An Analytical Study of Primus Stove Burns: A Catastrophic and Costly but Preventable Tragedy

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Background: Burns are still considered to be an enormous public issue. Syrian burn centers have to deal, especially during the current war, with burns caused by manually processed petroleum derivatives, and particularly, primus stove injuries. This kind of burn is severe and devastating. Prevention is key in management. This is one of the leading studies to include this high number of cases in relative medical literature.

Methods: This retrospective descriptive cross-sectional study was conducted at Al-Mouwasat University Hospital, from June 2021 to October 2021. Inclusion criteria included admitted patients with a clear history of kerosene primus stove burn, either gender, and any age. Exclusion criteria included no clear history of a primus stove burn, injuries with causes other than primus stove, and outpatients. Data were recorded in Microsoft Excel sheets, and analyzed using IBM SPSS Statistics 26 software.

Results: In total, 135 burn patients were included. Of the total number of 135 patients, 65 (48%) patients were admitted with primus stove burns, with 70 (52%) non-primus stove injury patients. Of the 65 patients, 25 were men and 40 were women (38% and 62% respectively). The mean percentage of total body surface area was 45%. Average hospital stay was 30.5 days, whereas 16 of 65 (25%) primus stove admissions died.

Conclusions: Primus stove injuries are catastrophic and costly, but preventable. This study provides a detailed analytic and epidemiological approach to these injuries, hoping to shed light on the severity of such cases, and stresses the importance of prevention, which is always better than cure. (Plast Reconstr Surg Glob Open 2022;10:e4602; doi: 10.1097/GOX.0000000000004602; Published online 13 October 2022.)

INTRODUCTION

Despite outstanding medical advancements in burn management in recent decades, burns are still among the leading causes of disability-adjusted life-years (DALYs) lost in low- and middle-income countries. Therefore, burns are still considered an enormous public issue, especially in developing countries like Syria, in terms of mortality rates, morbidity, and long-term consequences.1–5 According to WHO reports, in 2004, nearly 11 million people worldwide were burned severely enough to require medical attention.5 Like those in other developing countries such as India, Pakistan, and South Africa, Syrian burn centers have to deal, especially during the current war, with burns caused by manually processed petroleum derivatives, and particularly, primus stove injuries that represent the practical usage of those products, taking into account that mixing kerosene with other petroleum products calls for a real disaster. Moreover, WHO considers the use of kerosene (paraffin) as a fuel source for non-electric domestic appliances like the primus stove as a risk factor for burns.5

Primus stove burns are catastrophic, with long-term psychological and physical sequelae on patients themselves, in addition to the resultant grave financial burden on national health resources and communities.1–4 This kind of injury has a larger burned area, can affect multiple body parts, is associated with higher prevalence and severity of inhalation injury component, requires more debridement sessions, and is more common among the less educated population, and thus, has higher mortality and morbidity rates, compared to other burn injuries.1–4

Prevention is key in management because of poor prognosis.3 This is considered one of the leading studies to include this high number of cases in relative medical literature, as it presents a detailed analytic and epidemiological approach to such injuries. This study describes...
the characteristics, management, and outcome in primus stove burn patients at Al-Mouwasat University Hospital, during a 5-month period.

MATERIALS AND METHODS

A retrospective descriptive cross-sectional study was undertaken on 135 patients admitted to the burn unit at Al-Mouwasat University Hospital, Faculty of Medicine, Damascus University, Syrian Arab Republic, for 5 months, from June 2021 to October 2021. Inclusion criteria include admitted patients with a clear history of kerosene primus stove burn, either gender, and any age. Exclusion criteria include no clear history of primus stove burn, injuries with causes other than primus stove, and outpatients. Ethical aspects (including decision-making capacity, informed consent, medical decision-making, patient autonomy, the patient-physician relationship) were followed.

