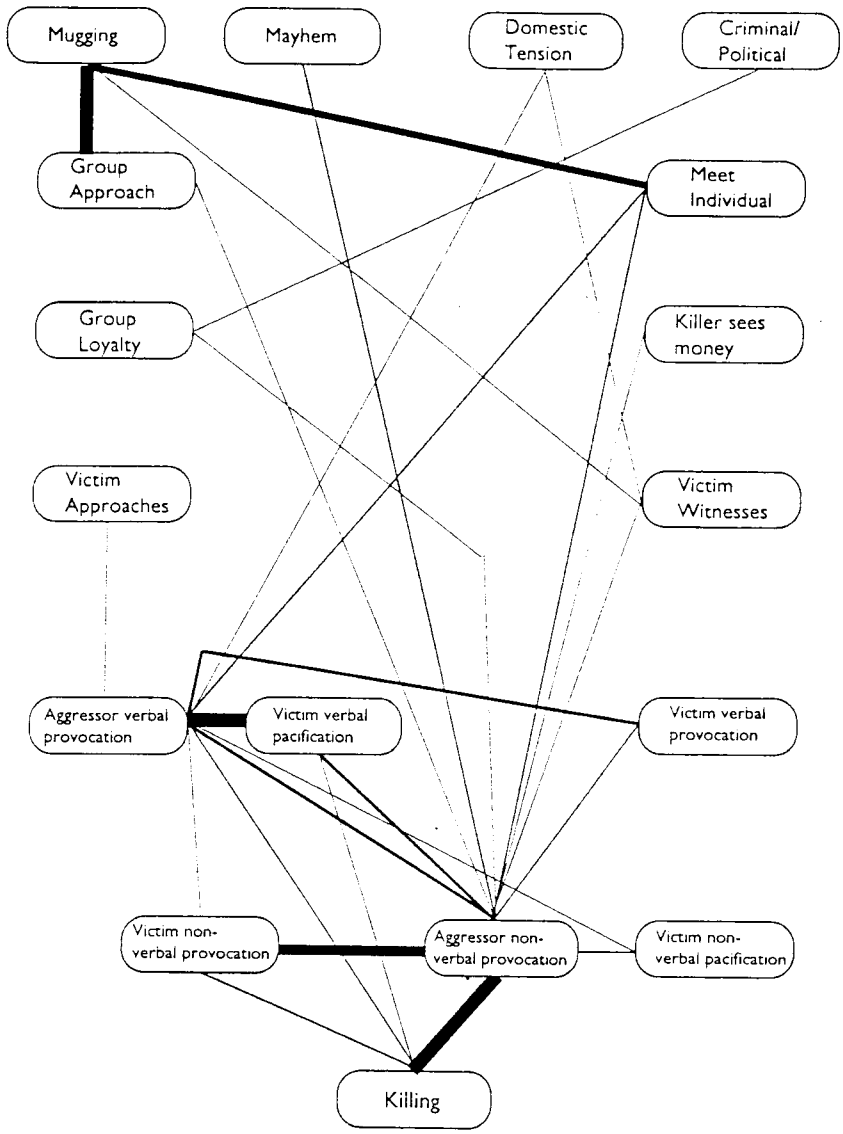

Fig. 1. Narrative signature, 45 accounts of imagined female homicide (line thickness corresponds to frequency of path occurrence).

A further two stories refer to the attacker's alcoholism, although in both cases he is depicted as sober at the time of the killing, while two more imaginary homicides occur after parties or visits to shebeens — contexts in which it must be assumed drinking takes place.

While the divergence between imagined and forensically reconstructed scenarios of female homicide outweighed points of agreement, there were three areas of convergence. The first concerned the violent interaction between aggressor and victim immediately preceding death, with the manhandling and physical abuse which was prominent in the imaginary accounts being mirrored in the forensic evidence, with

53% of the mortuary sample having multiple wounds on their bodies. The second concerned the rape of victims prior to death, with police data referring to this possibility in 18% of the mortuary sample, while rape and attempted rape was depicted in 20% of the imaginary accounts. The third relates to the type of force resulting in death, with both imaginary accounts and forensic records (Table 1) agreeing on the predominance of sharp force.

