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).
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). Corticosteroid 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 colddrink, 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 (Caelters, 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 Africa.

\(^2\)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.
Paraffin ingestion in 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 Matzopoulou (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.

REFERENCES


**APPENDIX A**

**PERSONAL COMMUNICATIONS WITH KEY INFORMANTS**

