

## Review Article

# Primus stove burns: a persisting problem in developing countries

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**Abstract:** Primus stoves account for a large proportion of burn injuries in the developing world. The mechanism of these injuries is closely linked with factors relating to stove design, fuel characteristics and the socioeconomic profile of victims. We review the current literature on these injuries with particular attention to the injury mechanisms and epidemiological data available. We additionally summarize the initiatives so far developed worldwide for their prevention and define directions for further research into reducing the burden associated with Primus stove burn injuries.

**Keywords:** Primus, kerosene, pressure stove, developing countries, burn prevention, stove burn mechanism

## Introduction

Burns are a significant cause of injury across the developing world. In India they account for the second largest group of injuries after road traffic accidents, occurring with an estimated annual incidence of 6-7 million in a country with a population of over one billion [1]. They are a particular problem in low and middle income nations, where unintentional injury is a leading cause of death and mortality rates are up to 100 times higher than rates in the developed world [2,3]. Primus or pressure kerosene stoves are widely used for domestic purposes in developing countries and are responsible for a great proportion of burn injuries. A useful estimate of their relative incidence comes from a large epidemiological study of burn admissions over an 8-year period to the second largest burns unit in India (Lok Nayak Hospital and Maulana Azad Medical College, New Delhi) [4]. This retrospective analysis of 11,196 burn admissions between January 1993 and December 2000 concluded that in adults, flame was the predominant cause of burn (82.15%), and overall 35.31% involved malfunctioning kerosene pres-

sure stoves. Two earlier reports, from the Burns Unit of the Postgraduate Institute of Medical Education and Research in Chandigarh, India, identified kerosene pressure stoves as the predominant mechanism of injury and death accounting for 66% and 76% of burns admissions and autopsy examinations respectively [5,6].

Separate studies have generated a similar figure for the proportion of burns admissions attributable to Primus stove fires in other developing countries: 40% in an urban hospital in Egypt, 41% in a general hospital in Eastern Sri Lanka and 31.9% in a teaching hospital in Nigeria [7-9].

## Profile of victims and characteristics of Primus stove burn injuries

An epidemiological study of adults hospitalized with burns in Karachi, Pakistan gives an evocative description of the typical patient as:

'...young, uneducated woman, wearing loose clothing, injured in the kitchen, around a stove, who [was] ignorant of fire safety, experienced

## Primus stove burns

prolonged contact with fire, received no first aid, was transported to the hospital in a common carrier...'[10]

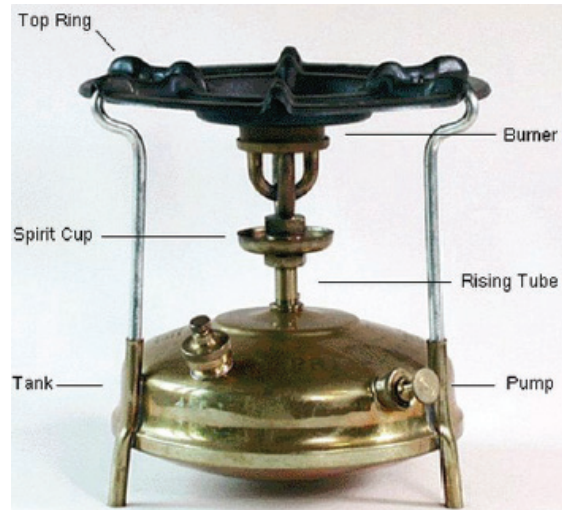
Sawhney's sub-analysis of thermal burns admissions in Chandigarh in the late 1980s identified cooking on kerosene pressure stoves in the kitchen at ground level as the most common activity associated with such injury (65.7%) and the next most common as wearing loose garments whilst near the stove (28.3%). These accidents affected the age group 16-35 with a 3.5:1 female to male preponderance. 90% patients classified as poor, equivalent to an income of below 500 rupees [5].

Autopsy records of fatal burn cases from the same hospital in Chandigarh, over a longer time period of 1971 to 1996, provide additional evidence that clothes catching fire while using kerosene stoves is a common risk factor, which in this study was associated with 39% of burns deaths. Other risk factors include spillage of kerosene (implicated in 27% of burns deaths), stove bursting (11%) or falling (4%). The mean age of the subjects in this study was 26.8 years and the female to male ratio was 1.19:1 [6].

Several independent reports from hospitals across India confirm the low socio-economic status and female preponderance of victims as well as the domestic setting of the accidents [11-13].

A small proportion of burns from stoves are non-accidental in nature [6,14]. A forensic study in Kanpur, India in 1985-6 found that 14.4% of fatal Primus stove burns were homicidal and 23.9% suicidal acts [14]. These victims were mostly young women and cases were usually related to unfulfilled marital demands and disputes within the community, in which a dowry system was commonplace. Self immolation has also been recorded as a significant cause of self harm and suicide in Sri Lanka, particularly among women with marital problems [15]. Burns from Primus stoves may also in rare cases occur due to an epileptic fit, which is a known risk factor for burns worldwide [5].

