

**Burns and Fires from Flammable Non-electric Domestic Appliances:  
Part I. The Scope of the Problem**

Michael D Peck, MD, ScD, FACS  
Professor, Division of Trauma, Critical Care, Burns  
Director of International Outreach Programs, North Carolina Jaycee Burn Center  
University of North Carolina at Chapel Hill  
101 Manning Drive  
Chapel Hill, North Carolina 27514  
USA

Gerebreg E Kruger, BCom  
Chair, South African Bureau of Standards Technical Committee for Paraffin-Operated  
Equipment  
Senior Projects Manager – Safer Systems  
Paraffin Safety Association of Southern Africa  
Cape Town, South Africa  
Suite 11  
Rozenhof Court  
20 Kloof St.  
Cape Town 8001, South Africa

Anna E van der Merwe, MB ChB, MSc  
Head, Research and Surgical consultant, Tygerberg Burn Unit  
Department of General Surgery  
University of Stellenbosch  
Francie van Zyl Avenue  
Tygerberg, 7505  
Cape Town, South Africa

Wijaya Godakumbura, MBBS, FRCS  
Consultant General Surgeon (retired), formerly of the National Hospital of Sri Lanka  
President, Safe Bottle Lamp Foundation  
Member, National Committee for Prevention of Injuries  
Member, Technical Review Panel of the Lindbergh Foundation  
Colombo, SRI LANKA  
Street address: 20/14, Narahenpita Road  
Nawala, SRI LANKA

Rajeev B Ahuja, MBBS, MS, MCh, DNB, FICS, FACS, FAMS  
Head, Department of Burns and Plastic Surgery  
Lok Nayak Hospital and associated Maulana Azad Medical College  
J L N Marg  
New Delhi, India 110092

The authors are members of the International Society for Burn Injuries (ISBI) Prevention Committee.

Corresponding author

Michael D Peck, MD, ScD, FACS

Professor, Division of Trauma, Critical Care, Burns

Director of International Outreach Programs, North Carolina Jaycee Burn Center

University of North Carolina at Chapel Hill

101 Manning Drive

Chapel Hill, North Carolina 27514

USA

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## **SUMMARY**

### **Background**

Burn injury is a major public health issue in developing nations. Although burn injuries and smoke inhalation in 2002 were documented as being responsible for over 322 000 deaths worldwide, this figure is most likely a gross underestimate. The burden of suffering from fire is exceedingly distributed among the poor. A large proportion of burn injuries are related to the nature of domestic appliances that are used for cooking, heating, lighting or all three.

### **Materials and Methods**

We undertook a retrospective review of the literature as well as analyzing our institutional and regional experiences with injuries caused by non-electric domestic appliances.

### **Results**

The incidence of injuries is largely associated with the use of stoves and lamps; and from kerosene or petroleum as well as butane, liquid petroleum gas and alcohol. Associated problems include appliance design and construction, fuel combustion and instability, and mechanical inefficiency. Ignorance of safe usage techniques is also contributory. Industry and government regulations and standards are either nonexistent or not adequately enforced.

### **Conclusions**

Solving this substantial problem will depend on improved surveillance by means of formal epidemiologic studies, and the contributions and collaboration of international governmental and nongovernmental organizations.

## **BACKGROUND**

Fires and burn injuries have taken a toll on human existence since Prometheus gave the gift of flame to mortal man. Without question one of the most powerful tools in our history, fire nonetheless leaves its scars. Whereas it is reported that worldwide in 2002, burn injuries and smoke inhalation were responsible for over 322 000 deaths,(1) these data are likely to reflect a gross underestimate. There are no valid, comprehensive statistics being consistently collected by developing countries.

For example, India has no registry where statistics are properly and universally recorded. One of our authors (RBA) estimates that India alone probably has 200,000 deaths annually from burns. In Delhi, which has a total population of 14 million, there are approximately 2200 deaths annually from burns. Of these deaths, 600 deaths occur annually in Lok Nayak Hospital. Extrapolating these figures to India's population of 1.2 billion produces a figure which, in itself, far exceeds published global estimates.

The burden of suffering from fire is exceedingly distributed among the poor. Over 98% of deaths from fire and burns occur in developing nations, which are least able to provide the resources for care or the community support for rehabilitation. The rate at which developing nations will acquire experienced personnel and modern facilities for burn care will lag behind their general socioeconomic development.

