9 Childhood burn injury: Epidemiological, management and emerging injury prevention studies

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Reports have indicated that burn injuries are dangerous and often result in fatalities among young children in low-income contexts. Burn injuries in childhood are often severe events resulting in painful long-term effects. Apart from causing death, thermal injuries may cause disabling scars not only to the skin or body of the child, but also to her or his psyche. Psychological, educational and social adjustment to the injury and its physical consequences may be complicated by a range of factors, including the site of the injury, and the child's personality and social relationships. In terms of economic impact, the younger the child at the point of injury, the greater the loss in productive years. In low- and middle-income countries these problems are likely to be exacerbated by the unavailability of specialised staff and medical technologies (Barss, Smith, Baker & Mohan, 1998).

In the last decade a steady stream of medical, epidemiological and psychological research on childhood injuries in South Africa has emerged. These studies all indicate that burns are an important cause of mortality, injury, disability and psychosocial trauma in young children, especially those aged between one and five years. In this chapter we report in more detail on this recent research, providing:

a) An outline of the emerging prominence of childhood burn injury as a priority global, African and South African public health threat;

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b) Core definitions of childhood burn injury that inform research and injury prevention interventions in South Africa;
c) A review of recent epidemiological studies on injury distribution, the affected populations, and determinants;
d) A review of current educational, infrastructural, product and legislative interventions; and
e) Recommendations for future epidemiological and injury prevention interventions.

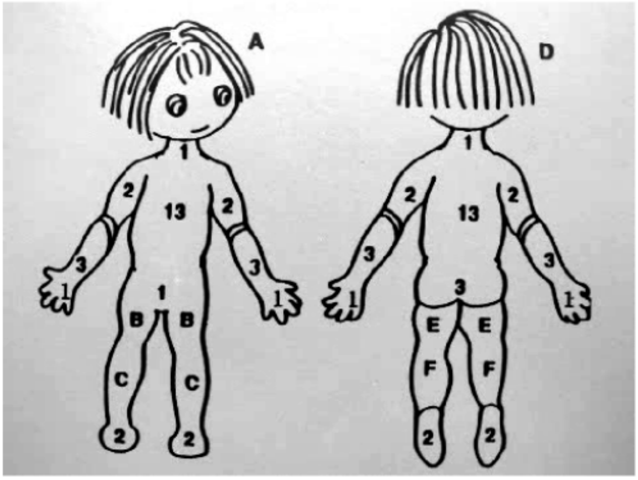
A GLOBAL AND NATIONAL CHILD HEALTH PRIORITY

The majority of burn deaths due to fires, scalds, chemicals and electricity occur in low- to middle-income countries. Burns fatalities and injuries affect mainly children and the elderly. Burns are the leading cause of the global burden of disease and injury (based on deaths and disability) among children aged between 5 and 14 years (World Health Organisation [WHO], 2003). Most burn injuries occur in and around the home, particularly among children and women. Remarkable differences in burn outcomes can be observed between high-income and low- or middle-income countries. This is probably related to differences in the provision of adequate burn care in severe cases and the resulting sequelae (WHO, 2003).

In South Africa burn injuries due to scalding, open flames and other causes constitute one of the leading causes of non-natural death in children aged 14 years and younger (Burrows, Bowman, Matzopoulos & Van Niekerk, 2001). The increasing epidemiological recognition of childhood burn injuries in South Africa (Burrows *et al.*, 2001; Godwin, Hudson & Bloch, 1996; Hudson & Duminy, 1995; Kibel, Bass & Cywes, 1990; Peden, 1997; Zwi *et al.*, 1995) indicates that burn injuries are a leading cause of injury in young children, especially those aged between one and five years. These recent studies have indicated that the majority of injuries are due to scalding, with some variation depending on urban or rural location. These injuries often result from hot fluids from kettles, pots and baths (Child Accident Prevention Foundation of Southern Africa [CAPFSA], 1999). A further significant proportion of injuries are due to open flames. In South Africa flame injuries are reported to be especially dangerous, and result in more severe injuries and fatalities (Burrows *et al.*, 2001; CAPFSA, 1999). Childhood burn injuries usually occur in the late afternoons, often after school hours, and in the evenings. The majority of these injuries occur to male children, to their heads, necks and upper bodies (Burrows *et al.*, 2001; CAPFSA, 1999).

DEFINITIONS AND CLASSIFICATION SYSTEMS

A burn or thermal injury occurs when some or all of the different layers of cells in the skin are destroyed by hot liquid (scalds), a hot solid (contact burns), or a flame (flame burns). Injuries due to electricity, chemicals, ultraviolet radiation and radioactivity, as well as respiratory damage due to smoke inhalation are also defined as burn or thermal injuries (WHO, 2003).



Age (years)		0	1	5	10	15
		Total body surface area %				
A/D head	10	9	7	6	5	
B/E thigh	3	3	4	5	5	
C/F leg		2	3	3	3	3

Source: Rode, Millar, Van der Riet & Cywes (1989)

Figure 1. Total body surface area (%) according to age

The international and South African public health sector has tended to focus on the demographic profiles, physiopathological sequelae and increasingly in recent years, on the prevention aspects of moderate to severe burn injuries. In general, these injuries are classified according to two major factors that influence management and prognosis: the extent of the injury, and the depth of the burn. The extent of the injury is expressed as a percentage of the total body surface area (TBSA), which is calculated according to the injured individual's age (see Figure 1).

Figure 2. Partial-thickness injury burn

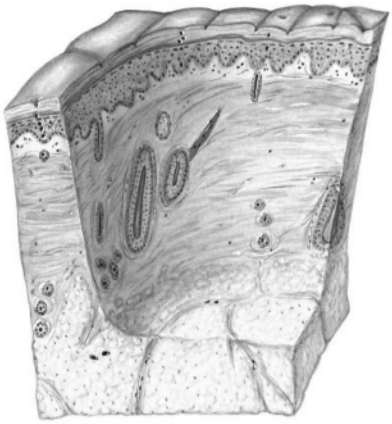


Figure 3. Full-thickness injury burn

The depth of the burn is expressed either as a partial-thickness or full-thickness injury. Partial-thickness burns involve the epidermis and may extend into the dermis. They are red, wet, soft, and pliable, with blisters. Sensation is usually present, making them extremely painful. Full-thickness burns involve the epidermis, dermis, and all the deep dermal elements, such as the nerve endings, sweat glands and hair follicles. They appear brown, grey, or white, are firm and without blisters or sensation (see Figures 2 and 3). In practice, most burns are a combination of both types (Rode, Millar, Van der Riet & Cywes, 1989).