The characteristics of Primus stove burns are illustrated by a review of 33 patients admitted to the Burns Unit at Woodstock Hospital, Cape Town, between 1990 and 1992 [16]. The average total body surface area was 16.8% (range:



**Figure 1.** ([http://en.wikipedia.org/wiki/File:Primus\\_Stove.jpg#file](http://en.wikipedia.org/wiki/File:Primus_Stove.jpg#file)). Figure released into the public domain by its author, John Fogarty at the English Wikipedia project. This applies worldwide.)

5-48%) with all burns being at least deep partial thickness in depth: 48% had full thickness involvement. 27% patients were burnt in more than one anatomical area with the most prevalent areas being the upper and lower limbs, followed by head and neck and anterior trunk. Other reports confirm the extensive and deep nature of these burns as well as an associated high mortality (38.4-58.4%) [5].

The financial burden of Primus stove burns is grave, on both individuals and their communities. A large study of childhood burns in Bangladesh reports that the average healthcare expenditure on a severe burn is \$462, while 61% of families in the same cohort earn less than \$50 a month [17]. Experience in Cape Town reports the average cost per patient admitted for acute management of Primus stove burns as US\$325, including an average of 24 days in hospital (range: 8-47). The authors estimate that in their experience this is twice the cost of initial management of scalds, and also assert that rehabilitation takes longer for Primus stove injuries than scalds [16].

### Factors implicated in Primus stove burns

#### Stove

The primus stove (**Figure 1**) is the first pressurized kerosene stove designed in 1892 and due

## Primus stove burns

to its low cost is in widespread use throughout India and other developing countries.

It is composed of a tank, which contains kerosene fuel, and an overlying circular spirit cup. To begin using the stove, a small amount of alcohol is poured into the cup. This is then lit and the heat generated warms the adjacent burner and tubing. Secondly, air is pumped into the tank, which pressurizes the kerosene and causes it to ascend via the rising tube to the burner head. Here the hot metalwork causes the kerosene to vaporize, and the vapor is forced by the pressure beneath to emerge in a jet at the centre of the ring, where it mixes with air and burns with a blue sootless flame. Vigorous pumping will increase the pressure behind the kerosene and cause a larger flame. Conversely, there is a valve in the tank which will reduce pressure in the system if left open [18].

The jet opening often becomes partially blocked due to incomplete combustion of kerosene and mechanical inefficiency; this results in a smaller flame. To increase the size of the flame the user pumps air into the chamber, thereby increasing the pressure, and then clears the opening using a pin. The resulting gush of kerosene can result in a flash fire or spillage of kerosene over clothing and subsequent ignition. Occasionally, if the outlet is blocked and the pressure within the stove becomes excessive, the whole apparatus can disintegrate into its component parts, resulting in widespread spillage of kerosene and an explosion known as "stove burst" [5]. The likelihood of the vapor accumulating and igniting is greater where there is poor ventilation [19].

There are no compulsory design standards for the stoves in India: as a result they are often manufactured without instructions for users and with stands that are too small, therefore predisposing the stove to falling over [19].

### *Fuel*

Kerosene, also known as paraffin, is an affordable and convenient fuel in many lower-income countries including India. It burns at 900°C/1600°F although it has a relatively low flash point of 109°F/43°C, and creates minimal soot. Its low viscosity causes it to disperse rapidly once spilled [19]. Incomplete combustion of kerosene produces carbon monoxide and other

toxins, which can cause dizziness and drowsiness, thus making users more prone to accidents and inhalational injury. The potential for contamination of kerosene is of major concern. For example, in Kota, India, in 1994, a railway tank wagon containing petrol was accidentally emptied into a kerosene storage tank. This dangerous mixture was distributed to oil retailers and sold to unsuspecting consumers. There was a resultant dramatic increase in burns admissions in the Rajasthan area, due to explosions, which occurred when the petrol vapors ignited above the more dense kerosene [20].

Kerosene is also contaminated on a smaller scale when consumers use the same container for petrol and kerosene. There may be several re-sellers between the petrol filling station and the consumer, including "village vendors", and this increases the risk of contamination [21].

### *Patient and community factors*

As detailed above, burns victims belong predominantly to low socio-economic groups, living in crowded conditions with cooking taking place at floor level. Marsh, in his study from Karachi, identifies pre-event human factors such as poor education, physical or mental disability and inexperience; event factors that include the wearing of loose flammable materials; and post-event factors such as lack of first aid and delayed hospitalization [10]. Although in his study burns victims were found to have significantly better rates of education than an earlier study in the early 1970s, also from Karachi [22], there is no convincing evidence that the health burden from Primus stove burns has decreased in turn.

