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Epidemiologic Investigation of Burn Patients in Sichuan Province, China

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Background: We investigated the epidemiology of patients admitted to the Burn Center of West China Hospital during 2011–2016, to provide measures for burn prevention.


Material/Methods: We conducted a retrospective review of patients admitted to the Burn Center of West China Hospital during 2011–2016. We collected information on patient demographics, burn etiology, burn extent, place of injury, education level, and burn knowledge of patients.

Results: A total of 1323 patients (1033 males and 290 females), mean age 35.4 years (range 10 days to 91 years), were admitted to our burn center. Among all patients, 214 were children aged 0–14 years, 998 were adults aged 15–59 years, and 111 were elderly adults over age 60 years. Scalds were the predominant cause of pediatric burns; however, flame burns were most common among adults and elderly patients. The injury location varied by age, with most burns occurring at work among adults; however, most children and elderly patients were burned at home. Educational levels were lower among adults from rural areas than those from urban areas, but both groups had little first aid knowledge. Furthermore, rural patients had received less vocational education and training than urban patients.

Conclusions: There has been a decrease in burn incidence in Sichuan Province. Flame injury should be a focus of attention in all age groups. Prevention programs for adults in the workplace are imperative. Burn prevention programs should continue to improve living conditions, especially for elderly people.

MeSH Keywords: **Accident Prevention • Burns • Education • Epidemiologic Studies**

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Background

Burns are a serious public health problem globally, accounting for an estimated 265 000 deaths annually. Non-fatal burns cause disability and disfigurement, which can lead to physical, psychological, and economic difficulties [1]. The Burn and Plastic Surgery Department of West China Hospital is the Burn Center of Sichuan Province. According to a population-sampling survey in China, the total population of the province was 82.04 million in 2015 [2]. Previous studies have reported the epidemiologic characteristics of burns among children and elderly adults admitted to the West China Hospital Burn Center [3,4]. Following rapid socioeconomic development and urbanization in China, standards of living in Sichuan province have risen substantially in recent years, accompanied by marked lifestyle changes. Therefore, further study of the epidemiologic characteristics of burns among patients admitted to the Burn Center of West China Hospital is warranted to re-evaluate burn prevention programs in the province.

Material and Methods

We performed a retrospective review of available medical records of all burn patients admitted to the Burn Center of West China Hospital between January 2011 and December 2016. Patients with mild burns that were treated in the home, local clinic, or in the emergency department were excluded from this study. Patients were stratified according to their activities and environmental factors and classified into 3 age groups: (1) children 0–14 years old, (2) adults 15–59 years old, and (3) elderly adults aged 60 years and above. Two attending physicians of the burn department estimated the total burn surface area (TBSA) among patients, according to the Rule of Nines and Rule of Palms. Patient demographics, burn etiology, burn extent, anatomical areas involved, place of injury, outcome, education level, and burn knowledge among patients were reviewed from the available medical records.

Results

Sex and age distribution and incidence rates

A total of 1323 burn patients were admitted to the Burn Center of West China Hospital between 2011 and 2016. The mean age of patients was 35.4 years, ranging from 10 days to 91 years old. A total of 214 cases (16.18%) were children aged 0–14 years, 998 (75.43%) were adults aged 15–59 years, and 111 (8.39%) were elderly adults aged over 60 years. The overall sex ratio was 3.56: 1, with 1033 male and 290 female patients. In the 3 age groups, the sex ratio was 1.97: 1 for children, 4.70: 1 for adults, and 1.58: 1 for elderly adults (Table 1). The catchment population of our department was recorded as approximately 82.04 million people, yielding a population-based admission rate of 2.69 per 100 000 population per year.

Annual and monthly distribution of burn events, 2011–2016

The annual average number of burn-related hospitalizations for the entire population from 2011 to 2016 was 221, with a maximum of 264 hospital admissions in 2013 (Figure 1). We determined the mean frequency of burn injuries for each month over the study period. The pattern of burn events fluctuated throughout the year, increasing between May and August, when the weather is relatively hot in Sichuan province. Monthly admissions data are shown in Figure 2.