Collected patient variables are summarized and shown in Table 1. Data were recorded in Microsoft Excel spreadsheets (Microsoft Corp, Redmond, Wash.), and analyzed using IBM SPSS Statistics 26 software. The mean percentage of total body surface area (% TBSA) was estimated based on the modified Lund-Browder chart. Assessment of inhalation injury was based on clinical features which include history of injury in enclosed places, burns around mouth and/or nose, soot in mouth or nostrils, singed nasal hairs, intraoral burns/swelling, hoarseness of voice, and inspiratory stridor. Patient arrival was classified into two types, according to required time for arrival: early referral (arrival within 5 hours post injury) and late referral (arrival after 5 hours post injury). Also, it was classified into two categories based on type of transfer: primary transfer (direct to our burn center) and secondary transfer (transferred from another medical centre). Morbidity is estimated by length of hospitalization (in days). Educational status was determined by literacy level, which, in our study, was defined as being able to read and write. Regarding the economic status, it was simply classified into three categories (upper, middle, and lower classes) depending on the average monthly income.

Regarding the statistical analysis, descriptive parametric variables will be represented by mean and SD, non-parametric variables by median and interquartile interval, and proportion by percentage. Data visualization will be presented through graphical figures, as shown below in this article.

RESULTS

In total, 135 burn patients were admitted, with 99 of them (74%) having sustained flame burns. Of the total number of admitted patients, 65 patients (65/135, 48%) were admitted with primus stove burns, with 70 non-primus stove injury patients (70/135, 52%). The 99 flame burns were divided as follows: primus stove injury (65/99, 66%), liquefied petroleum gas (LPG) injury (30/99, 30%), and other factors (4/99, 4%).

Gender, Age Distribution

There were 25 male patients and 40 female patients (38% and 62% respectively). Of the 65 patients, 22 (34%) were children (under 12 years), and 43 (66%) were adults (above 12 years). Average age of injured female patients was 22 years, ranging from 9 months to 51 years. Average age of injured male patients was 25 years, ranging from 10 months to 59 years.

Extent of Burns

The mean percentage of total body surface area (% TBSA) was 45%. The abdomen, upper limbs, chest, and face were the most affected areas.

Classification of Burns (Based on Depth of Injury)

All patients had deep partial thickness injuries (deep second degree), and 45 of 65 (70%) patients had full thickness (third degree) involvement.

Associated Inhalation Injury

Inhalation injury component based on clinical features was noticed in 36 out of 65 (55%) patients.

Treatment Options

Various treatment options were performed, such as escharotomy (30/65, 46%), debridement (45/65, 70%), tracheostomy (0/65, 0%), human skin allografting (7/65, 4%).

Table 1. Collected Parameters of Each Patient

| Patient Parameters                                      | Mean       | SD        |
|--------------------------------------------------------|------------|-----------|
| Name/patient medical record number (MRN)               |            |           |
| Age (y)                                                |            |           |
| Gender                                                 |            |           |
| Literacy level (literate/illiterate)                   |            |           |
| Marital status                                         |            |           |
| No. patients affected in the accident                  |            |           |
| Time from accident to arrival/direct admission or second transfer | |           |
| Degrees of burns and extent of burns (%TBSA)           |            |           |
| Inhalation injury component (present/absent) (based on clinical features) | |           |
| The affected areas                                     |            |           |
| Treatment options with number of episodes (conservative treatment, escharotomy, fasciotomy, debridement, tracheostomy, split-thickness skin grafting (STSG), full-thickness skin grafting (FTSG), allografting, others) | |           |
| Morbidity (length of hospitalization/days)             |            |           |
| Mortality                                              |            |           |

Takeaways

Questions:

What are the profiles of victims and characteristics of primus stove burn injuries?

Findings:

Mixing kerosene with other petroleum products results in disaster. Primus stove injuries are devastating and long-lasting.

Meaning:

This study provides a detailed analytic and epidemiological approach to these injuries, hoping to shed light on the severity of such cases, and stresses the importance of prevention, which is always better than cure.
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11%), split-thickness skin grafting (38/65, 58%), full-thickness skin grafting (10/65, 15%), and conservative treatment (4/65, 6%).

Characteristics of Arrival
Patient arrival was classified into two types, according to required time for arrival: early referral (arrival within 5 hours post injury) and late referral (arrival after 5 hours post injury). In total, 62 out of 65 (95%) patients arrived late.

Also, arrival was classified into two categories, based on type of transfer: primary transfer (direct to our burn center), and secondary transfer (transferred from another medical centre). In total, 59 out of 65 (90%) patients were secondarily transferred.