When these points of divergence and convergence are considered together, it is evident that the divergences cluster around the circumstance and personal actions that put a women at risk for entering a violent situation — place of injury, relationship with attacker and the role of alcohol. In contrast, the convergencies concern the physical abuse, possible rape, and use of sharp force that precede a killing — all concrete actions that unfold once a violent situation has been entered.

3.1.2 Limitations of this study

Interviewees were mostly employed commuters who may not represent the same sample base from which the actual homicides were drawn. Sampling bias of the actual interviewees was limited due to the high response rate, although it must be noted that the venue (a railway station) may have influenced the responses. However, commuter attack scenarios were equally prominent in a sample of imaginary accounts of non-fatal violence drawn from male and female residents of Soweto who were interviewed at home (Butchart and Terre Blanche, unpublished data). This suggests it is unlikely that the site of interview exerted a significant influence upon narrative content. Another limitation is that the attempt to contrast imaginary and actual incidents may be problematic in that it poses a question concerning a fatal attack to interviewees for whom non-fatal violence against women would be a more relevant issue.

It may, therefore, be appropriate in similar studies to vary the way in which the interviews are conducted. For instance, women who are first asked to talk about non-fatal violence may be more willing to countenance husbands and boyfriends in the role of perpetrators than those who are asked at the outset to imagine deadly violence. Further, asking respondents to imagine a violent incident involving 'a woman' as opposed to the respondent herself could reduce the level of psychological threat and defensiveness associated with talking about such dangers in the first person ('I'). However, this latter strategy is problematic, in so far as it invites the tendency to attribute risks to others but not to oneself, identified by Taylor and Brown [27] as one of the mechanisms by which people maintain a positive sense of psychological well-being.

The forensic data are based on police accounts which are often impoverished and possibly biased reflections of the circumstances surrounding a homicidal attack, and, as in the case of the imaginary narratives, concentrate exclusively on fatal violence. It is unlikely that many non-fatal attacks on women even come to the attention of the police in South Africa, and all law enforcement activities in this country should be viewed in the broader context of a 'culture of violence' [2].

3.1.3 Images and themes of fatal violence

Incidents of violence against women occur largely 'behind closed doors' [17] and

this invisibility is further increased by the complex psychological dynamics that trap battered women in a vicious circle of abuse and reconciliation [18]. This inaccessibility may force non-victims to base their beliefs and attitudes on indirect, vicarious experiences of interpersonal violence obtained through sources such as rumour, gossip and the media. If this is the source of the 'factual' aspects of the narratives, then it is likely that the backdrop would reflect the texture of township life, and the following section highlights some of the common themes relating to both imagined and real fatal violence against women.

3.2 Perpetrators and victims

Thirty six of the 45 interview respondents (80%) imagined themselves being killed by men. Most of these imaginary accounts did not reflect the reality that attacks against women are often carried out by members of family or intimate acquaintances, a victim-aggressor relationship closely paralleled in the developed world [9,19,20]. Of the seven who imagined that another woman might be the killer, five nevertheless accorded pivotal roles to men (boyfriends or husbands), who were presented as catalysts of sexual rivalry that culminated in killing. Respondent 31 succinctly captures the tenor of references to power and gender relationships characteristic of almost all the stories:

> If I had to think of being violently attacked, I would think of being violated by men. Maybe a situation of being physically violated, being raped and then killed afterwards.

3.3 Rape

The large number of stories involving rape suggests that female homicide is experienced as an element in a wider theme of gender related violence [10,11]. A rape — kill sequence concluded the story of seven respondents, as in the following examples:

> they raped me — after that they killed me (Respondent 14)
>
> He just came in, raped me and killed me' (Respondent 24)
>
> then he raped me and afterwards he killed me' (Respondent 38).

In other instances the rape and killing were described in greater detail but still occurred in quick succession, as in the following story:

> They took me to their house and tied me on the bed and raped me, exchanging me amongst themselves. When they were finished they shot me to death' (Respondent 47).

The immediate precursor to the homicide is not, of course, always presented as rape, but the weak position of women relative to men is emphasised in a variety of other ways. Sexual jealousy on the part of husbands or boyfriends accounted for four of the killings, while in other cases women imagined being killed simply as a consequence of being associated with husbands or lovers.