Location of burn injury, by age category

In our study, 869 burns occurred outside the home and 454 occurred in the home. The location of injury varied by age, with most burn injuries (69.9%) occurring in the workplace among adults; however, among children (79%) and elderly adults (76.6%), most burns occurred at home. Interviews of all patients injured at home revealed that burns most commonly took place in the kitchen (52.3% in children, 11.1% in adults, and 36% in elderly patients) followed by the living room (18.7% in children, 20.7% in elderly adults, and 3.9% in adults) and the bedroom (4.7% in both adults and children, and 15.3% in elderly patients). The fewest injuries occurred in the bathroom, and 1 adult patient had burn injuries as a result of a lightning strike (Figures 3–5).

Table 1. Age and sex distribution of burn patients.

Age	Male	Female	Male/Female ratio	Patient (%)
Child (0–15 y)	142	72	1.97: 1	214 (16.18)
Adult (15–60 y)	823	175	4.70: 1	998 (75.43)
Elderly (>60 y)	68	43	1.58: 1	111 (8.39)
Total	1033	290	3.56: 1	1323 (100%)

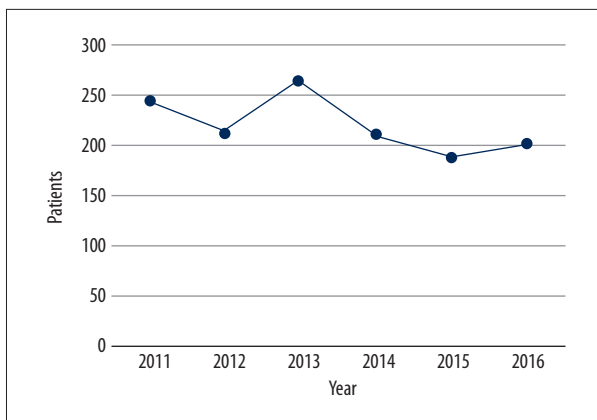


Figure 1. Annual number and distribution of burn events, 2011–2016.

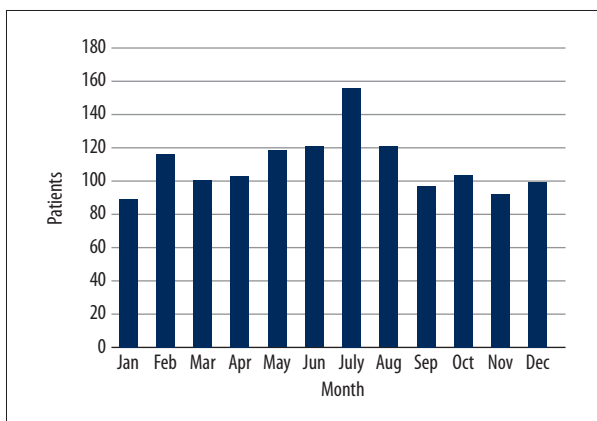


Figure 2. Mean monthly distribution of burn events, 2011–2016.

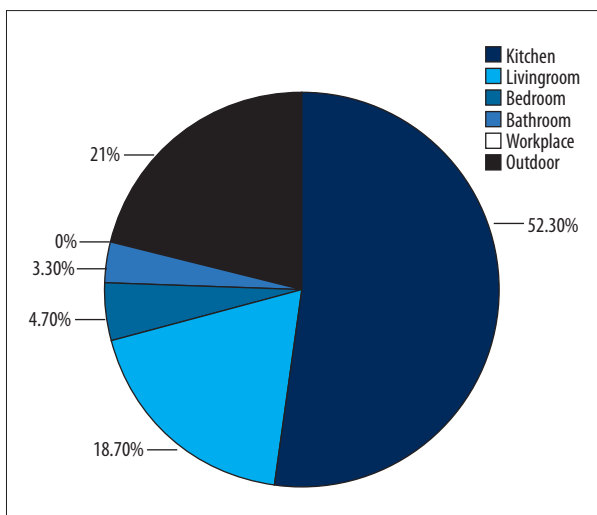


Figure 3. Location of burn injuries for children.