Receiving First Aid
Forty-two out of 65 patients (65%) received first aid, but mostly inappropriately.

Morbidity and Mortality
Morbidity is estimated by length of hospitalization; average hospital stay was 30.5 days, whereas 16 of 65 (25%) primus stove admissions died.

Number of Persons Affected by the Same Episode
In 23 out of 65 (35%) cases, more than one person was reported to be affected by the same accident.

Marital Status
Higher incidence was noted in married patients; 42 out of 65 (65%) patients were married.

Level of Primus Stove (Platform/ Floor)
In total, 100% of cases were at the floor level.

Economic Status
Economic status is simply classified into three classes (upper, middle, and low), depending on the average monthly income. In total, 52 out of 65 (80%) patients were within the middle class.

Educational Status
Educational status is estimated by literacy level as literate and illiterate; 55 of 65 (85%) patients who were more than 6 years old were illiterate.

Patient Clothing
An estimated 55 of 65 (85%) patients wore loose clothes.

DISCUSSION

Incidence
Burns are a leading cause of unintentional injuries across developing countries. Up to now, they are still considered to be a major public problem responsible for significant morbidity and mortality in developing countries, where mortality rate is one hundred times higher than that in developed countries.1-4 Flame burns in developing countries like in ours (74% of admitted cases in our study) are still dominating the burn admissions, according to reports by Ahuja et al in India in 2011.4

Due to the consequences of war and an energy short-age (mainly electricity) in our country, a growing number of people have started to use hand-made petroleum derivatives in their daily activities, in most cases dealing with a widely-used apparatus commonly known as primus stove. Worldwide, there are two types of stoves: gas stoves and kerosene stoves,5 of which the most widely used is kerosene, and it is the included type in the study. The standard fuel used in this type is kerosene, which cannot be obtained in its pure form manually; so alternatively, impure kerosene or, more often, a combination of manually derived contaminated gasoline, diesel, and kerosene is used.

Analyzing of Results, Profile of Victims, and Characteristics of Primus Stove Burn Injuries
As we have mentioned, of the total number of 135 admitted patients, 65 (48%) cases were admitted with primus stove burns, with 70 (52%) non-primus stove injury patients. This study details the profile of primus stove injury patients. So far, the medical literature is lacking about this specific injury and no national database is yet established. Therefore, it would be of a great benefit to report and compare with what others stated to create a database, aiming to evaluate the efficacy of proposed preventive strategies. Primus stove burns accounted for 48% of our admissions, indicating that this percentage is one of the highest reported in the medical literature with 12%, 52%, 40%, 41%, 31%, in South Africa (1994), Pakistan (1996), Egypt (2000), Sri Lanka (2002), and Nigeria (2007), respectively.1-4 Each included parameter will be discussed independently.

Gender/Age Distribution
The majority of patients were women (40/65, 38%), and this goes with what Ahmad et al reported in Pakistan in 2007.2 This feminine preponderance is well justified in our country, as most of the accidents were related to housekeeping activities. In total, 22 of 65 (34%) patients were children (under 12 years), and 43 of 65 (66%) patients were adults (above 12 years). Average age of female patients was 22 years, ranging from 9 months to 51 years. Average age of male patients was 25 years, ranging from 10 months to 59 years. Sadly, we noticed that most patients were of the younger productive age group, which negatively affects the national economy.

Extent and Depth of Injury
Mean %TBSA was 45% (range 14%–90%). Two previously published papers reported a mean %TBSA of 36% and 17% in Pakistan (2007) and South Africa (1996), respectively.1,2,5,4 In 52 of 65 (80%) cases, more than one anatomical area were involved. The abdomen, upper limbs, chest, and face were the most affected areas. In contrast, Sawhney et al showed that only 27% of cases in India included more than one anatomical area.1,2,3,4 All patients had deep partial thickness injuries (deep second
degree), and 45 of 65 (70%) patients had full thickness (third degree) involvement. It is notable that our reported %TBSA, the anatomical distribution, and the depth of injury were the vastest and the most severe in the literature, and this can confirm the extensive and deep nature of this kind of burn (Figs. 1, 2).