For the purpose of referral, burns are classified as minor, or moderate to severe. Minor burns are partial-thickness injuries of less than 10% of the TBSA, in a child older than a year. Moderate-severe burns are partial-thickness burns of greater than

10% of the TBSA, full- thickness burns of greater than 3% of the TBSA, all burns involving the hands, feet, face, eyes, ears, and perineum, all inhalation injuries, circumferential injuries, electrical injuries, neonatal burns, or those affecting children with serious pre-existing illness. Special attention should always be provided for burns occurring on the face, hands and perineum. Burns in these areas are often referred to as "special burns", since the management of these takes priority over other burns. Mismanagement of these burns can interfere greatly with the physical and psychological functioning of the injured child (Rode *et al*., 1989).

SOUTH AFRICAN BURN RESEARCH

Recent South African research has tended to focus on the clinical profile and management of burn injuries, initial descriptions of the epidemiology of burn injuries, (among some adults, but mostly among children), and preliminary discussions around injury prevention (for example, Burrows *et al*., 2001; Du Toit, 1999; Goodwin & Wood, 1998; Hudson & Duminy, 1995; Kibel, Bass & Cywes, 1990; Peden, 1997; Rode, Millar, Le, Van der Riet & Cywes, 1989). Despite the increasing scientific interest in these injuries, there remains a dearth of systematic national epidemiological information, considered vital for the development of prevention interventions. Recent research in the sector has taken two approaches, namely: (a) the exploration of diagnostic and management protocols, with the aim of reducing long-term morbidity and mortality; and (b) the exploration of public health schemes, with the aim of reducing the incidence and risks of thermal injury.

Burn injury diagnosis, management and mortality reduction

Mortality in serious thermal injury in children is predominantly determined by the TBSA burned and often-unrecognised inhalation injury. A number of recent Southern African studies have examined diagnostic efficacy and the relationship to mortality or hospitalisation times. Whitelock-Jones, Bass, Millar and Rode (1999) undertook a retrospective review of thermal injuries over a 10-year period to examine more fully the impact of inhalation injury. They found the incidence of inhalation injury to be around 2.2%, although they conceded that this was probably an underestimation caused by the low pick-up rates among clinicians. Inhalation injuries were most likely to occur following fire burns, and were uncommon in scalds or steam inhalation due to the swallowing reflex and the rapid dissolution of heat by the hypopharynx. Delay in diagnosis was a common feature, especially in scald injuries when inhalation injury was not anticipated. The most reliable clinical signs were stridor and respiratory distress, and it was stated that there should be a low threshold to performing a diagnostic endoscopy on the day of admission. Of 4451 children included in the study, there was 1.8% mortality overall, but nearly 50% mortality in the subset of children identified with inhalation injury. The conclusions of the study stated that inhalation burns were often not recognised, could present late and usually had significant consequences. It is postulated that earlier clinical diagnosis, supported by endoscopic findings, would improve mortality rates.

A widespread study on the factors contributing to mortality rates after admission was recently undertaken in Zimbabwe (Muguti & Mazabane, 1997). Between January 1990 and December 1993, 49 patients died from burns at Mpilo Central Hospital. The main factors contributing to death were septicaemia, pneumonia and acute renal failure. The study concludes that the key to survival for burns patients is early presentation and active resuscitation, followed by the successful management of complications. Despite this, some patients with severe burns will die regardless of optimal management.

A general review of paediatric burns in a rural South African hospital found that a delay in presentation was associated with a longer length of hospital stay (Chopra, Kettle, Wilkinson & Stirling, 1997). The average time from sustaining the injury to presentation was 42 hours. Children presenting within 24 hours had a mean length of stay of 12.8 days, while those presenting after 24 hours had a mean length of stay of 25.2 days. Delay in presentation has been attributed to several reasons, including self-treatment at home, consultation with traditional healers and transport costs (Chopra *et al.*, 1997).

Public health interventions: Identifying the nature, extent and scope of the problem

In South Africa a number of public health studies have reported on the occurrence of burn injuries among children nationally (Bradshaw, Schneider, Laubscher & Nojilana, 2002; Burrows *et al.*, 2001), and in specific communities in Gauteng and the Western Cape (Peden, 1997; Zwi *et al.*, 1995). Since 1999 the National Injury Mortality Surveillance System (NIMSS) has produced information on injury fatalities. The NIMSS constitutes the beginnings of what is hoped will become a national mortuary-based system. In 2001 NIMSS recorded the details of 18 876 non-natural deaths (approximately 24% of the estimated 80 000 fatal injuries nationwide). Of these, 806 deaths were due to burns, of which 122 occurred in children younger than 14 years. Burns were the leading cause of non-natural death in infants and children younger than 5 years, and the fourth major cause in children aged 5 to 9 years (Burrows *et al.*, 2001). The database is non-representative and still relatively small. Consequently, it does not allow for extrapolations to the national population.

The Red Cross War Memorial Children's Hospital located in Cape Town has also registered moderately to severely burned children since 1992. Between 1992 and 2001 a total of 7241 patients presented with burns, of which 72.1% were fluid burns and 11.7% flame burns. Of 54 unconscious patients, 44.4% had flame burns (Du Toit, Dragosavac, Van As & Rode, 2001). Fluid burns are often due to hot fluid from kettles, baths, pots and hot tea and coffee. Flame burns are a particular problem in informal settlements, where house fires begin easily with the drop of a match or candle, and spread quickly, destroying many homes (CAPFSA, 2001).

The vast majority of burns occur in the home of the patient. Burn injuries also largely occur in the late afternoon and evenings, perhaps once children are home from school, and when there are more activities and distractions around the home (CAPFSA, 2001). In addition, most children suffer head and neck and upper-body burns as their primary cause of injury. This could be related to their small size and the cause of the burn. When examined in the context of most burns being caused by hot liquids, this is consistent with children pulling on kettle cords, pot handles, and tablecloths, all of which could lead to burns on the head, neck, and upper body (CAPFSA, 2001). The NIMSS and CAPFSA findings are supported by a number of earlier studies (Peden, 1997; Zwi *et al.*, 1995).