Over the centuries, the use of simple appliances such as stoves and lamps has resulted in inestimable damage to persons and property. This is largely a result of overcrowded and substandard living conditions; faulty design; improper use of the device; ignorance; inexperience; intoxication or carelessness. **(Figure 1)** The flammability of fuel types varies greatly. For instance, ethanol has a low flash point (the

lowest temperature at which a flammable fuel forms an ignitable mixture with oxygen) but kerosene has a higher flash point. This variability could add to the inherent dangers because most developing countries do not have regulated infrastructures in place dealing with fuel integrity, specifically whether the fuel has been contaminated with another type of fuel. This aspect can dramatically change the fuel's chemical properties and therefore its functionality and effect on unsuspecting consumers. This article provides an overview of the depth and breadth of the problems connected with the use of small flammable-fueled domestic appliances in developing nations.\*

## **FIGURE 1 HERE**

### **METHODS**

Retrospective review of the literature was performed using the terms “burns,” “stoves,” and “lamps” in the PubMed database of the National Library of Medicine. In addition, the authors reviewed their institutional and regional experiences with injuries caused by non-electric domestic appliances.

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\* There are at least two terms in this text that may be used interchangeably. Both “petrol” and “gasoline” refer to the fuel commonly used for internal combustion engines. Similarly, “paraffin” and “kerosene” refer to the same hydrocarbon liquid.

## RESULTS

The incidence of injuries is largely associated with the use of stoves\*\* and lamps; and from kerosene or petroleum; however, butane, liquid petroleum gas (LPG), and alcohol used as fuels are also risks.

### Stoves

Fires started by domestic appliances using flammable fuel are responsible for incalculable property damage. In South Africa it is estimated that over 46 000 dwellings each year are razed as a result of fires.(2) From 2002 to 2004, between 11% and 13% of households in South Africa were the structures commonly referred to as “shacks.” These structures are built in informal settlements without proper town-planning, with cramped living quarters, made of highly combustible and toxic materials such as treated or painted wood and plastics, and are usually assembled close to one another on uneven ground.

**(Figure 1)** Paraffin is used as fuel with inferior designed cooking devices. This dangerous circumstance contributes to the rapid spread of fires between homes, making them highly unsuitable for storage and use of flammable fuels. During a simulated shack fire triggered by a non-pressure paraffin stove that was knocked over after burning for one hour, the temperature in the shack reached an excess of 900° C (1670° F) in less than four minutes.(2)

Shack fire burns are the second most common reason for admission of patients to burn units in Cape Town, SA.(3) In a 30-month period from January 1993 through June 1995, 99 victims of shack fires were admitted to the University of Cape Town Red Cross

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\*\* There are two types of stoves mentioned in this document: the flame (non-pressure) stove and the Primus (pressure) stove.

Memorial Hospital Burns Unit. The most common underlying cause was the use of Primus (pressure) stoves, which were involved in 16 out of 56 fires (29%).

Injuries from shack fires are severe. In this study,(3) the average area of the body surface burned was 31%, and two-thirds of these patients had third degree burns. Sixty-one percent of these patients also sustained smoke inhalation injury, and 40% of them died as a result of their injuries.

This same burn unit had previously studied 33 patients who sustained Primus stove burns and were treated for 18 months from January 1990 through June 1992.(4) Primus stove burns caused injuries to 17% of all burn patients (33/194), with a nearly even gender distribution (17 females/16 males), but who were almost exclusively black (29/33; 87%). The mean burn size was 16.8% TBSA (range 5%-48%), which was almost twice as large as scald burns treated in the same time frame. The cost per patient (US\$325) with burns caused by Primus stoves was twice that of those caused by scalds. Rehabilitation also took longer than that for scald patients. The face, hands and extremities were the areas most commonly involved, and 22 (48%) patients had third degree burns. All patients required at least one surgical procedure. The mean length of stay was 24 days, with a range of 8 to 47 days. Four patients also sustained inhalation injury. The only death was due to delay in resuscitation.

Flame (non-pressure) stove injuries accounted for 13% of all adult burn injuries admitted to the burn units at Tygerberg Hospital and the Red Cross Children's Hospital in Cape Town.(5) The majority of these patients (45%) were adult women, who had more severe injuries and a higher mortality rate (22%) than men. These flame stove injuries

were caused by explosions, ignition of spilled paraffin, ignition of clothing by stove flames, falls onto stoves, and assaults.

The cost of care for patients injured by flame stoves is high. In a sample of 17 patients from Cape Town, the mean total cost per patient was US\$6410 and the highest cost was US\$14 853.(5) Extrapolating these costs to South Africa nationwide supplies an estimated annual expense of US\$26 250 000, which is more than 50 times the annual fuel turnover rate.

A more detailed analysis of the burden of care for victims of flame stove incidents was conducted in a prospective study at Tygerberg Hospital, Cape Town, from 1998 to 1999.(6) Of the 160 adult patients admitted with burns during that period, 40 (25%) were injured in stove-related incidents. Reasons given for those incidents are presented in Table 1.