Anatomical site of burns

In this study, burns were categorized into 4 distinct anatomical areas. The extremities were the most common burn sites

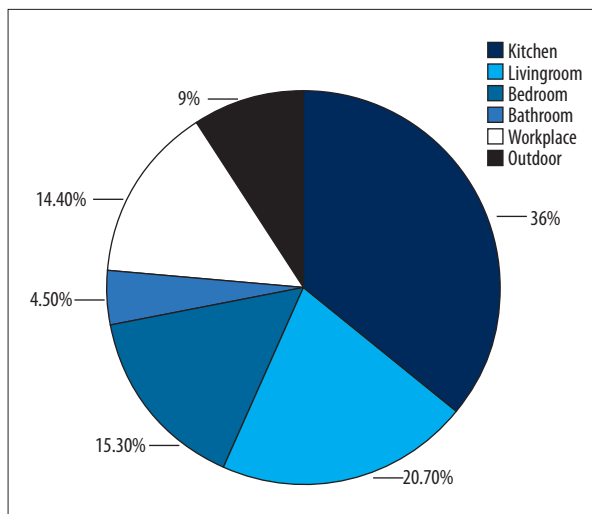


Figure 4. Location of burn injuries for elderly adults.

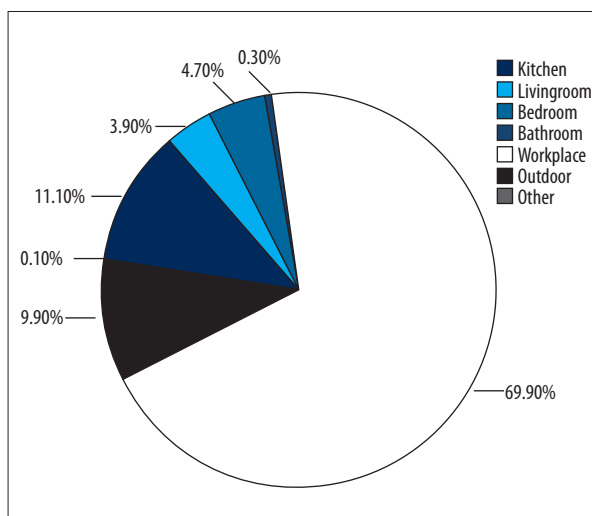


Figure 5. Location of burn injuries for adults.

(721 patients); this was followed by the head and face (635 patients), hands (601 patients), and trunk (including the buttocks and genitalia) (579 patients).

Severity of burns by age category

Burn severity was classified as mild, moderate, extensive, or critical, according to the Chinese categorization. For children, burn severity is classified as follows: mild (TBSA below 5%), moderate (TBSA 5–15%), extensive (TBSA 15–25%), and critical (TBSA above 25%). In our study population of children, the distribution of burn severity was as follows: 53.7% of burns were classified as mild, 25.7% as moderate, 11.7% as extensive, and 8.88% as critical. For the adult group, 46.8% of burns were classified as mild (TBSA below 10%), 25.2% as moderate (TBSA 10–30%), 15.8% as extensive (TBSA 30–50%), and 8.21% as critical (TBSA above 50%). Using the same severity categorization

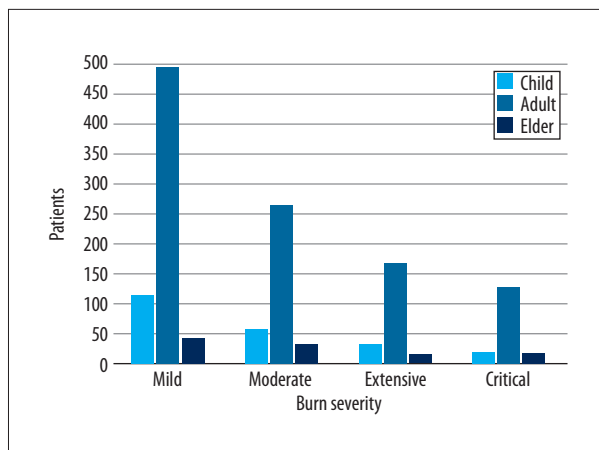


Figure 6. Severity of burns by age.