Childhood burn injury risk factors

Despite the increasing epidemiological attention to the South African occurrence of burn injury, there remains a scarcity of controlled empirical studies identifying the mechanisms underlying the occurrence of these injuries. The available South African burn injury studies have tended to examine the associations between burn injuries and sociodemographic variables, such as age, gender, and geographical location. Less attention, if any, has been directed towards the impact of the more transient and modifiable individual, household, familial, and neighbourhood factors and circumstances. It is assumed that the absence of comprehensive burn risk research has limited the impact of burn injury prevention and control initiatives. In order to facilitate the development of effective injury prevention and control interventions, it is therefore proposed that the epidemiological work on burn injuries utilises information about both permanent and transient risk factors (Roberts, 2000; Rossi *et al.*, 1998).

Although the need for such research is generally accepted, globally very few if any empirically controlled burn injury risk studies had been identified prior to 1989 (Van Rijn, Bouter & Meertens, 1989). A handful of more rigorous studies have emerged in recent years, particularly in Ghana (for example, Forjuoh, Guyer & Smith, 1995; Furjuoh, Guyer, Strobino, Keyl, Diener-West & Smith, 1995), Nigeria (Iregbulem & Nnabuko, 1993), Bangladesh (Daisy, Mostaque, Bari, Khan, Karim & Quamruzzaman, 2001), Greece (Petridou *et al.*, 1998), Brazil (Delgado *et al.*, 2002; Werneck & Reichenheim, 1997), and the Netherlands (van Rijn *et al.*, 1989).

This emerging international body of burn injury risk studies largely recognises that a complex interaction between individual, social, environmental, and injury-inducing agent factors may contribute to the occurrence of burn injuries. Factors related to childhood burn injury include age, gender, pre-existing physical impairments, poor living conditions, overcrowding, and maternal illiteracy or educational level. A number of other factors have generated either less or conflicting support from the limited epidemiological research. These include activity levels, parity, and history of burns in siblings. Much less is known about the contribution of environmental conditions, home construction, the use of various fuels for heating and cooking, and the use of various heating and cooking appliances. Information on these and other risk factors are argued to be critical for the development of environmental and product-related interventions. However, as indicated by others in the sector, scientific conclusions about risk factors can only be drawn if the presence of these factors in persons with injuries is compared with that in persons from a control group without burns (Van Rijn *et al.*, 1989). Few such studies had been identified prior to 1989 (Van Rijn *et al.*, 1989), with none before or since from South Africa.

PREVENTION INTERVENTIONS

Systematic and rigorously collected epidemiological data on burn injury incidence, patterns, causes, medical care and costs are necessary for the design of effective prevention and advocacy programmes (Liao & Rossignol, 2000). Burn prevention programmes have been implemented and evaluated in America, Australasia, India and Europe, and have demonstrated significant reductions in burn morbidity and mortality (Liao & Rossignol, 2000). Passive measures, protecting the public through product modification, environmental redesign or control and legislation, have generally been more effective in preventing burn injuries than have active measures that require persistent, long-term behavioural or lifestyle change (Linares & Linares, 1990). Many of the more effective international burn prevention programmes have been multi-pronged, including both active and passive measures, and have incorporated one or more of three main strategies. These are education, which is primarily an active measure requiring behavioural or lifestyle change, product design or environmental modification, and the enforcement and regulation of legislation, the latter being primarily passive measures. These strategies and their overall contributions to burn injury prevention are briefly described.

Environmental and product modifications

Environmental and product modification strategies include the design of products or environmental changes that reduce the potential for burn injuries and death. Passive strategies directed at the home environment, such as smoke detectors, reducing water temperature, fire-safe cigarettes and reduced flammability of clothing products, have all received significant support in the international literature (Liao & Rossignol, 2000). Other potential interventions that may be significant in the South African context include the development of safe housing and safe housing standards, firebreaks between informal housing, access to water in informal settlements, and fireguards. The electrification of houses, undoubtedly, will also have some impact on the reduction of fire- related burns.

Education

There is little evidence that interventions based solely on educational strategies can prevent burns. Often vulnerable groups, such as the very young, are difficult to reach with educational messages, or are less able to adopt safe practices, even if they are exposed to educational messages (McLoughlin, 1995). Publicity campaigns, teaching, children's television programmes, and other educational strategies may have a short-term impact, but this is unlikely to be sustained without repetition (Liao & Rossignol, 2000). Older children may be more amenable to school education programmes, although inclusion of prevention materials in the school curriculum may on its own not be sufficient for burn reduction. Successful educational interventions, typically the more focused ones, have had some success in lowering burn incidents and their severity. Successful interventions have been developed around "stop, drop and roll", "apply cool water to burn injury", and "crawl low under smoke" messages (Liao & Rossignol, 2000).

An important target group for educational strategies are also those who are responsible for policies relating to our physical, social and economic environment. Traditionally, education in the injury prevention field has been utilised in an excessively narrow way (Towner, 1995). Critics of the effectiveness of this approach have proposed a focus that still concentrates on changing individual decision-making, but uses prevention education to encompass a broader range of recipients, including professionals, practitioners, policy-makers and the targeted children and families themselves. This type of education also shapes a local safety culture by developing the pro-safety beliefs and attitudes of the general public, which in turn, may stimulate governments to act.

Legislation and enforcement

The implementation and enforcement of regulations can be used to reinforce safe practices. Regulatory interventions include legislation controlling clothing and cigarette flammability, stove design, lowering tap water thermostat settings and others. In an Australian study over a 25-year period a legislative approach is reported to have resulted in a substantial decline in burn admissions (Streeton & Nolan, 1997). The reduction was primarily attributed to mandating and enforcing legislative standards for sleepwear and water-heating devices. Supplementary public burn prevention education campaigns, especially those directed towards the control of hot water and flame burns among young children, were also reported to contribute to this success (Streeton & Nolan, 1997).

Towards good practices

So what are we doing? In South Africa there is minimal documentation of burn prevention initiatives and even fewer systematic evaluations of successful prevention interventions. Some South African organisations such as CAPFSA, the Paraffin Safety Association of South Africa (PASASA), some local municipalities, hospitals and clinics have initiated programmes that are designed to reduce the incidence or risk of sustaining burn injuries.