**Inhalation Injury**

Inhalation injury component based on clinical features was noticed in 36 of 65 (55%) patients, whereas Rajeev et al cited a percentage of 31% in India in 2011. Clinical features include history of injury in enclosed places, burns around mouth and/or nose, soot in mouth or nostrils, singed nasal hairs, intraoral burns/swelling, hoarseness of voice, and inspiratory stridor.

Mostly, this high incidence of inhalation injury is because of domestic activities like cooking in poorly ventilated, single room dwelling units. Moreover, others reported how just a single episode of inhalation injury in kerosene burns can leave a victim with chronic respiratory effects.

**Treatment Options**

Variable options of treatments are shown in Figure 3. Conservative treatment was indicated for only 4 of 65 (6%) cases, and this low percentage has also been confirmed.

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**Fig. 1.** These are examples of primus stove injuries. Note the large affected area and the depth of such injuries.

**Fig. 2.** These are further examples of primus stove injuries. Note the large affected area and the depth of such injuries.

**Fig. 3.** A bar chart showing the variable options of treatments in primus stove burn patients. FTSG, full-thickness skin graft. STSG, split-thickness skin graft.
by Ahmad et al in 2007 in Pakistan. In our study, a high percentage of surgical interventions with more than one theater session was reported, which reflects the severity of this kind of injury.

**Characteristics of Arrival**

Patient arrival was classified into two types based on required time for arrival: early referral (arrival within 5 hours post injury) and late referral (arrival after 5 hours post injury). In total, 62 out of 65 (95%) patients arrived late, which worsened the prognosis because the later the arrival, the worse the prognosis. Additionally, we can notice that 59 of 65 (90%) patients were transferred secondarily, which also worsened the prognosis. To explain the cause of the last two points, most of our burn patients come from regions unqualified enough in burn management in addition to their distant location from the capital, where our burn unit is located.

**Receiving First Aid**

In total, 42 out of 65 (65%) patients received first aid, but it was mostly inappropriate and, in some cases, was related to traditional medicine, which implies the low level of awareness pertaining to first aid for burns. This demonstrates the necessity of burn first aid training to raise this awareness.

**Morbidity, Mortality**

In our study, the average hospital stay was 30.5 days. In the medical literature, three authors documented it as 24 days in South Africa in 1994, 21 days in Pakistan in 2007, and 27 days in India in 2011. It is clear that our time period was the longest, and this is due to several factors, including high %TBSA, remote patient residences, and the current war.

In total, 16 of 65 (25%) primus stove burn patients died, whereas other authors have reported a mortality rate of 9% in Pakistan in 2007, 30% in Pakistan in 2006, and 50% in India in 2011. Numerous factors like high %TBSA, associated inhalation injury, age, preexisting illness, and time delay in receiving adequate resuscitation need to be considered in mortality statistics. Despite high TBSA and inhalation injury incidences in our article, mortality rate (25%) is considered moderate relative to the former figures.

**Number of Persons Affected by the Same Episode, Marital Status**

In 23 of 65 (35%) cases, more than one person was injured simultaneously—mostly family members, which negatively impacts the family structure emotionally and socially. In total, 42 out of 65 (65%) patients were married, and that aggravated the situation, similar to what Rajeev et al have reported.

**Educational and Economic Status**

Educational status was determined by literacy level, which, in our study, was defined as being able to read and write. It would be logical to suppose that the incidence would be lower among literate when compared with illiterate persons, and this is what we found in our study, as 55 out of 65 (85%) patients older than 6 years were illiterate. By revising what Rajeev et al have published (55%), we can note that the authors also linked these injuries with accidents and negligence. We can refer our high rate to the lack of education in the Syrian community, as a direct outcome of the ongoing war.

Regarding the economic status, it was simply classified into three categories (upper, middle, and lower classes) depending on the average monthly income. To our surprise, 52 of our 65 (80%) patients were within the middle category, in contrast to those reported by Rajeev et al, where they reflected in their study that all burn admissions were significantly higher among the lower middle class individuals when compared with the upper middle class.

**Level of Primus Stove (Floor/Platform), Clothing**

In total, 65 of 65 (100%) cases were at floor level, which reflects lack of acquaintance with safety usage instructions; besides, 55 of 65 (85%) patients were loosely dressed, therefore prone to catch fire.