3.4 Victim precipitation

Another group of stories depicted scenarios where a man's temper was ignited by the victim saying the wrong thing, or by her refusal to respond to his verbal advances. These male attackers were presented as forcing themselves on women, or as bearing grudges for being rejected, and simultaneously believing, as did respondent 44's imaginary father, 'that he will never be told what to do by a woman'. The term 'victim precipitation' was created to describe a situation in which the victim was the first to use physical force during the fatal confrontation [21]. Large variations exist between the proportion of homicides in which victim precipitation is thought to play a role [21,22] and little information is available on the role of verbal provocation by the victim.

3.5 Types of violence

The method of fatal attack may reflect the types of violence that predominate in a particular society [5,19]. In the case of Cape Town, knives are the most commonly used weapons in violent attacks [5], although the increasing availability and use of firearms may result in higher mortality associated with family and intimate assault [23].

3.6 Alcohol

A clear association exists between alcohol consumption and interpersonal violence [24]. It can be hypothesised that the relative exclusion of alcohol consumption from the imaginary accounts expresses a reluctance to present oneself as given to drinking. This may be due to 'flawed' personal constructions of violence that blame the intoxicated victim [25], and the sociocultural complexities of alcohol use [26], which include the tendency of entertainment and advertising to romanticise the effects of alcohol and mask its negative associations [14].

3.7 Disempowerment and social enmeshment

Pervasive female disempowerment would appear to be modulated in its expression by regional and socioeconomic specifics. In this study these included entrapment in the endemic violence of poverty [11,12] as articulated by the expectation of eight women that they would be killed as consequence of being able to identify criminals. For example:

> The thing which caused them to kill me was because they saw that I could recognise one of them because I called his name (Respondent 16)

> When they saw that I had seen them, they just shot me (Respondent 31)

> When they came back they heard rumours that I was the one who told the police about them. (Respondent 41)

A further three women imagined that homicide might follow from being identified (albeit mistakenly in one instance) as criminals or associates of criminals:

> This person had been sent to kill someone, and when they are going on an assassination they killed the wrong person — me (Respondent 11)

> and they said it was me who sold her children out with the tsotsies (gangsters)' (Respondent 37)

> In the township there are rumours that my brothers are the ones who are killing people. (Respondent 42)

Other stories problematised identity by constructing scenarios where the attacker made a point of dragging personal information (such as name and destination) out of his victim, and overall the identity issue appears related to the ethos of revenge that pervaded many stories. Attackers, although perhaps nominally strangers, suddenly reveal themselves as bearing a grudge from some past incident or, alternatively, metamorphose from friends into killers when a past grudge is revealed.

4. Implications for prevention

4.1 Regulatory strategies

Regulatory strategies are most effective 'when the risk behaviours of many individuals have a common pathway through publicly controllable institutions' [14]. Violence against women occurs, for the most part, in domestic settings beyond the public eye and at the hands of known assailants [5,17], making it singularly unamenable to prevention through regulatory means.

There is no common pathway through the 'publicly controllable institutions' referred to by Jeffery [14] — except through post-hoc action, possibly of limited utility, such as the prosecution of perpetrators [9]. If killings were actually most likely to occur while women were commuting to or from work, as the majority of our sample imagined, improved security measures on trains and taxis, and in township streets, could have a major impact on female homicide (as it may well have for male homicide), but the privacy of the domestic setting renders it very difficult to regulate the behaviour of perpetrators.

Alcohol use can to a certain extent be regulated. The large number of informal taverns or 'shebeens' operating in South Africa's townships have increasingly joined into larger networks and, for the most part, obtain their liquor from central merchants, thus facilitating regulation through price control [28]. Further, control could be exerted over the commercial promotion of alcohol in an attempt to reduce the unrealistically positive light in which advertising portrays its use [14].

4.2 Educational strategies

Educational strategies work best when individuals expect substantial benefits at little personal cost from behaviour change [14]. From the point of view of an individ-

ual woman, the risk of homicidal death is small, while the personal cost of behaviour change to avoid the identified 'risk factors' (being at or near one's home, in the company of male friends or relatives, drinking) is impossibly high. There may, however, be some utility in alerting women to the fact that the real threat comes from men who are 'near and dear', rather than from faceless strangers in public places, and to point out that they may be at greater risk when drinking. Although avoiding these risks is, for the most part, impossible, greater vigilance in such situations could increase a woman's safety, an assumption that underlies educational programmes aimed at alerting female adolescents to the dangers of 'date rape' [29]. The tendency to generalise on the assumption that 'if it hasn't happened to me yet, it probably will not (happen to me) in the future' [30], could be highlighted in the area of abusive relationships which have not yet resulted in physical violence, and education programme to the precursors of violence such as the combination between alcohol and verbally provocative behaviour.