CAPFSA. This organisation has implemented various burn prevention education campaigns. These campaigns and programmes are targeted at adults, children and professionals. The methods used by CAPFSA to educate communities on burn prevention are extensive use of the media, the development and distribution of educational resources (posters, pamphlets, videos), workshops, lectures, training courses and exhibitions targeting specific vulnerable communities. In response to the scant resources for educators to cover injury prevention in the school curriculum, CAPFSA and the Western Cape Education Department have recently compiled a life-orientation pack for Foundation Phase learners. The pack focuses on childhood injury prevention and contains a burn prevention module. This project is currently in the pilot stage.

PASASA. This organisation has also developed educational resources that facilitate especially paraffin-related burn prevention. PASASA plays an important watchdog role since it encourages all producers of illuminating paraffin to conform to established safety standards, and ensures that paraffin remains uncontaminated while under their care. PASASA also targets the identification and dissemination of better practices for the handling of illuminating paraffin and supports the development of legislation consistent with the South African Bureau of Standards (SABS) appliance standard (PASASA, 2003).

Emergency services. A number of the emergency services departments of local municipalities, especially in the Gauteng and Western Cape Provinces, conduct Fire and Life Safety Educators' Courses. These courses target fire service personnel and other safety practitioners who are required to present fire and injury prevention programmes. The trained educators then structure their own intervention strategies appropriate to the requirements and concerns of those communities at risk. From this course the "learn not to burn" campaign was initiated. This campaign is hosted by the City of Cape Town. It is currently run by a group of volunteers from emergency services who have been trained to teach children what to do in the event of a fire and how to avoid burn injuries.

Children of Fire Trust. The Trust conducts various burn prevention educational programmes with a specific focus on the secondary and tertiary levels of burn prevention. Various hospitals and clinics in the country run their own burn prevention educational campaigns. One example is the "stop burns" campaign that was implemented at the Chris Hani Baragwanath Hospital in Soweto, Johannesburg. The success of this programme was measured by the drop in burn admissions to this hospital during the implementation stage of the campaign.

Ukuvuka Operation Fire Stop. This four-year campaign started as a direct result of the January 2000 fires that ravaged the Cape Peninsula and thereafter the regular fires in various informal settlements, such as occurred in the Joe Slovo neighbourhood. This campaign is a joint initiative between the National Government of South Africa (represented by the Working for Water Programme), the Western Cape Provincial Government, the City of Cape Town and the South African National Parks (Ukuvuka, 2003).

Many of the interventions by CAPFSA, PASASA, Ukuvuka, the Children of Fire Trust, and various emergency services have documented encouraging or positive results, but unfortunately with little scientific evidence to support these. The majority of these interventions do not report any systematic external evaluation, mainly because of a lack of resources, insufficient time or personnel, or because of limited technical skills (Du Toit, 1999). It therefore remains difficult to assess how effective these initiatives really are.

PRIORITY RECOMMENDATIONS

Recent South African research has identified childhood burn injuries as a priority concern. A number of specific research, management and prevention priorities are identified in this chapter.

A key research priority includes the ongoing surveillance of both fatal and non-fatal injury data, an essential monitoring and evaluation tool for prevention. The development, analysis and dissemination of the findings produced by the National Injury Mortality Surveillance System (NIMSS), and sentinel burn injury surveillance sites such as those located at the Red Cross Children's Hospital and elsewhere, constitute a critical information base for further analysis, and ultimately to stimulate and monitor interventions in the sector. In addition, it is proposed that expansion of the current fatal and non-fatal injury data sources includes information on permanent disfigurement and disability suffered by survivors, imperative for a more complete determination of burn prevention priorities (Liao & Rossignol, 2000). Finally, the identification of aetiological patterns peculiar to South African conditions is essential for understanding the multiple and often complex occurrences of childhood burn injury. Identification of individual, familial, household and community risks specific to the local occurrence of childhood burn injuries implies the implementation of specifically focused studies, although risk patterns, to some extent, may also be derived from current databases.

Recent international and South African research supports the prioritisation of public health interventions, especially preventative efforts. However, most local burn prevention projects are largely scientifically untested. Key recommendations for the South African sector therefore include the identification, evaluation and dissemination of good burn injury prevention practices which explicitly benefit children who may be vulnerable to burn injury, such as those aged 1 to 6 years. To assist in the evaluation of current interventions, it is proposed that appropriate evaluation protocols be utilised or developed for use in local injury prevention projects. This review also specifically supports the evaluation and implementation of primarily passive environmental, product and legislative injury prevention interventions; the development of mandatory specifications on high-risk products, including children's clothing, portable stove construction, and cigarette flammability; the promotion of electricity and other safe forms of home energy consumption; and the implementation and evaluation of targeted safety education, especially for health professionals, children and parents (via the school curriculum), and policy-makers.

We also identified a number of key recommendations in terms of diagnosis, management and reduction of inpatient mortality, namely the early identification and appropriate referral of patients with moderate to severe burn injuries, especially inhalation burns; and the effective management of complications, especially septicaemia, pneumonia and acute renal failure.

In conclusion, a number of reports have indicated that burn injuries are especially dangerous and often result in fatal injuries amongst young children. Despite increasing epidemiological attention to the occurrence of burn injury, there remains a paucity of empirical studies identifying the incidence, extent, and contributory mechanisms underlying these injuries. Similarly, there is a lack of systematic investigation into burn injury prevention practices in South Africa. Despite these limitations, there remains considerable public interest in and support for childhood burn injury prevention initiatives.

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10 Paraffin ingestion

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Of the different external causes of death from unintentional injury among children between the ages of 1 to 14 years in 2000/2001, poisonings ranked fourth after road traffic accidents, fires and drowning (Taft, Paul, Consunji & Miller, 2002). Paraffin (known as kerosene in some countries) poisoning by ingestion is known to be the most common cause of acute unintentional poisoning in the South African black paediatric population (De Wet *et al*., 1994; Ellis, Krug, Robertson, Hay & MacIntyre, 1994; Joubert, 1990).