**TABLE 1 HERE**

**Table 1.?** Reasons for incidents of flame stove-related burns at Tygerberg Hospital, Cape Town from 1998 to 1999.

<b>Flame stove incidents</b>		
Stove exploded	24	60%
Assaulted with stove	5	13%
Knocked stove over	4	10%
Clothes/blankets caught fire	3	7%
Fell on stove after epileptic fit	2	5%
<b>Primus stove incidents</b>		
Indian print skirts ignited	2	5%
<b>Total</b>	<b>40</b>	<b>100%</b>

The mean age of these patients was 32 years and the mean size of body area burned was 24%. Mortality was 25% (10/40). Length of stay for survivors was 29 days compared to

21 days for patients hospitalized with other types of burns. The cost of treatment for a patient with a 25% burn and 20-day length of stay was US\$4531.

Other regions in Africa suffer from the same problem. In Mekele town, Tigray (northern Ethiopia), a community-based study showed that 9.7% of women aged 15 to 59 years had sustained burns in the previous 12 months.(7) Most injuries occurred at home (88%) and were related to cooking activities. The risk of burn injury based on the employed means of cooking is presented in Table 2.

**TABLE 2 HERE**

**Table 2.?** A community-based study of Mekele town, Tigray, demonstrated the risk of burn injury based on means of cooking.

<b>Means of cooking</b>	<b>Incidence of burns</b>	<b>Odds ratio (95% confidence interval)</b>
Open fire	0/15 (0%)	0.00 (0.00, 109.2)
Protected fire	25/383 (6.5%)	2.86 (0.44, 120.38)
Kerosene stove	1/4 (25%)	13.67 (0.13, 1097)
Electrical stove	1/7 (14%)	0.00 (0.00, 234)

At Ain Shams Hospital in Cairo, 40% (242/622) of outpatient burns treated within 18 months (1995-6) were caused by kerosene stoves.(8) During this same period, 45% of admitted patients (62/137) had been injured by kerosene stove use. Of these admissions, 69% (43/62) were using a newer import, easily-explosive stove model, which used wick gauze fed from a container of kerosene. There was also an increased incidence in winter and spring (214) compared to summer and fall (90) with a ratio of 2.4:1. The mortality rate was 26/304 (8.5%) and the majority of deaths (20/26; 77%) were related to the newly imported stove model.

Approximately one-third of children hospitalized at Ain Shams Hospital sustained flame burns from kerosene stove explosions. In poor neighborhoods of Cairo, the kerosene stove, which lacks any safety measures, is used extensively for boiling water and cooking. Children frequently stumble on the stove, which is placed on the ground.(9)

Kerosene stoves have also caused serious injuries in India for many generations. From 1982 through 1987, 198 (58%) of the 339 patients admitted with burn injuries to the Postgraduate Institute of Medical Education and Research in Chandigarh, India, had burns from kerosene stoves.(10) Of the patients described, 90% were either poor or lower middle class. Middle- or upper-class Indians rarely sustain kerosene stove injuries, presumably because they have smaller families, live in larger houses, and use cooking devices that are elevated above floor level. On the other hand, patients burned by kerosene stoves resided in single or double rooms with large families, and cooking was done at floor level. The vast majority of injuries (95%) were non-intentional, and though 3.2% were documented as assaults, some of which resulted in homicide, and 1.8% was listed as suicides, this may not represent the true incidence of death rates because of attempts to cover up the facts to avoid medical-legal risk. The majority of incidents (84%) occurred at home, 69% in the kitchen; over 77% of victims were females, with a 3.5:1 ratio. Women between ages 11-40 were most frequently burned, with kerosene stove injuries rare under age 10 and over age 50. The following were the causes of these stove accidents:(10)

### **TABLE 3 HERE**

**Table 3.?** Causes of kerosene stove accidents from 1982 through 1987 in 198 patients admitted with burn injuries to the Postgraduate Institute of Medical Education and Research in Chandigarh, India.

<b>Cause</b>	<b>Female</b>	<b>Male</b>	<b>Total</b>
Working on kerosene stove	92 (60%)	37 (82%)	130 (66%)
Moving around stove with loose clothing	50 (33%)	6 (13%)	56 (28%)
Epileptic seizure while working on stove	11 (7%)	2 (4%)	12 (6%)
<b>Total</b>	<b>153 (77.3%)</b>	<b>45 (22.7%)</b>	<b>198 (100%)</b>

These were extensive injuries, with burns greater than 50% total body surface area (TBSA) in 61% of males and 65% of females. Mortality from kerosene burns was higher in women (58%) than in men (38%).