Whatever form educational interventions take, fine-grained information could alert women about how women think about the possibility of being killed can provide invaluable clues on how to structure preventive messages. Besides the factual information provided, this study indicated that violence, whether imaginary or real, has an element of 'process, narrative or choreography' as the fatal attack unfolds. This aspect is especially highlighted by the difference between perceptions and realities concerning the circumstances surrounding a fatal attack. The tensions between the imaginary and factual aspects, such as violence in intimate relationships, the role of alcohol and provocatory behaviour combined with the idea that violence is not an isolated event but a 'process', yielded a hypothetical foundation for an experimental violence prevention programme. A community-based dance-theatre company, Jazzart, was approached with the research material and asked to incorporate the salient features of both the imaginary and actual homicide data in a programme designed for presentation at various venues including factories, community centres and public areas [31,32]. The dance sequences depict both fictitious commuter scenarios commonly found in stories about female death and the interpersonal violence suggested by forensic evidence, embedding these within the wider context of poverty and oppression[3]. The success of the intervention in broadening audiences' repertoires for thinking about violence against women is currently being evaluated using both questionnaires and a methodology similar to that described in this paper.

5. Conclusion

Imaginary narratives of violent death produce an evocative portrait of a population at risk and exposes the violence of everyday life amongst the poor. The present study is limited by its use of only one method to collect and analyse individual women's perspectives and this exclusive focus on women, furthermore, provides a partial view of the problem, and risks blaming the victim, a situation distant from

[3]A videotape of the dance-theatre program, 'Women and Violence: Unclenching The Fist', may be obtained by writing to the authors.

the true determinants of violence against women [5,33]. It is also important to acknowledge that a different reading of the fictional accounts (such as from an explicitly feminist perspective) may well have revealed different and equally important common factors. The perceptions of men — both perpetrators and non-perpetrators — need to be articulated too. Only once a comprehensive picture is produced that merges population and individual perspectives drawn from potential victims and aggressors will it be possible to design fully comprehensive prevention strategies. Despite these limitations, the present study not only revealed some remarkable similarities and important disjunctions between perceptions and realities of female homicide, but also emphasised the preventive utility of interpreting epidemiological data in the light of the psychosocial milieu reflected in ordinary peoples' talk about violent death.

6. References

1 S.K. Stansfield and G.S. Smith, McGreevey, Injury. Forthcoming In D.T. Jamison, W.H. Mosley, J.L. Bobadilla and A.R. Measham (eds.), *Disease Control Priorities in Developing Countries*, Oxford University Press for the World Bank, New York, 1993.

2 S. Marks and N. Andersson, The epidemiology and culture of violence. In N.C. Manganyi and A. du Toit (eds.), *Political Violence and the Struggle in South Africa*, Southern Books, Halfway House, 1990, pp. 29–70.

3 D. Bradshaw, R.E. Dorrington and F. Sitas, The level of mortality in South Africa in 1985 — what does it tell us about health? *S. Afr. Med. J.*, 82 (1992) 237–240.

4 A. Butchart and D.S.O. Brown, Non-fatal injuries due to interpersonal violence in Johannesburg, Soweto: Incidence, determinants and consequences. *Forensic Sci. Int.*, 52 (1991) 35–51.

5 L.B. Lerer, Women, homicide and alcohol in Cape Town, South Africa. *Forensic Sci. Int.*, 53 (1992) 93–99.

6 J.R. Blau and P.M. Blau, The cost of inequality: Metropolitan structure and violent crime. *Am. Sociol. Rev.*, 47 (1982) 114–129.

7 H.A. Bulhan, *Frantz Fanon and the Psychology of Oppression*, Plenum Press, New York, 1985.

8 D. Yach and J. Seager, *Urbanisation and Health in South Africa: The Medical Research Council's Experience* (Medical Research Council report to the President's Council), Medical Research Council, Cape Town, 1991.

9 A. Goetting, Female victims of homicide: A portrait of their killers and the circumstances of their deaths. *Violence Victims*, 6 (1991) 159–168.