This chapter provides a review of the literature on unintentional paraffin ingestion. It discusses the clinical features of paraffin poisoning, management of paraffin ingestion, incidence of paraffin ingestion, risk factors, and current paraffin ingestion intervention and prevention strategies. The chapter concludes with recommendations for future research in the field.

CLINICAL FEATURES OF PARAFFIN POISONING

The ingestion of paraffin may cause minor or no harm. However, if there are complications, it may result in poisoning and could be lethal (Stones, Van Niekerk & Cilliers, 1987). Chemical pneumonitis, an inflammation of the lungs or breathing difficulty caused by inhalation of the noxious chemical, is the most serious complication following paraffin ingestion. It is largely due to aspiration of the paraffin and refluxed gastric contents. According to the South African Medicines Formulary (SAMF) (undated), chemical pneumonitis reportedly occurs in 12% to 40% of cases. The low viscosity of paraffin renders the chemical a major aspiration hazard. There are reports indicating that a small amount (as little as 1 ml) can result in chemical pneumonitis (SAMF, undated).

The clinical presentation of paraffin ingestion may include respiratory symptoms (cough, tachypnoea, cyanosis and grunting), gastro-intestinal symptoms (vomiting, abdominal pain), fever, and neurological manifestations (restlessness and drowsiness) (National Department of Health, 1998; Reed & Conradie, 1997; SAMF, undated). Respiratory symptoms and signs are common and have been reported in 51% to 80% of paraffin ingestion cases at two rural hospitals (Ellis *et al*., 1994; Reed & Conradie, 1997). The respiratory symptoms and signs usually appear within 30 to 60 minutes after ingestion, but may be delayed for up to 8 hours (SAMF, undated).

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According to the SAMF, the clinical presentation usually deteriorates over the first 24 hours.

The presence of a fever 24 to 48 hours after ingestion may be suggestive of secondary infection (SAMF, undated). Two studies conducted in South Africa (Reed & Conradie, 1997; Simmank, Wagstaff, Sullivan, Filteau & Tomkins, 1998) found that secondary infection in the acute stage is very uncommon. However, Simmank *et al.* (1998) reported that complications might result when poor socio-economic circumstances and nutritional deficits are present and particularly when there is an underlying respiratory illness. This was highlighted by the cases of two children with clinical signs of AIDS who developed severe pneumonia and required prolonged hospitalisation following paraffin ingestion. With correct management most children recover (Reed & Conradie, 1997; Simmank *et al.*, 1998). Pneumatoceles may be an uncommon development during the recovery period of pneumonitis (Simmank *et al.*, 1998; Stones *et al.*, 1987). While the pneumatoceles may resolve spontaneously, the children who develop them are more clinically ill and are hospitalised for longer (Stones *et al.*, 1987).

MANAGEMENT OF PARAFFIN INGESTION

The management of paraffin ingestion generally consists of observation, prevention or the early treatment of complications and supportive therapy (National Department of Health, 1998). The specific care given to victims of poisoning is usually determined by the symptoms. Accurate assessment of the patient is therefore essential.

Asymptomatic patients should undergo a physical examination, a chest X-ray is recommended 5-6 hours after the ingestion, and the patient should be observed for 8 hours (SAMF, undated). The standard treatment guideline at the paediatric hospital level promotes a 12- to 24-hour period of observation (National Department of Health, 1998). The patient can be discharged if she or he is asymptomatic after the observation period and if the chest X-ray proves to be normal.

Symptomatic patients require an X-ray on admission to the hospital. A careful assessment of the respiratory and central nervous systems should be undertaken in patients with pulmonary involvement, and arterial blood gases and electrolytes should be assessed where possible. Patients displaying signs and symptoms of chemical pneumonitis should be provided with oxygen therapy. Specific antimicrobial therapy is required in the presence of a secondary infection (SAMF, undated).

The use of any substance that may induce vomiting is contraindicated. While there does not seem to be any conclusive evidence with regard to the impact of vomiting on the clinical features of paraffin poisoning (Reed & Conradie, 1997; Simmank *et al.*, 1998), induced emesis or gastric lavage is contraindicated since it reportedly increases the risk of aspiration and chemical pneumonitis (SAMF, undated). Corticosteriod therapy is also not recommended since it has been shown to increase the risk of secondary bacterial infection. Finally, the SAMF does not advocate the use of antibiotics prophylactically in hydrocarbon pneumonitis, although it is acknowledged that some experts do.

INCIDENCE OF PARAFFIN INGESTION

Reliable and accurate information or statistics concerning ingestion of and/or poisoning caused by paraffin are lacking in South Africa. Nevertheless, we have tried to make sense of the various estimates reported in the literature. To supplement this information we have solicited inputs from various key informants in the field (see Appendix A).

The literature shows that paraffin ingestion accounted for a considerable proportion of all paediatric admissions at state hospitals, ranging from 5.5% to 16.5% of all admissions (U. MacIntyre, personal communication, 2003; Reed & Conradie, 1997; Violari & Levenstein, 1991). At Ga-Rankuwa Hospital just north of Pretoria paraffin poisoning accounted for 78% of acute accidental poisoning in 1992 (Ellis *et al*., 1994), while at Red Cross Children's Hospital and Tygerberg Hospital in the Western Cape paraffin poisoning accounted for 22-30% of all poisonings between 1999 and 2001 (Child Accident Prevention Foundation of South Africa, 2002; Marks, 2001). The higher rates of paraffin poisoning at Ga-Rankuwa can be explained by the hospital serving a mainly peri-urban black community, who rely extensively on paraffin as a source of cheap fuel. The ingestion rate in rural areas is reportedly three times higher than in urban areas (Yach, 1994).

There are two methods for estimating the national incidence of paraffin ingestion, namely household surveys and the review of hospital databases, neither of which are entirely reliable. A national survey conducted by Markinor in 2001 indicated that there were 145 000 cases of child poisoning by paraffin ingestion annually (Biggs & Greyling, 2001). Although the small sample size resulted in a wide confidence interval of 84 600 to 169 200 ingestions, the results confirmed that there were considerably more ingestions than there were hospitalisations.