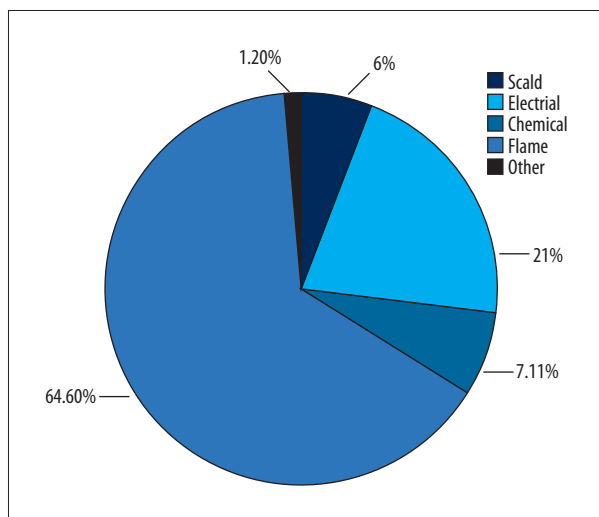


Figure 7. Etiology for adults.

as adults for elderly patients, 37.84% of burns among elderly adults were classified as mild, 29.73% as moderate, 15.32% as extensive, and 17.12% had burns of critical severity (Figure 6).

Burn etiology by age category

On the whole, burn etiology varied by age. In the adult group, flame was the predominant cause of burns, accounting for 64.6% of injuries, followed by electrical injuries (21%), chemical burns (7.1%), and scalds (6%) (Figure 7). Among elderly patients, flame was also the primary cause of burns (69.4%), followed by scalds (16.2%) and electrical (9.9%) and chemical (1.8%) injuries (Figure 8). Among children, scalds were the primary burn injury (50%), followed by flame burns (43.5%) (Figure 9).

Patient outcomes according to etiology

A total of 443 (33.48%) admitted patients required surgery for their injuries. More than half of surgeries were owing to flame

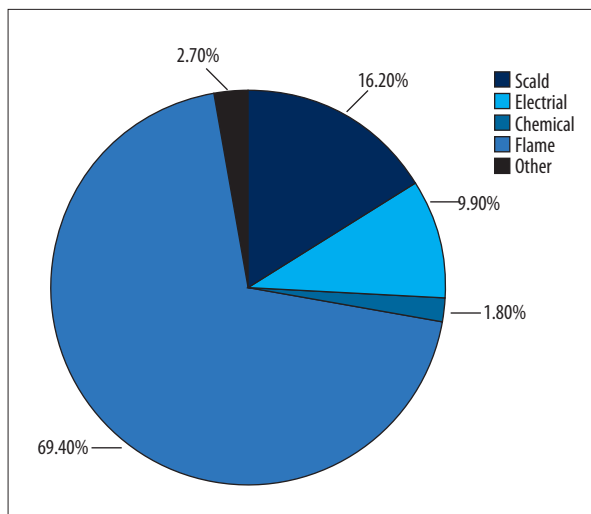


Figure 8. Etiology for elderly adults.

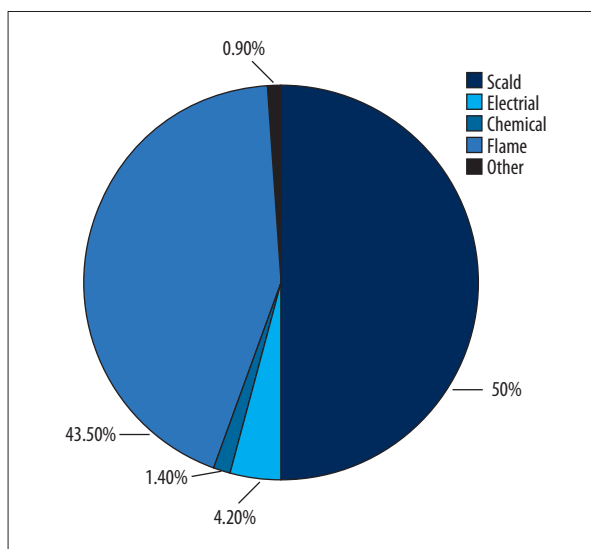


Figure 9. Etiology for children.

injuries, with a surgery rate for patients with flame burns of 30.6%. However, electrical injuries resulted in the highest surgery rate (59.1%), followed by chemical burns (44.7%). A total of 84 patients required amputation; 64 of these cases were owing to electrical burns, which had the highest amputation rate (27.8%). The mean length of stay (LOS) in the hospital among all burn patients was 25.8 days. Patients with flame burns had the longest mean LOS (28.8 days), and those with scalds had the shortest mean LOS (13 days). A total of 40 deaths yielded an overall mortality rate of 3.02%. Flame burns led to 30 of these deaths, with the highest mortality rate (3.68%); 6 deaths were owing to electrical burns, 2 to chemical burns, and 2 were owing to scalds, with the lowest mortality rate (1.08%). The burn severity among all 40 patient deaths was TBSA >45% (Table 2).