In another study in northern India, of 11 196 burn patients admitted to a tertiary burn center over an eight-year period, 29% were due to malfunctioning kerosene stoves.(11) These injuries represented 35% of all flame burns (3249/9198).

A single episode of smoke inhalation following an accident from a malfunctioning kerosene pressure stove can lead to varying grades of inhalation injury. Inhalation injury can occur even though the injury takes place in a semi-closed space such as a kitchen, where entrapment of the victim for a prolonged period in a smoky atmosphere is less likely. A significant proportion (12%) of burn victims who present with stridor, carbonaceous sputum or dyspnea following smoke inhalation will go on to develop symptomatic chronic obstructive lung disease within 6 to 18 months after injury.(12)

In February 1994, a sudden increase in the number of kerosene flame burns occurred in four districts of South East Rajasthan, India.(13) Over a period of two months, 303 patients were admitted to hospitals in Rajasthan. Most of the injuries

occurred while filling already-ignited lamps. On February 15, 1994, railway tank wagons reached the station at Kota; 12 carried petrol, 20 carried kerosene, and 14 carried diesel fuel. By mistake, one of the tank wagons of petrol was emptied into a kerosene storage tank, mixing 27 000 litres of petrol in 600 000 litres of kerosene. Although prior to this stage (i.e., between oil refineries to oil terminals via pipes, and then at loading of tank wagons at the terminals), at each stage of loading and unloading, the identity of the products is confirmed by checking both density and flash point, after the storage tanks were filled this safety check was not routinely performed. Thus kerosene mixed with petrol was distributed to oil dealers and retailers, and sold to consumers who had no knowledge of the explosive nature of the mixture. Despite a catastrophic incident in which a road tanker exploded and four people died, the nature of the problem was not recognized until staff from hospitals in Jhalawar and Baran Districts noted a doubling in admissions due to kerosene explosions. In poorer neighborhoods, homemade lamps that are used for illumination were the usual source of ignition of the petrol-kerosene mixture. Explosions would occur in one of two instances: either when petrol vapors would ignite as the lighter-weighted petrol rose to the top of the fuel chamber, or when the petrol vapors were emitted as the mixture was poured into the chamber when the lamp was already lit.

Elsewhere in Central Asia kerosene stoves are a problem. In a study from Karachi, Pakistan conducted between 1992 and 1993, in the 47 adult survivors of stove flame burns the largest burns (mean = 47% TBSA) were due to “stove bursts”; that is, the stove disintegrates under increased pressure, spraying flammable mixture throughout the room.(14)

Kerosene stoves were responsible for 27 burns (57%); flames from normal use caused 11 burns, catastrophic explosions caused five burns, and unintentional ignition of fuel outside containers caused 11 burns. The circumstances contributing to the incidents included the following.

- Adding kerosene to a hot stove
- Lack of other illumination in the dwelling
- No pressure gauges on pump stoves
- Inexperience — user kept valve open while pumping
- Stoves placed at ground level, igniting clothing
- No smoke detectors or fire extinguishers
- Average time to extinguish was 6 minutes
- No knowledge of first aid
- No emergency medical system
- Lack of schooling
- Physical or mental disability
- Seizure disorder
- Forgetfulness
- Unawareness of material's flammability

The typical profile of a hospitalized burn patient in Karachi in 1992-1993 was, “... (a) young, uneducated woman, wearing loose clothing, injured in the kitchen, around a stove, who (was) ignorant of fire safety, experienced prolonged contact with fire, received no first aid, was transported to the hospital in a common carrier, had 57 percent TBSA burned, and died after 2 days.”(14)

The substitution of gasoline (petrol) for kerosene also leads to disasters.(15) In March 1984 in Lagos, Nigeria, 96% of patient admissions to the Lagos University Teaching Hospital were caused by kerosene stove and lamp explosions. All patients came from Lagos Mainland, a lower socioeconomic area, and the majority (62%) of them were children. Overall mortality during this epidemic was 44%. All these incidents were caused by gasoline contamination of kerosene during the storage-tank filling at one

domestic supplier (petrol filling station). Because the supply chain is unregulated, this is not an uncommon phenomenon.

### **Lamps**

Burns caused by homemade bottle lamps or commercial wick lamps are a cause of major morbidity and mortality in developing nations. In northern India during an eight-year period in which 11 196 patients were admitted for burn care, 226 (2%) of injuries were caused by flame lamps.(11) In Sri Lanka between July 1999 and June 2001, 91/221 patients (41%) with non-intentional burns who were admitted to Batticaloa General Hospital in the Eastern Province were burned by fires caused when homemade kerosene bottle lamps fell.(16) Similarly, during 1998 and 1999, 151 (31%) of 487 patients age 12 years and older admitted to the National Hospital in Colombo had non-intentional burns from kerosene lamps. Of these, there was a slight female predominance (54%) and 44% (66) of the 151 total cases involved individuals who were between 21-30 years old.(17) The causes of bottle lamp burns were as follows.