10 Council on Scientific Affairs, Violence against women. *J. Am. Med. Assoc.*, 267 (1992) 3184–3189.

11 J.A. Grisso, A.R. Wishner, D.F. Schwarz, B.A. Weene, J.H. Holmes and R.L. Sutton, A population based study of injuries in inner city women. *Am. J. Epidemiol.*, 134 (1991) 59–68.

12 A.R. Wishner, D.F. Schwarz, J.A. Grisso, J.H. Holmes and R.L. Sutton, Interpersonal Violence Related Injuries in an African-American Community in Philadelphia. *Am. J. Public Health*, 81 (1991) 1474–1476.

13 L.E. Saltzman, J.A. Mercy, M.L. Rosenberg, W.R. Elsea, G. Napper, N.K. Sikes, R.J. Waxweiler and the Collaborative Working Group for the Study of Family and Intimate Assaults in Atlanta. Magnitude and pattern of family and intimate assault in Atlanta, Georgia, 1984. *Violence Victims*, 5 (1990) 3–17.

14 R.W. Jeffery, Risk behaviours and health: Constrasting individual and population perspectives. *Am. Psychol.*, 44 (1989) 1194–1202.

15 J. Potter and M. Wetherell, *Discourse and Social Psychology: Beyond Attitudes and Behaviour*, Sage, London, 1987.

16 N. Loraux, *Tragic Ways of Killing a Woman*, Harvard University Press, Cambridge, MA, 1987, p. 9.

17 N. Avni, Battered Wives: The home as a total institution. *Violence Victims*, 6 (1991) 137–149.

18 Z. Dangor, Women and violence in our time. *Azanian Labour J.*, 4 (1992) 19–24.

19 A.L. Kellerman and J.A. Mercy, Men, women and murder: gender specific differences in rates of fatal violence and victimisation. *J. Trauma*, 33 (1992) 1–5.
20 J.L. Thomsen, S.B. Albrektsen, O. Aalund, V.B. Beiting, L. Dainelsen, K. Helweg-Larsen, J. Jacobsen, H. Kjaerulff and H. Staugaard, Injuries due to deliberate violence in areas of Denmark. II. Victims of homicide in the Copenhagen areas. *Forensic Sci. Int.*, 40 (1989) 291–297.
21 M.E. Wolfgang, *Patterns in Criminal Homicide*, University of Pennsylvania, Philadelphia, 1958, pp. 252–254.
22 L.A. Curtis, *Criminal Violence*, Lexington Books, Lexington, MA, 1964.
23 L.E. Saltzman, J.A. Mercy, P.W. O'Carroll, M.Z. Rosenberg and P.H. Rhodes, Weapon involvement and injury outcomes in family and intimate assault. *J. Am. Med. Assoc.*, 267 (1992) 3043–3047.
24 J.J. Collins, *Drinking and Crime: Perspectives on the Relationships between Alcohol and Criminal Behaviour*, Guilford Press, New York, 1981.
25 B. Aramburu and B. Critchlow Leigh, For better or worse: Attributions about drunken aggression towards male and female victims. *Violence Victims*, 6 (1991) 31–41.
26 Alcohol and Violence (Editorial). *Lancet*, 336 (1990) 1223–1224.
27 S.E. Taylor and J.D. Brown, Illusion and well-being: A social psychological perspective on mental health. *Psychol. Bull.*, 103 (1988) 193–210.
28 D. Levy and N. Sheflin, New evidence on controlling alcohol use through price. *J. Stud. Alcohol*, 44 (1983) 929–937.
29 G. Marie, Breaking the silence, destroying the lies: An educational programme on violence against women. *Stud. Contin. Educ.*, 7 (1989) 337–355.
30 N.D. Weinstein, Unrealistic optimism about illness susceptibility: Conclusions from a community-wide sample. *J. Behav. Med.*, 10 (1987) 481–500.
31 G. Davis, "Unclenching the Fist": Jazzart Dance Theatre. *Speak*, 46 (1992) 5–7.
32 C. Terre Blanche, Intervening with dance. *Vrye Weekblad*, 178 (1992) 35.
33 L. Walker, *The Battered Woman*, Harper and Row, San Francisco, 1979.

A PROPOSAL FOR AN INJURY SURVEILLANCE SYSTEM IN SOUTH AFRICA.