There are several reasons why the study may have overestimated the true incidence of ingestion. Markinor defined the recall period as 1 year, although respondents may have included events from before this period. Furthermore, paraffin usage for cooking among Markinor's sample of black and coloured households was 48% (Biggs & Greyling, 2001), whereas paraffin usage in black and coloured households was reported as only 28% and 10% respectively by Statistics South Africa (2002). If we deduce that the Markinor sample over-reported general paraffin usage to the same extent as paraffin usage for cooking (and assuming that the Statistics South Africa data are in fact accurate), paraffin usage in South African households was only 55% of that reported in the Markinor study. By extension, the annual number of paraffin ingestions would also be 55% of the Markinor estimate, i.e. 79 750 ingestions per annum, with an interval estimate of 46 530 to 93 060 ingestions per annum.

Yach (1994) provides a frequently quoted estimate for paraffin ingestion of at least 16 000 children per annum based on hospitalisations. The data are apparently extrapolated from Ellis *et al.* (1994), De Wet *et al.* (1994), and from other previous studies, but Yach (1994) does not explain how the estimate was calculated. Yach's estimate implied that there were at least 30 children hospitalised each year for every million litres of paraffin sold, and that another way of expressing the impact of paraffin poisoning on health was to "use litres sold as the denominator of the rate" (Yach, 1994, p. 717). Using Yach's estimate of 30 hospitalised cases per million litres sold, the current paraffin sales volumes of 745 million litres in 2002 (South African Petroleum Industry Association, 2003) would imply that there were approximately 22 350 hospitalised cases in 2002.

This estimate provided by Yach may be an overestimation of the incidence of paraffin poisoning. However, there are several indications that Yach's estimate under-reports the true incidence of ingestion. Firstly, there is some uncertainty as to the reliability of injury data recorded from hospitals, particularly with regard to poisoning data. Hospitals typically collect data for curative or secondary prevention, i.e. to prioritise and plan resource allocation for curative services. Diagnosis rather than the cause of injury or illness is more useful for these purposes, and when patients and their records are referred to tertiary facilities for treatment the external cause of the injury is not always noted. Since many of the ingestion cases at large secondary and tertiary hospitals are referred from primary health care facilities in rural areas, paraffin ingestion cases are often recorded according to their diagnosis, which in many cases will be pneumonia, pneumonitis, or other respiratory-related ailments. Secondly, even if hospital data were 100% accurate, Yach's estimate would exclude the large number of children who do not reach state hospitals. Markinor showed that only 50% of paraffin ingestion cases were referred to clinics and hospital (Biggs & Greyling, 2001). This finding implies that doubling the number of hospitalised paraffin ingestion cases would provide a more realistic estimate of the actual incidence of ingestion.

Based on the available information we have attempted to replicate Yach's (1994) national hospital caseload estimate for paraffin ingestions. In our review of the medical literature and hospital caseload reports from various hospital data sources, we recorded caseload figures for between 30 and 40 facilities over a 20-year period and estimated that there are more than 24 000 hospitalisations due to paraffin ingestion per annum (Carolissen & Matzopoulos, 2003). Doubling the number of hospitalised cases implies that there were more than 48 000 ingestion cases per annum.

However, even a cursory examination of the available data reveals several obvious deficiencies. Firstly, the data are not routinely recorded or reported and only three hospitals (all in the Western Cape) reported more than 2 years of caseload estimates. For this reason, we assumed that the rate of paraffin ingestion had remained constant over the 20-year period. Secondly, the data were concentrated in certain provinces. The Western Cape and Limpopo were over-represented, while there were limited data from the Eastern Cape, North West Province and Free State, the three provinces with the highest per capita paraffin usage (Statistics South Africa, 1996). Therefore, the current estimate for hospitalised cases should not be seen as definitive and additional hospital information needs to be taken into account as it becomes available.

Nevertheless, the current estimate for ingestions based on hospitalised cases (48 000 ingestions per annum) falls within the re-estimated Markinor range estimate of 46 530 to 93 060 ingestions per annum. The inclusion of additional hospital caseload information from under-represented high paraffin usage areas may bring the two estimates closer together. Therefore, we believe that the true incidence of paraffin ingestion in South Africa lies somewhere between 46 530 and 93 060 cases per annum.

Hospital case fatality rates from paraffin ingestion of 0.72% to 2.1% have been reported in South Africa (Crisp, 1986; Joubert, 1990; Krug, Ellis, Hay, Mokgabudi & Robertson, 1994; Simmank *et al.*, 1998). While the fatality rates appear to be low, one study showed that paraffin ingestion was responsible for 26.7% of all deaths at Ga-Rankuwa Hospital (Joubert, 1990).

Based on an estimate of 16 000 hospitalised cases per annum, Van Horen (1996) estimated 208 deaths per annum (range 75-490 deaths). Since this estimate is based on hospitalised cases only, it may be an underestimate since many cases of paraffin poisoning do not reach hospital, particularly in the rural areas. Using the hospital case fatality rates (Crisp, 1986; Joubert, 1990; Krug *et al.*, 1994; Simmank *et al.*, 1998) and the updated hospitalisation estimate of 24 000, we estimate that between 171 and 498 children die of paraffin poisoning in South African state hospitals every year. If we assume that the case fatality rate for the 50% of ingestion cases that do not reach hospitals is the same, we could surmise that there are between 342 and 996 fatal paraffin ingestions in South Africa annually (see Carolissen & Matzopoulos, 2003, for the method of extrapolation).

RISK FACTORS FOR PARAFFIN INGESTION

Paraffin ingestion mainly affects children below the age of 5 years, with a peak incidence between the ages of 1 and 2 years (Crisp, 1986; Freedman & Norzi, 1987; Joubert, 1990; Krug *et al.*, 1994) and 1 and 3 years reported (De Wet *et al.*, 1994). With regard to gender, the incidence of paraffin ingestion has been shown to be greater among males than females, with reported ratios of 1.3:1 (Ellis *et al.*, 1994) and 1.7:1 (De Wet *et al.*, 1994). It has been said that the underdeveloped sense of smell and taste of toddlers makes it impossible for them to discern between paraffin and other liquids. It has also been proposed that children in this age group are orally orientated and very inquisitive and are therefore more vulnerable to ingesting poisons (Korb & Young, 1985). The greater incidence of paraffin ingestion among males can perhaps be explained by the gender differentiation in socialisation. There may be a greater parental tolerance of male toddlers engaging in risky exploratory behaviour.