Table 2. Patient outcomes by etiology.

Patients (n)	Operated patients	Amputation rate	Mean length of stay (day)	Deaths
Electrical	136 (59.1%)	64 (27.8%)	25.4	6 (2.61%)
Chemical	34 (44.7%)	3 (3.95%)	21.3	2 (2.63%)
Scald	23 (12.4%)	0	13	2 (1.08%)
Flame	250 (30.6%)	17 (2.08%)	28.8	30 (3.68%)
Total	443 (33.48%)	84 (6.35%)	25.8	40 (3.02%)

Table 3. Association of education level with prevalence of burns.

15–59 908 (998)	Primary education (%)	Secondary education (%)	Tertiary education (%)	Knowledge of burn (%)	Knowledge of first aid (%)	Vocational education and training (%)
Rural 691 (769)	55.5% (384)	35.2% (243)	9.3% (64)	11.7% (81)	7.7% (53)	5.8% (40)
Urban 217 (229)	13.4% (29)	35% (76)	51.6% (112)	42.2% (121)	17.1% (37)	18.9% (41)

Relationship of education level with prevalence of burns

The educational levels of children and elderly patients included here were reported in our previous study. In the present study, we surveyed 998 patients aged 15–60 years, accounting for 75.43% of the total cases. Detailed information on 908 patients was available, including 237 from urban areas and 671 from rural areas. The majority of patients from rural areas had a primary (55.5%) or secondary level education (35.2%), and only 9.3% had a tertiary education. With respect to patients from urban areas, 51.6% had a tertiary level education, 35% a secondary education, and 13.4% a primary education level. Only 5.8% of rural patients in this study and 18.9% of urban patients had received vocational education and training. Regarding knowledge about and prevention of burns, 11.7% of rural patients and 42.2% of urban patients had some knowledge about burns; only 7.7% of rural patients and 17.1% of urban patients had knowledge of first aid (Table 3).

Discussion

In this study, we observed that the number of inpatients admitted to the Burn Center of West China Hospital decreased considerably, to 221 per year with a population-based admission rate of 2.69 per 100 000 population per year, compared with our previous study reporting 428 admitted patients per year with a rate of 5.15 per 100 000 population per year [3]. A decreasing trend was evident over the study period, which is similar to recent trends in burn epidemiology worldwide [5,6]. In recent years, China has joined the group of high-income countries

according to Human Development Index (HDI) data, published in the 2015 Human Development Report [7]. Following rapid socioeconomic development and urbanization in China, the standard of living and social environment has greatly improved, which may have contributed to the decreased prevalence of burns found in our study. For example, large houses with separate kitchen, dining, and living areas are now common. Even in rural areas, safer cooking facilities are installed in ordinary family homes, including water heaters, so that parents or guardians do not have to boil water using open fires. These changes help to protect children from being burned by flames and boiling water, which were common burn injuries among children in our previous study. This is reflected in the lower number of children among hospitalized patients (214 cases) and lower proportion of children (16.18% of total burn patients) in this study, compared with 1387 cases and a proportion of 46% of total burns in our previous study. The reduction in the number of pediatric burn patients may also be attributed to effective educational programs in burn prevention and first aid for children and guardians, especially those provided in schools by the government department of education.

In contrast to children, there were 111 elderly burn patients in our study, accounting for 8.39% of the total cases, which is much higher than in our previous study (103 elderly cases, 3.4% of total cases). This may be because many elderly adults still live in relatively old houses because of their lower pensions and social insurance. These dwellings are often poorly maintained and have aging electrical circuitry and old household appliances that are prone to fire. With the continuously growing elderly population in China, burn injuries among elderly

adults remain a challenge. More effective burn prevention programs should be implemented in this population, such as efforts to increase the investment of social security and improve the living conditions for elderly people in China.

Most previous studies have focused on limited patient populations, such as children or elderly patients. Children need to be supervised for prevention of accidents, due to not being mature enough to protect themselves, with little awareness of risk factors, and elderly people generally have multiple illnesses, and their reflexes are decreased, so they are also more vulnerable to accidents. In this study, 998 burns occurred among adults aged 15–60 years, accounting for 75.43% of total cases. Considering there are 52.03 million people aged 15–60 years (63.42% of the total population of Sichuan province, according to China National Bureau of Statistics data in 2015 [2]), epidemiological studies focused on this age group are also warranted to determine appropriate burn prevention measures to implement among adults. Burn prevention programs are always important in all age groups, because burns can happen anywhere, anytime, and to anyone.