Little doubt exists that injury is a disease requiring urgent attention, both in the industrialised and developing world. Worldwide, injury ranks fifth amongst the leading causes of death and there is a growing body of literature on injury as vital public health issue [1,2]. Prior to examining the broader issues surrounding its surveillance, it is important to know what injury is. An injury is physical damage to the body resulting mainly from exposure to various forms of energy. The term "injury" is often used interchangeably with the term "trauma". Unintentional injuries are sometimes referred to as "accidents", although it is felt that this term should be avoided as it leads people to believe that injuries are merely random unfortunate events[3]. Intentional injuries are mainly related to homicide, suicide, interpersonal or intergroup violence, sexual assault, torture or genocide.

Very little is known about the incidence and causes of injury in developing countries[1]. In South Africa, the poor quality and inadequacy of local mortality statistics have been described in a number of studies[4-6], and whilst these studies did not specifically concentrate on injury deaths, there is more than sufficient evidence that injury is a major cause of mortality in children[7], adolescents[8] and adults[5,9]. In fact, trauma was the leading cause of death for the majority of South Africans between the ages of 5 and 64 years in 1988[9].

What is injury surveillance?

It is necessary to obtain data on injury in order to plan, implement and evaluate public health interventions in this field - this in the principle of injury surveillance[10]. An injury surveillance system is usually a government or privately maintained system that continually or periodically collects data on injuries in order to measure trends, detect clusters and identify factors related to injury[11]. Such a system should be sustainable over a long period in order to monitor the results of any interventions and ensure that information is available in order to facilitate timeous changes in policy.

The uses of injury surveillance include:

a) Observing changes in demographic and injury patterns

Trends in the epidemiology of injury in less developed countries have resulted in interest in the role of economic development in injury. Countries may move from a disease pattern dominated by infectious diseases to one characterised by noncommunicable conditions, such as heart disease, cancer and injury[12]. Rapid urbanisation has extensive health consequences[13] and it is often vital to develop innovative epidemiological methods to measure health status in areas of growing informal settlement. One such method is sentinel surveillance, a part of the Rapid Epidemiologic Assessment (REA) methodology to evaluate health status and the delivery of health care, mainly in the developing world[14]. It is based on the principle of collecting good quality data using innovative techniques that require minimal resources and allow for rapid and simple analysis.

b) Resource allocation decisions

Decisions often have to be made, with minimal information, in areas such as expenditure on emergency medical services, trauma units, rehabilitation and prevention. The strengthening of epidemiological surveillance is one of the first steps in ensuring that developing countries move in the direction of appropriate regulatory and promotive strategies to improve health[15].

c) Recognition of remediable disparities in health status

We know very little about injury in the developing world and even less about those groups at risk of such injury[1]. Injury is an important women's health issue as high levels of non-fatal injury occur due to both domestic 'accidents'[16] and interpersonal violence[17]. The utility of injury surveillance in the field of domestic violence may lie in the fact that many cases requiring hospital treatment are not reported to the police and, therefore, this problem may escape attention in official crime statistics. Certain groups, such as workers, are exposed to substantial risk of injury and are generally under-observed by health services; hence it is important to highlight occupational and agricultural injuries through the use of surveillance systems. An example of this problem is in the under-reporting of fatal occupational injuries[18], due to the lack of a unified occupational safety investigation and compensation authority. In the rural areas, although it is a notifiable condition, agrichemical poisoning is under-reported and a lack of information hampers the improvement of the health status of farm workers[19]. Even in the developed world, existing documentary sources for injuries related to agricultural work are poor and innovative multiple site surveillance methods are required[20].

Prevention orientated injury surveillance

The public health strategy designed to reduce the impact of injury on a society is called injury prevention and control. A major part of this strategy is the introduction of surveillance systems which are designed to promote and monitor injury prevention[3]. Injury prevention often involves the use of regulatory strategies. These strategies are most effective when "risk behaviour of many individuals have a common pathway through publicly controllable institutions"[21]. Areas such as alcohol and driving or seat belt use involve substantial law enforcement activity and surveillance systems are required to monitor the effectiveness of a wide range of interventions. The beneficial effects of the introduction of restrictive gun control legislation in the District of Columbia were demonstrated using time series data available for a substantial period[22]. An area which has received little attention in South Africa is that of injury control through passive protection or the modification of hazardous environments (primary prevention). Interventions such as the installation of street lighting and fencing of highways to reduce fatal pedestrian injuries, or the electrification of homes in informal settlement areas require evaluation. Educational strategies, such as media campaigns by the National Peace Secretariat, require surveillance based monitoring as do the deleterious consequences of alcohol advertising and violence in the media.