None of the studies specifically investigated risk factors for paraffin ingestion, although several risk factors are alluded to. The most obvious risk factor for ingestion is the presence of paraffin in the domestic environment. Paraffin is the most frequently used source of energy for cooking, after electricity. In some provinces it is the dominant source of energy for cooking (Statistics South Africa, 2001). Secondly, the absence of safe packaging legislation results in the distribution of paraffin in indistinct and unlabelled containers. Paraffin is frequently stored in cooldrink, milk and juice bottles or other containers, which children associate with beverages (Abrahams, 1994; Ellis *et al.*, 1994; Krug *et al.*, 1994). Children may also drink paraffin from intermediate containers such as cups, which are used for refilling appliances (Caelers, 2001; Krug *et al.*, 1994). Drinkable substances stored in child-resistant containers (CRCs) may also contribute to the risk of unintentional poisoning since children may associate hazardous substance containers with those used to store drinkable substances (K. Venter, personal communication, 2003).

The unsafe storage of paraffin, i.e. within reach of children, has been identified as a risk factor for paraffin ingestion (Ellis *et al*., 1994; Krug *et al*., 1994; Reed & Conradie, 1997). According to Reed and Conradie (1997), 78% of caregivers in their study of 110 children did not store paraffin above ground level. The study by Krug *et al.* (1994) showed that 75% of children in the study had access to the paraffin containers, which has been attributed to overcrowding and limited storage space (Ellis *et al*., 1994).

In addition to the risk factors already mentioned, lack of parental supervision is a frequently mentioned risk factor for poisoning. Krug *et al.* (1994) found that a minority of children (12%-25%) were under adult supervision when paraffin ingestion occurred. Reed and Conradie (1997) and Krug *et al.* (1994) also found that in 19% to 33% of cases, poisoning occurred when a child was left in the care of another child. This implies that adult supervision may be necessary to prevent poisonings.

Summer is the season of greatest risk to children (De Wet *et al*., 1994; Ellis *et al*., 1994; Krug *et al*., 1994). Most authors have highlighted increased thirst due to the warmer weather as a risk factor (Ellis *et al*., 1994; Krug *et al*., 1994), but Korb and Young (1985) provided other explanations, such as school holidays resulting in children being left in the care of an older child or being left unattended. The authors also noted that parents or siblings may have been less alert to accidents during this period, and particularly during the festive season due to the atmosphere of merriment and carelessness, which may also have seen increased attention-seeking behaviour by younger children.

INTERVENTION: PREVENTION OF PARAFFIN INGESTION

The importance of intervention and preventative strategies to reduce and prevent paraffin poisoning has been recognised by government (Department of Minerals and Energy, 1998) and petroleum companies, who established the Paraffin Safety Association of South Africa (PASASA) in 1996 with the primary objective of communicating product safety and distributing safety resources to users of paraffin.

PASASA has implemented various interventions for reducing the incidence of paraffin-related injuries, including the distribution of safety tops or closures (i.e. not including the containers due to their prohibitively high cost) with safety information. The safety tops, which fitted a variety of commonly used bottles, were distributed free of charge via clinics and schools, traders, community workshops and even Ster Kinekor mobile cinemas. A problem with this strategy was that safety tops applied to the wrong bottles were neither child-resistant nor airtight, and were often discarded. Furthermore, the distribution of free resources was not seen as being sustainable and the safety tops were not always valued by the users (J. Bopape, personal communication, 2002).

In order to ensure that child-resistant containers (CRCs) were valued and maintained by the users, and also to increase the effectiveness of the child-resistant safety tops, PASASA started to sell CRCs (containers with safety tops). Several projects were piloted in Limpopo and Mpumalanga with traders and schools, who sold the CRCs at R2 for a 2-litre container and R5 for a 5-litre container. The participating traders and schools also received safety education and incentives. Although people who purchased the containers were invariably satisfied with their purchases, the low sales figures meant that project implementation on a national basis was not viable. Since the containers were sold empty, another problem was that they were used to store several other substances, including petrol, liquor, clean water (a precious commodity in some areas) and even holy water.

It was clear that another strategy was required, and in 2001 PASASA piloted a small filling site with the South African Black Hawkers and Micro Business Association (SABHIBA) at Daveyton (Gauteng). Paraffin was pre-packed by a manual filling system at the SABHIBA site and sold via a network of traders on a deposit basis. Paraffin was supplied by Total and marketed under the Kleen Paraffin brand name, which was developed by PASASA. Implementation was successful and SABHIBA continues to sell 15 000 to 20 000 litres of pre-packed paraffin per month. In 2001 a rural site was piloted in Mathathiele (KwaZulu-Natal) in partnership with the Caba Mdeni Community Co-operative and Shell, who supplied the paraffin, again marketed under the Kleen Paraffin brand name.

After implementation of their pre-packaging sites at Daveyton and Mathathiele, the Department of Minerals and Energy (DME) requested that PASASA assist in implementing pre-packaging sites at integrated energy centres (IeCs) in collaboration with Total and the community co-operatives. DME identified developmental nodes for the implementation of IeCs, which will be run as co-operatives, part-owned by the government and the participating communities. The IeCs will provide a variety of energy services and will assist in providing the safest, cheapest, and most efficient integrated energy packages at a household level.

The DME and PASASA's vision is that communities will be supplied with pre-packed paraffin free of contaminants and fitted with child-resistant closures at the same price as unpackaged paraffin. The paraffin will be packed at the IeCs and distributed through a network of affiliated village vendors, who trade the paraffin bottles on a deposit basis. Training programmes coordinated by the IeC stakeholders will incorporate all aspects of safe energy usage, including paraffin, electricity and gas. Although these programmes will primarily be aimed at members of the cooperatives, knowledge will reportedly be passed on to the communities through the village vendors and traders. PASASA community workers will also coordinate safety workshops about paraffin, specifically at clinics and schools, and will be supported by various media and promotional materials (Matzopoulos & Methvin, 2002).

Paraffin ingestion seems to result from the interplay between a variety of factors, including individual, social and economic factors. A comprehensive approach to prevention is therefore imperative. The increasing use of paraffin among the black population (Statistics South Africa, 2002) also suggests that there is an urgent need for preventative strategies.