This was confirmed by other authors, as they provided clear evidence that clothes catching fire while using kerosene stoves is a common risk factor. Additionally, they identified cooking on kerosene pressure stoves in the kitchen at ground level as the most common activity associated with such injuries. This imposes the necessity to launch awareness campaigns.

Based on our results and compared with other epidemiological and analytic reports, this study can give a descriptive profile of the patients injured by primus stove: the typical patient is young, illiterate, female, wearing loose clothing, injured in the kitchen around a stove, ignorant of safety instructions, experienced prolonged contact with fire, received inappropriate first aid, and was a secondary transfer with late referral.

To summarize, regarding the characteristics of primus stove burns, this kind of injury is larger in burned area, can affect multiple body parts, is associated with higher prevalence and severity of inhalation injury component, requires more debridement sessions, is more common among the less-educated population, and thus, has higher mortality and morbidity rates, compared with other burn injuries.

**Mixing Kerosene with Other Petroleum Products Calls for a Disaster, Mechanism of “Stove Burst”**

The current war situation prevents adequate supply of pure kerosene to consumers who would rather take the risk of refining crude oil themselves domestically. Hence, the resulting substances are impure and often contain a mixture of petrol, kerosene, and other petroleum products. Mixing kerosene with other petroleum products decreases the flash point, making the resultant admixture highly inflammable, and that is what was presented by Gupta et al in India, where they reported the resultant dramatic increase in burn admission due to this mixing.
escape of petrol and other product vapors under high pressure, which will catch fire, leading to the stove bursting into flames.\textsuperscript{2,6}

Additionally, the nozzle—which, through kerosene oil in jet form, goes to the burner—is often blocked due to the incomplete combustion of petroleum products, which results in a smaller flame. So the consumer continues to pump the stove, leading to an explosion known as “stove burst.” Moreover, while cleaning the blocked nozzle with a pin, a jet of burning kerosene oil under pressure can result in a flash fire or spillage of kerosene over clothing and subsequent ignition. The illiteracy and lack of acquaintance with possible risks is the most important factor in spreading this tragedy.\textsuperscript{2,3,6}

Economic Burden
The economic burden of treating primus stove burns is extremely grave on individuals themselves because of delay in returning to normal social and professional activities, on communities by loss of young productive population, and on national health resources for several factors such as long-lasting hospitalization, indication for more than one debridement session, and the increasing demand of transmission of blood units in addition to daily wound dressings. For example, acute management of primus stove burns costs more than twice as much as that of scald burns,\textsuperscript{1–4} not to mention the high cost of the rehabilitation and psychological support in the long run.\textsuperscript{1–4}

Prevention Strategies
Prevention is key in management. Prevention strategies should be based on Haddon’s Matrix tool, which is approved by WHO in burn injury prevention.\textsuperscript{1–7} This triangle tool consists of three elements: host (primus stove), environment (patient and community factors), and agent (fuel).\textsuperscript{1–7}

First, the stove should be manufactured with strict instructions that should be checked regularly by specialized organizations and health service systems such as the Paraffin Safety Association of Southern Africa and the South African Bureau of Standards, due to which primus stove admissions dropped in South Africa.\textsuperscript{1–7} For instance, manufacturing stoves that have big stands, are self-extinguishing in case of being knocked over, and are labeled with safety instructions with pictograms. Patient and community factors ought to rely on several points, including encouraging burn prevention programs, raising awareness of safe usage, media engagement, and promoting national days to commemorate the importance of burn prevention.\textsuperscript{1–7} In case of inevitable usage of primus stove, the fuel must be in a pure form—preferably, kerosene—due to the strong correlation between the impurity of fuel and the severity of injury.\textsuperscript{1–7}

CONCLUSIONS
Mixing kerosene with other petroleum products results in disaster. Primus stove injuries, which increased during war, are devastating and long-lasting, as they place a heavy emotional and economic burden on individuals themselves, the community, and health resources. This study provides a detailed analytic and epidemiological approach to these injuries, hoping to shed light on the severity of such cases, and stresses the importance of prevention, which is always better than cure. Analysis of the severe and long-lasting sequelae of primus stove burns does not only contribute to providing preventative strategies, but it also plays a crucial part of assessing the actual effectiveness of such preventative measures.

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