#### **TABLE 4 HERE**

**Table 4.?** Causes of bottle lamp burns in 151 burn injury patients between 21 and 30 years old admitted to the National Hospital in Colombo, Sri Lanka, during 1998 and 1999.

<b>Cause of injury</b>	<b>Number</b>	<b>Percentage</b>
Hand striking lamp	73	48%
Rat/cat toppling lamp	22	15%
While pouring oil into burning lamp	18	12%
Came off the wall	17	11%
Lamp fell on the body during sleep	6	4%
Other or not certain	15	10%
<b>Total</b>	<b>151</b>	<b>100%</b>

### **Injuries from Other Fuels**

Non-kerosene fuel sources, used elsewhere in small domestic appliances, are also associated with significant numbers of burn injuries. In Casablanca, Morocco, for example, explosions of small (3 kg) butane containers are responsible for nearly all flame burns in children. From April 1985 through November 1993, these incidents accounted for 15% of all childhood burns.(18) In Rio de Janeiro, Brazil, from May 1991 through March 1992, 25% of children under age 11 who were admitted to burn centers had sustained injuries caused by the instability of alcohol-fueled stoves.(19)

### **DISCUSSION**

The gender distribution of burns in developing countries is not consistently reported. The vast majority of papers focus on childhood burns. Infant and toddlers up to 4 years of age have a disproportionately higher number of burns than other children. In late adolescence burns begin to increase again due to the engagement of work in the kitchen and improper use of flammable substances. For adults the number of burns is found to be relatively low until 30-39 years of age. In countries with all-year-round warm temperatures, such as Angola and Côte d'Ivoire, a slight preponderance of burns in males is reported, while in settings with seasonal weather, such as Egypt and Pakistan, a higher proportion is reported for females.(20) This again emphasizes the danger of cooking in a confined space, which is a particular risk for the poor and those living in households without electricity.

In India, burns are ranked as the highest cause of injury death in infants and the third highest for children under 14 years old.(10) Some injuries reported as non-intentional kerosene stove accidents may represent intentional (either assault or self-inflicted) injuries associated with the a domestic violence syndrome seen around the Indian subcontinent, sometimes referred to as “dowry death,”(10, 21) but perhaps more aptly titled “bride burning.”(22) This is a practice begun in the last quarter of the 20th century. Due to an unfulfilled ‘dowry demand’ or marital dispute, the husband or his family douses the wife with kerosene and sets her alight. The majority of cases of bride burning are in fact suicides. Because of constant and severe physical abuse, the depressed wife is unable to escape and usually resorts to suicide by burning. Incidents of bride burning as either homicide or suicide are often disguised as kitchen accidents.

Burns are among the top 10 external causes of death in South Africa, and in 2004 burn violence was the leading cause of unnatural death in children aged 1-4 years.(23) This high number of burns in infants and toddlers is attributable largely to their total dependence on their parents and caretakers. It is a growing phenomenon because there are increasingly more child-headed households as a result of the HIV/AIDS pandemic. In addition, there are extremely poor communities in South Africa where rural-to-urban migration is occurring at a faster rate than the provision of proper housing. These informal settlements are characterized by overcrowding into structures not fit for human habitation, built from wooden frames and plastic, and easily susceptible to rapidly spreading fires. (Figure 2)

**FIGURE 2 HERE**

Poverty is a risk factor for burns.(10, 24-26) There is a clear relationship between thermal injuries and overcrowding in small dwelling spaces.(4, 19) Because of the overcrowding, cooking is often done at floor level in the midst of crowds of women and children. Lack of electrification is also a risk factor and throughout the world there is significant inequity in the distribution of electrification of households. For example, household electrification in Sri Lanka increased from 50% to 65% in the decade 1990-2000, but in Mozambique only 10% of homes are electrified.(27) The number of electrified households is only slowly changing. There are many countries in which little progress has been made. In 1999, electricity use averaged 2436 kilowatt-hours (kw-hrs) per capita and ranged from 515 kw-hrs per capita in Africa to 10 289 kw-hrs per capita in North America.

Multi-energy usage is a characteristic of low-income households in South Africa. Electricity is now the main source of energy for cooking (51.5%), heating (49.0%), and lighting (69.7%).(28) Kerosene is the second most commonly used fuel for cooking (21.4%), heating (14.6%), and to a lesser extent, for lighting (6.8%). Usually the introduction of electricity to a household shifts the use of kerosene from lighting to the more dangerous cooking and heating applications. There is also a lack of accurate electricity usage measures and illegal “siphoning” of electricity from industrial sources or neighbors is a common practice.