INJURY SURVEILLANCE IN SOUTH AFRICA

In South Africa, injury data is collected by a variety of organisations, including the police, local authorities and their various departments such as ambulance, traffic and fire services, the Workmen's Compensation Commissioner, Central Statistical Services and hospital

discharge summaries, but little effort is made to combine, compare or report these records. South Africa may have many of the sources of injury information available in the developed world, but in the absence of an integrated injury surveillance system, these sources cannot be utilised fully.

Data concerning deaths due to injury form a key element of injury surveillance. Prior to the introduction of the new Births and Deaths Registration Act (1992)[23], details of injury deaths could be obtained from the vital statistics collected by local authorities or the Central Statistical Services. Since the introduction of the new Act, the detailed cause of death is not required in the case of External Causes and hence the vital statistics will not reflect this information.

A proposed Injury Surveillance Strategy for South Africa

The need exists for a South African national sentinel surveillance network in order to ameliorate the paucity of morbidity and mortality statistics and provide information in order to allocate health resources[25,26]. This priority was recognised by Gear in 1937 who called for an effective national 'vital statistics' system[27]. A proposal for a sentinel surveillance network in South Africa is based on the establishment of specific sites from which reliable data will be collected. It is hoped that these sites will be representative of the spectrum of ill-health in the country. Injuries certainly fall within the definition of sentinel health events, as they are unnecessary and result in untimely death[28].

In order to introduce a pilot injury surveillance system in South Africa, it is important to start with a critical review of available data sources with recommendations on how they could be improved and the identification of priority areas[1]. This has been proposed by

the WHO as a primary area of injury research[24].

We suggest the formation of a national working group on injury surveillance which would attempt to joint together all parties involved in the collection of injury related data, such as the police, National Road Safety Council, the CSS, government departments and public health scientists in a coalition to create a reliable and permanent national injury database.

In the area of non-fatal injury, trauma registries could be established at the proposed sentinel surveillance hospitals. A trauma registry would provide demographic, injury type and severity information on all injury admissions. Ideally, such systems would be based on the existing experience in the field, which would include the use of personal computers and coding software which are now freely available and could, at a later stage, be expanded on a regional basis[29]. Injuries could be coded using the International Classification of Diseases E-Codes by nursing or clerical staff following a short period of training, as this method appears to be relatively easy and requires few extra resources[30]. The advantages of establishing a hospital based trauma registry include the ready availability of information for both audit of emergency care and resource allocation decisions. The easy availability of data facilitates further research using a wide variety of methods, such as case-control studies or projects using qualitative methodologies.

Injury mortality surveillance should be conducted in both the proposed sentinel sites and within the large metropolitan areas of South Africa. Since all injury deaths are subjected to medico-legal post-mortem examination, the various State Mortuaries constitute an ideal site for the installation of long-term surveillance systems similar to the trauma registries proposed for non-fatal injury surveillance. Larger

cities have academic Forensic Medicine departments and it may be possible for these departments to be involved in producing detailed annual reports on injury mortality which could have far-reaching implications in decisions relating to the allocation of resources for injury prevention.

Finally, injury must be included in future health and demographic surveys and given a higher level of priority in existing health information systems.

Conclusion

Despite having a sophisticated economy and infrastructure, South Africa falls far behind many countries far less developed than itself in the area of providing accurate and timeous information on the health status of its population. This fact has negative implications in areas such as health care resource allocation and the obtaining of international development aid. An urgent need exists for remedial action and this must include innovative methods such as sentinel surveillance. The measuring of mortality and morbidity, whether due to injury or illness, should be regarded as a national priority vital to the health of every South African.

[This paper was produced in collaboration with Dr D Bradshaw of the Medical Research Council].

REFERENCES:

1. Smith GS, Barss P. Unintentional injuries in developing countries: The epidemiology of a neglected problem. Epidemiologic Reviews 1991;13:228-266.

2. Stansfield SK, Smith GS, McGreevey W. Health Sectors Priority Review: Injury. In: Jamison DT, Mosley WH, editors. Disease control priorities in developing countries. New York: Oxford University Press for the World Bank, 1993.