### **Prevention strategies**

It is estimated that over 98% of deaths from fire and burns occur in developing nations, which are least able to finance acute care and rehabilitation [19]. It is widely agreed that prevention strategies are of primary importance when attempting to manage burn injuries in these countries [1,23].

The Haddon matrix has been employed to help devise general interventions to prevent accidental burns from all sources across the developing world. The Haddon matrix considers epidemiological components (agent-host-environment

## Primus stove burns

interactions) alongside temporal components (pre-event, event and post event) [12]. When looking specifically at Primus stove injuries, it is useful to consider the three main sources of accidents: the appliance itself, the fuel and the user/patient.

### Stove

The Indian Standards Institute has established specifications for primus stoves manufactured in India; however, it is not mandatory for all stoves to have the ISI stamp of approval and given their higher price they are not widely used [21]. The Paraffin Safety Association of Southern Africa is a non-government organization established in 1996 by South African oil company representatives to promote health and safety practice in the use of domestic paraffin [24]. The South African National Standard (SANS) 1906, which became compulsory from January 2007, regulates non-pressure appliances: it mandates on stove requirements, for example, ensuring stability of the appliance; self-extinguishing if knocked over; and providing safety instructions with pictograms. There is an equivalent standard for pressure stoves: SANS 1243: 2007 [25]. Such experience in South Africa gives hope that despite taking time and effort to implement, and not forgetting the relatively larger population of India, it should be achievable to enforce safe stove standards nationwide across India.

Substitution of wick for pressure stoves is a possible alternative. However, not only is the non-pressure stove more expensive in India [19]; but it is also inferior in thermal/combustion efficiency, flame stability (susceptible to air drafts) and flame creep [26].

### Fuel

The use of liquefied petroleum gas (LPG), an inexpensive alternative to kerosene, is becoming more popular in India. The stoves themselves, however, are more expensive to set up and maintain than wick or pressure stoves in India. It has also been commented that, although less common, the effects of an LPG fire are often more devastating to person and property than those of kerosene [21].

It is important to have a national standardized system of kerosene containerization, and bot-

ties should have distinguishing labels which are familiar to users. In order to prevent contamination, consumers can be taught to use different containers for different substances. A way of tracking kerosene as it passes from manufacturer to consumer, via various vendors, would be very useful in order to recall fuel in the event of accidental contamination at source [21].

### Patient and community factors

A train-the-trainer model of education has shown to improve kerosene-related safety practices in South Africa [2]. This intervention consisted of experts training local paraprofessionals, who in turn delivered educational materials to community residents. The aim of this approach was rapid and wide dissemination of education with minimal cost. Results showed a greater self-reported knowledge about kerosene safety, and smaller but still significant changes in actual safety practices.

Further research is required to prove the applicability of similar approaches in different communities and the duration of the effects. Nonetheless it is certain that in one form or another, education plays a crucial role alongside other health and safety strategies; for example, to enforce new legislation or to familiarize communities with safer stove designs. The institution of a widespread, culturally-appropriate and specific public health program across a nation as large and diverse as India, targeting the vast number of people from lower socio-economic groups who are most at risk of kerosene stove burns is a considerable task. Such an education program should aim to disseminate simple consistent messages, for example structured around pre- peri- and post-burn events, such as: safety in the kitchen while cooking; how to extinguish a fire when necessary; and performing first aid if a burn does occur.

### Conclusion

Although there is widespread lack of national burns databases in the developing world, the assimilation of reports on Primus stove burns in developing countries provides a revealing insight into the magnitude of the problem. An Indian 'National program for prevention of burns injuries' has recently been introduced by Gupta et al [1]. This exciting venture focuses on preventative, curative and rehabilitative aspects of

burns injuries at local, district and tertiary levels. Interestingly, public education plays a key part in strategy, including media engagement and institution of a national commemorative day for prevention of burns injuries. Alongside these aims, the program stresses the need to establish a central burns registry.

The main advantage of this scheme is its appropriateness and specificity for Indian infrastructure and culture. To achieve optimal utilization of existing health care services it would coordinate government, non-governmental organizations and private sector resources. The securing of finance, consistently for a significant period of time, however, will not be without difficulty, although the initiators of the program have support of the Secretary of Health.

The implementation of schemes such as this should be encouraged. The establishment of central burns databases is essential, and they should not only record acute data for incidence and epidemiology purposes, but also long-term sequelae. Analysis of the severe and long-lasting sequelae of Primus stove burns does not only contribute to the design of appropriate preventative strategies, but it is also a crucial part of assessing the actual effectiveness of such preventative measures.

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## Primus stove burns

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