## Design Problems

The underlying problem of appliance-related fires often lies with design issues. In many currently available Primus stoves, the combination of mechanical inefficiency and incomplete combustion of kerosene leads to partial blockage of the jet opening, which reduces the intensity of the flame. To increase the intensity of the flame, air is pumped into the chamber to increase the pressure, but this maneuver is dangerous if the pressure valve is left open. The blocked opening is then cleared by introducing a pin, and the kerosene/air mixture is rapidly emitted. When this cloud of flammable gases ignites, the stove explodes. Ignited kerosene vapors burn in the proximity of 1600° F (900° C). The vapor is heavy and tends to accumulate in a hollow container or space. In a well-ventilated appliance, the vapor will not accumulate and ignite, but with closed-space usage, the oxygen of even a small draft of air ignites the vapor at the flash point of paraffin (110° F/43° C). This can be particularly deadly if the kerosene vapors permeate clothing prior to ignition.

Another design deficiency is the aforementioned “stove burst.”(10, 14) Poor design also allows fuel leakage, which is especially common when individuals fill stove reservoirs. Kerosene can leak onto clothing, or if heat or flames are present nearby during fueling, vapors can ignite. Ignorance of safe techniques in using fuel and appliances will also lead to catastrophic explosions if gasoline (petrol) contaminates kerosene or is substituted for or mixed with kerosene.

Most small appliances are portable, but their designs are often physically unstable; they may easily tip over while being moved or when resting in place. Often the small lightweight stove is used as a weapon, thrown at the opponent while arguing or

fighting. In the governorate of Menoufia, Egypt, 63% of burn-related deaths in women of reproductive age were due to the use of portable kerosene and butane gas cooking stoves.(29)

Design standards appear to be nonexistent, insufficient, or poorly regulated. In South Africa in 2003, nine commonly used designs of both flame and Primus stove varieties all failed national standards. The following issues were cited frequently.

- There were no labels for instructions.
- The pot stand was too small for the weight of the pot.
- Leakage
- Fuel overheated easily up to 80° Celsius
- Non-durable construction
- Devices emitted toxic emissions linked to respiratory problems.
- All non-pressure stoves erupted into flames if knocked over.

Although South Africa has two national standards for stove designs, they are not enforced. In 2004, however, the South African government committed to regulating the industry. In May 2004, the Paraffin Safety Association of Southern Africa (Paraffin Safety Association) ran a safe paraffin-stove design competition in anticipation of the regulation of the industry, and awarded six innovative design ideas. Unfortunately, none of the 35 entered prototypes met all the competition's health and safety criteria as had those that were endorsed in the national standards.

The non-pressure standard (SANS 1906) was revised and in June 2005 it was published as a new standard. As of January 1, 2007 that standard became compulsory.

Of great concern, however, is the apparent lack of stove designs that meet the new standard. The standard for pressure stoves, SANS 1243, is currently being revised and is due for release as a new standard April 1, 2007.<sup>1</sup>

### **Flame stoves**

The most commonly used stove in South Africa is the non-pressure or wick stove, also known as a flame stove. Flame stoves are now used in approximately 31% of households, which represents about 70% of the stove market.<sup>(5)</sup> The cost of a flame stove is only US\$3.33 compared to US\$12 for a Primus stove, a significant difference for impoverished families. Flame stoves are small and portable, have low set-up costs, and sometimes double as space heaters when zinc sheets are placed on the stove to disperse the heat.

The flame stove has a cotton wick dipped into the fuel cell, where paraffin or another fuel is stored. It is inferior to the Primus stove in thermal efficiency, combustion efficiency, flame stability and flame creep (that is, the appearance of a flame on the rim of stove that is burning separately from the main flame). However, it is superior in surface temperature and stability.<sup>(6)</sup>

Flame stoves are potentially dangerous because they are susceptible to drafts of air, which suddenly increase flame size and intensity.<sup>(6)</sup> Often this rapidly increasing flame ignites clothing, resulting in the typical injury that includes bilateral hand, face and chest burns as well as smoke inhalation. Because a rush of oxygen causes the leaking fuel to flare, even the act of lifting a pot from the stove can cause enough draft for the

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<sup>1</sup> The text of SANS 1906 is available at the South African government announcement online at [http://search.sabinet.co.za/pdf/ggaz\\_pdf/2006/jul/gg29338\\_nn1091.pdf](http://search.sabinet.co.za/pdf/ggaz_pdf/2006/jul/gg29338_nn1091.pdf)

stove to explode. These stoves will also explode if the kerosene is contaminated with petrol.