3. Robertson LS. Injury Epidemiology. New York: Oxford University Press, 1992.

4. Botha JL, Bradshaw D. African vital statistics - a black hole? S Afr Med J 1985;67:977-981.

5. Kielkowski D, Steinberg M, Barron PN. Life after death - mortality statistics and the public health. S Afr Med J 1989;76:672-675.

6. Van der Merwe S, Yach D, Metcalf C. Peering into the black hole - the quality of black mortality data in Port Elizabeth and the rest of South Africa. S Afr Med J 1990;79:419-422.

7. Kibel SM, Joubert G, Bradshaw D. Injury related mortality in South African children, 1981-1985. S Afr Med J 1990;78:398-403.

8. Flisher AJ, Joubert G, Yach D. Mortality from external causes in South African adolescents, 1984-1986. S Afr Med J 1992;81:77-80.

9. Bradshaw D, Dorrington RE, Sitas F. The level of mortality in South Africa in 1985 - what does it tell us about health? S Afr Med J 1992;82: 237-240.

10. Klaucke DN, Buehler JW, Thacker SB, et al. Guidelines for evaluating surveillance systems. MMWR 1988;37:1-18.

11. Graitcer PL. Injury surveillance in developing countries. MMWR Surveillance Summaries 1992;41:15-20.

12. Omram AR. The epidemiologic transition: A theory of the epidemiology of population change. Millbank Memorial Fund Quarterly 1971;49:509-538.

13. Yach D, Seager J. Urbanisation and health in South Africa: The Medical Research Council's Experience. Medical Research Council Report to the President's Council. Cape Town: Medical Research Council, 1991.

14. Smith GS. Development of rapid epidemiologic assessment methods to evaluate health status and delivery of health services. Int J Epidemiol 1989;(Suppl 2):S2-S15.

15. Jamison DT, Mosley WH. Disease control priorities in developing countries: Health policy responses to epidemiological change. Am J Public Health 1991;81:15-22.

16. Gordon JE, Gulati PV, Wyon J. Traumatic accidents in rural tropical regions: An epidemiological field study in Punjab, India. Am J Med Sci 1962;243:158-178.

17. Butchart A, Brown DSO. Non-fatal injuries due to interpersonal violence in Johannesburg, Soweto: Incidence, determinants and consequences. Forensic Sci Int 1991;52:35-51.

18. Lerer LB, Myers JE. The application of two documentary sources for the identification of fatal occupational injuries. Am J Industrial Medicine 1994;26:00-00.

19. Myers JE. Occupational health of farm workers. S Afr Med J 1990;78:562-563.

20. Gunderson P, Gerberich S, Gibson R, et al. Injury surveillance in agriculture. Am J Ind Med 1990;18:169-178.

21. Jeffery RW. Risk behaviours and health: contrasting individual and population perspectives. American Psychologist 1989;44:1194-1202.

22. Loftin C, McDowall D, Wiersma B, Cottey TJ. Effects of restrictive licensing of handguns on homicide and suicide in the district of Columbia. N Engl J Med 1991;325:1615-1620.

23. Republic of South Africa. Births and Deaths Registration Act (1992).

24. World Health Organisation. Research development for accident and injury prevention. Geneva: World Health Organisation, IPR/APR 216 M31I 8923E, 1989.

25. Sitas F, Zwarenstein M, Yach D, Bradshaw D. A national sentinel surveillance network for the measurement of ill-health in South Africa: A prerequisite for epidemiological research and health planning. S Afr Med J 1993;84:91-94.

26. Henry J Kaiser Family Foundation. Changing Health in South Africa - Towards new perspectives in research. Menlo Park, California, 1991.

27. Gear HS. A plea for improved South African medical and vital statistics. S Afr Med J 1937:149-154.

28. Rutstein DD, Bernberg W, Chalmers TC, et al. Measuring the quality of medical care. A clinical method. N Engl J Med 1976;294:582-588.

29. Gillot AR, Thomas JM, Forrester C. Development of a statewide trauma registry. J Trauma 1989;29:1667-1672.

30. Ribbeck BM, Runge JW, Thomason MH, Baker JW. Injury surveillance: A method for recording E-codes for injured emergency department patients. Ann Emerg Med 1992;21:37-40.