The need to implement child-resistant packaging[2] as a preventative strategy has been acknowledged by several authors (Carolissen & Matzopoulos, 2003; Crisp, 1986; De Wet *et al.*, 1994; Joubert, 1990; Korb & Young, 1985; Krug *et al.*, 1994; Lloyd, Rukato & Swanepoel, 2000; Violari & Levenstein, 1991; Yach, 1994). The study conducted in South Africa's rural North West Province by Krug *et al.* (1994) showed that CRCs significantly reduced the incidence of accidental paraffin ingestion by 47.4% over a period of 14 months. The study clearly showed that CRCs effectively reduced paraffin poisoning in the study area and it was recommended that all paraffin be sold in CRCs. However, the CRC used for the Krug study (a 2 litre plastic container designed according to the recommendations of the British Safety Standards Authorities, with a child-resistant cap, usage instructions and a health educational message in English and the local language of the study and control area) reportedly was not ideal since it tended to break. A more durable (Krug *et al.*, 1994), effective and low-cost CRC that is easy to pour from and that is distributed via petroleum companies and/or paraffin distributors (Ellis *et al.*, 1994) has been recommended. The container should be used exclusively for paraffin, and the CRC should conform to standards that have been proven to be effective in reducing paraffin poisoning in South Africa.

To avoid consumers using the container for drinkable substances, it has been recommended that the containers should be tamperproof, i.e. "reusable by the industry (petroleum refineries), but not reusable by the consumer, e.g. a one-way valve preventing refill (reuse) by the consumer, needing a special tool or equipment for re-filling, only available to refineries" (K. Venter, personal communication, 2003). Venter has also recommended the pre-packaging of paraffin in small quantities (for household use) at petroleum refineries only.

Although it has been shown that CRCs are an effective intervention for reducing accidental childhood paraffin poisoning, the residual rates of paraffin poisoning in the study by Krug *et al.* (1994) remained high. Therefore improved health education with a focus on (a) the role of intermediate containers in paraffin poisoning, (b) the safe storage of paraffin containers out of reach of children, (c) home visits aimed at the implementation of advice and the empowerment of the mother, and (d) health education stressing that children should not be left unsupervised, in combination with CRCs, have been recommended. Increasing the awareness of health care workers, administrators and paraffin distributors regarding the dangers of paraffin was also considered important (Ellis *et al.*, 1994). In addition, education should be targeted at all paraffin-using communities, taking into account the social background of the target group.

While the importance of education with a focus on prevention has been emphasised by other authors (De Wet *et al.*, 1994; Ellis *et al.*, 1994; Reed & Conradie, 1997), educational campaigns as a paraffin safety intervention on their own have not had a significant impact in terms of reducing the incidence of paraffin ingestion in South

[2]Packaging that is difficult for children to open within a reasonable period but that presents no difficulty for adults to use properly. CRCs such as the push down and turn, squeeze and turn, or lining up the arrows and then opening, are examples of child-resistant packaging. It includes the container, the safety top, label and in some cases, a tamper-proof seal.

Africa (Donald, Bezuidenhout & Cameron, 1991). The study by Krug *et al.* (1994) also indicated that the type of health education given to the control group did not lower the incidence of paraffin poisoning.

A possible solution to the health hazards associated with paraffin is the use of an alternative energy source. The electrification of all households has been recommended as a long-term solution (Community Health Research Group, undated; Ellis *et al.*, 1994). While electrification is expected to reduce the incidence of paraffin poisoning significantly, it does not ensure a complete shift to electricity (Lloyd *et al.*, 2000). Low-income households may continue to use paraffin because it is cheaper than electricity. Others have suggested the use of liquid petroleum gas (LPG) as an alternative source of fuel to paraffin (Lloyd, 2002). Although LPG is more expensive than paraffin, it is reported to be safer, and Lloyd (2002) has indicated that the distribution of the fuel can be rationalised to meet the needs of communities.

In addition to the above recommendations, the introduction of legislation that institutes pre-packaging of small quantities of paraffin (for household use) at petroleum refineries only has been recommended (K. Venter, personal communication, 2003). Venter and other authors also recommended legislation enforcing the retailing of small quantities of paraffin in CRCs (De Wet *et al.*, 1994; Ellis *et al.*, 1994; Yach, 1994). Venter highlighted the use of dedicated paraffin CRCs.

The South African Bureau of Standards (SABS) (1999) has set standards for the classification and labelling of dangerous substances and preparations for sale and handling; however, these standards are not enforceable by law. South Africa can draw on international experience that has shown a significant reduction in the incidence of poisoning after the introduction of legislation that enforced the use of child-resistant packaging (Clarke & Walton, 1979; US Consumer Product Safety Commission, 2001; Walton, 1982).

Finally, the lack of reliable statistics compromises the monitoring of any preventative strategy. Legislation should therefore be introduced that makes paraffin poisoning a notifiable condition. Notification of the condition will contribute towards obtaining reliable and relatively accurate information concerning paraffin poisoning and identifying high-risk geographical areas. This information is important for the development of prevention strategies as well as the evaluation thereof.

IMPLICATIONS FOR FORMULATION AND DEVELOPMENT OF RESEARCH

It is important to keep abreast of the incidence of paraffin poisoning since this information may serve as baseline data from which to evaluate various interventions. To this effect, additional hospital caseload information should be collected on an ongoing basis and the current estimate for paraffin ingestion should be reviewed and updated annually, based on the method of estimation described in Carolissen and Matzopoulos (2003). Alternatively, a national household survey focusing on high paraffin usage areas should be conducted to determine the extent of the problem.

With a focus on the prevention of paraffin ingestion, controlled risk factor research should be a priority. Further research on the design and ease of use of CRCs should also be a priority, together with rigorous experimentation with package and label designs to determine their effectiveness in reducing children's attraction to harmful substances. An intervention programme which includes CRCs and a combination of the complementary interventions should also be evaluated in order to determine the most effective strategy for reducing childhood paraffin ingestion.

In conclusion, due to the paucity of empirical studies on paraffin ingestion, this chapter has relied extensively on personal communications (see Appendix A), unpublished material, and undated and outdated sources. While the prevention actions required to reduce childhood ingestion are relatively clear, there is still a need to improve data collection systems to monitor their effectiveness, and to conduct further empirical research as highlighted previously.

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APPENDIX A
PERSONAL COMMUNICATIONS WITH KEY INFORMANTS

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