Flame stoves also tend to explode when the fuel tank is nearly empty. If the stove is toppled, all the heated fuel spills and erupts into flames. In India the non- pressure stove is more expensive than the Primus stove and thus the latter is widely used.(11) A kerosene pressure stove produces kerosene aerosol, which should be lit by a burning wick immersed in spirit. To start the flame, people generally put a lit matchstick to the burner and pump vigorously. In cases where burner holes are choked by carbon deposits, the pumping releases at high pressure a large volume of aerosol, which ignites as a fireball and leads to a fatal burn injury .

### **Lamps**

Lamps have also been plagued with design problems. In Sri Lanka lamp use is ubiquitous, with an estimated three million lamps in 1.5 million homes that lack electricity.(30) Traditionally the oil lamps were tall, narrow, lightweight, and had no screw-on lids; they toppled easily, spilling the kerosene. Daily, because of lamp-related incidents, nearly 15 to 20 injured Sri Lankans were being treated at the cost of US\$2500 per day, and one patient died every third day.

In Mozambique, xiphfo accidents cause most burn deaths in Maputo Central Hospital.(31) The xiphfo is a home-made bottle lamp, which is popular in suburban areas without electricity. The wick is fueled by kerosene, petrol, or even jet fuel; as with Sri Lankan lamps, the base is unstable.

## **Fuel Problems**

The fuels that are used in lamps and stoves carry inherent dangers. Kerosene (paraffin) has a chemical composition similar to jet fuel. It has a low viscosity, allowing it to disperse rapidly once spilled. The flash point is 109° F /43° C, a relatively low temperature that can easily be exceeded by smoldering wicks.

Kerosene is also dangerous as an indoor air pollutant. Carbon monoxide and other toxins are produced as a result of incomplete combustion. Low levels of carbon monoxide poisoning can cause dizziness, drowsiness and headaches, and higher levels or longer exposure may cause coma and death.

In South Africa nearly 800 million litres of kerosene are manufactured and sold each year; 70% of this is used domestically. More than one energy source will often be used in a household. Electricity is used mainly for illumination and media, because of the expense or government-sponsored portion,<sup>+</sup> and kerosene is used for cooking and heating. However, the habit, low cost and convenience of using the flame stove over many years surmounts the knowledge of the danger of keeping a stove in a house where electricity is also used.

Typical kerosene users have a low socioeconomic status, although not all users are illiterate or uneducated. Still, the sale of kerosene to illiterate paupers is truly a case of caveat emptor (let the buyer beware). There is no provision of safety information at the point of sale and the purchase of the fuel is often delegated to children. There is no formal packaging and therefore, no safety warning labels.

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<sup>+</sup> The South African government offers a Free Basic Electricity grant that is intended to provide a minimum amount of electricity free of charge to each household that qualifies.

Officials in South Africa are extremely concerned with the contamination of kerosene. However, because the petroleum industry is not legally responsible for the supply chain to the end user, the problem occurs during the resale, after the fuel leaves the gantry/refinery gates. The traders and retailers are not as strict (or regulated) in observing best practices or Standard Operating Procedures when shifting from one fuel type to another. In addition, consumers purchasing paraffin may sometimes present a container that has residues of other fuels, such as paraffin, which is not transported by pipeline in South Africa.

Kerosene is readily available in small quantities at US\$0.46 per bottle from the tiny, often family-run spaza shops in South African townships. Those who lack a regular daily income find it is more desirable to purchase fuel in small quantities, as compared with the cost of monthly electricity usage fees, or even in larger, more expensive bottles of liquefied petroleum gas (LPG). LPG is the most inexpensive energy source; small or large quantities of paraffin are much more expensive.(32) On the other hand, kerosene appliances have a low set-up cost. Research conducted by the Paraffin Safety Association shows that up to 40% of South Africans (approximately 2 472 003 households) use kerosene for at least some of their domestic energy needs.(28) The average annual income of these households is US\$1881. Although kerosene has a considerable number of safety drawbacks, it is a useful and affordable fuel so its use in impoverished communities will continue as long as it is the most convenient fuel choice. There is simply no evident alternative energy.

As the usage of LPG is becoming more popular in India, kerosene stoves use and the incidence of related injuries is decreasing dramatically. Data from Phase II of a study

conducted by the Department of Burns and Plastic Surgery at New Delhi's Lok Nayak Hospital burn unit reveal that between 2001 and 2005, the total number of admissions was 4364, and the average per month was 72.7 (Unpublished data; RBA). There was a drastic reduction in kerosene malfunction and cooking accidents: 60% and 35% respectively. As flame burns decreased, there was some rise in electrical injuries.

**(Figure 3)**

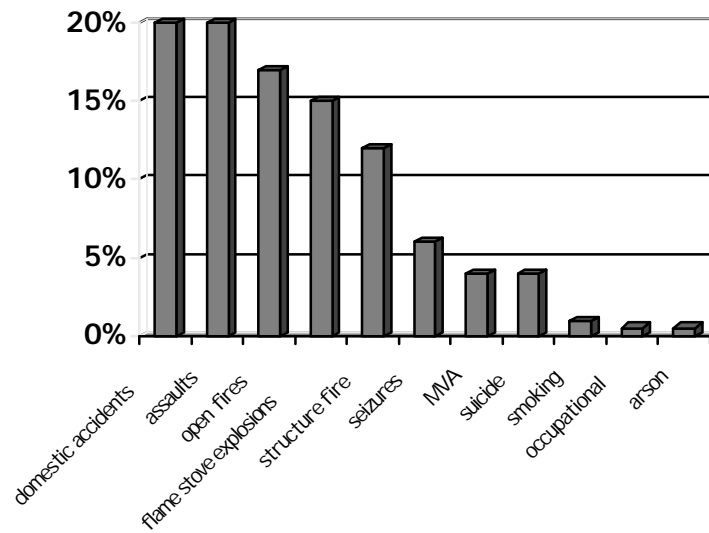
**FIGURE 3 HERE**

As M. H. Keswani, MD, one of India's leaders in burn care has said: "The challenge of burns lies not in the successful treatment of a 100 per cent burn, but in the 100 per cent prevention of all burn injuries."<sup>(33)</sup> Better surveillance with formal epidemiologic studies, which will more accurately assess the incidence and prevalence of fires and burn injuries in vulnerable populations, is imperative for the design and implementation of effective preventive interventions. A collaboration of international governmental and nongovernmental organizations will be needed to address this significant public health problem.

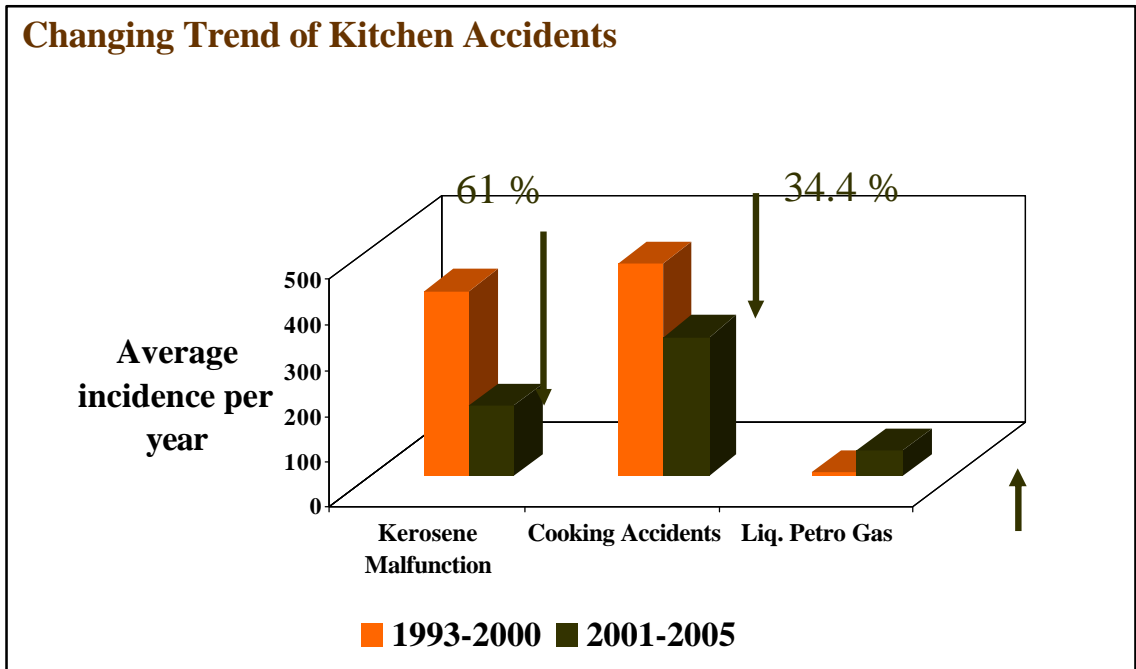
**Figure 1.?** Electricity supply to informal settlements is often shared illegally among neighbors or siphoned off the main supply.



**Figure 2.?** Causes of burn injury in patients treated at Tygerberg Hospital, Cape Town, SA, 1998-1999.(6)



**Figure 3.?** As LPG fuel use increases in India, the trends relating to the nature of kitchen accidents are changing. (Unpublished data; RBA)



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