Similar to other studies [8,9], there was a predominance of male burn patients in nearly every age group in our study, especially in adults, with a sex ratio of 4.70: 1. One explanation for this could be that more men than women are engaged in risky professions, and they are more likely to be injured in the workplace. Another possible reason is that men perform more household maintenance or leisure time activities that pose a higher risk of chemical, flash, and electrical injury.

Our study revealed that burns occurred most frequently from May to August, similar to other studies [3,10]. This may be attributable to the increased use of air conditioners and other electrical equipment due to relatively hot weather, leading to a high risk of fires. Burns can also occur more readily because of lighter clothing.

Similar to our previous study of children and elderly adults [3,4], the majority of burns occurred in the home (79% in children and 76.6% in elderly patients), and most burns happened in the kitchen. Burn prevention programs may benefit these 2 populations by emphasizing safety at home, especially in the kitchen. However, 838 burns injuries occurred outside the home and among adults, accounting for 84% of burn events among adults, similar to another report, from Beijing [11]. The majority of these injuries (698 cases) took place at work, accounting for more than half of all admitted patients. Unbalanced development of industrialization is reflected in Sichuan province, with a high proportion of labor-intensive production enterprises such as manufacturing, construction, mining, and chemical industries, which are associated with a high incidence of workplace accidents nationwide [12]. Therefore, this could be an

important cause of the high prevalence of burns in the workplace. Other reasons could be poor equipment maintenance and unsafe working environments, as well as a lack of safety protection measures and monitoring systems. Burn prevention programs for adults should emphasize safety and protection at work. Relevant supervisory institutions must improve monitoring and regulations, to reduce the incidence of burns at work.

In terms of the severity of burn injuries, as in other reports [13,14], we found that mild burns accounted for the largest proportion of injuries in all age groups. In children group, we observed a decreasing trend in burn severity, compared with our previous study on pediatric burns [3]. This trend may be explained by increased parental attention owing to smaller nuclear families and increased wealth, as well as expanded governmental healthcare coverage for children in China. The reduced injury severity of burns among children might be also attributable to effective programs teaching prevention and first aid. However, the proportion of severe burns was increased in the elderly age group compared with our previous elderly burns study [4]. This may be because many elderly patients lack access to medical treatment owing to lower pensions and health coverage. The number of elderly burn patients with TBSA under 10% is likely to be greater than that reported in our study. Overall, a clearly declining trend of burn severity was not seen among elderly patients in our study.

Similar to some pediatric burn studies [3,15] but in contrast to a report from Beijing [11], scalds were the primary cause of burn injury (50%) among children in the present study. However, flame was the predominant cause of burns in the adult and elderly patient groups, as in other reports [16,17]. Among adults in our study, 645 burn injuries were from flame (64.6%) and 230 from electrical injuries (23%). This indicates that 53.5% of burns occur at work and most are due to flame, electrical, and chemical injury, similar to the findings of an Egyptian study [18]. Although burn injuries have clearly decreased following improvement in the living standards and living environment in China, customs such as cooking food on an open fire, alcohol abuse, smoking indoors, and most importantly, a lack of fire safety monitoring systems in most residential homes (smoke alarms or sprinkler systems) are all likely causes of flame burns that occur in the home. Our results also showed that the proportion of flame injury among children increased to 44.4%, in contrast to our previous study (17.1%). Fire safety regulations and fire prevention in both the industrial and homebuilding sectors must be reviewed and improved.

Our findings revealed different outcomes according to the different causes of burn injury. Electrical burns led to more serious outcomes, with a 53.8% surgery rate; this was followed by chemical and flame burns. Electrical injury resulted in the

highest amputation rate (25.3%). In the present study, 40 patients died during the study period, yielding a total in-hospital mortality rate of 3.02%, which is much higher than in Western countries [19,20]. This may be related to the high proportion of patients with severe burns in this study. Among the 40 patient deaths, 30 were owing to injury caused by flame, the highest mortality rate (3.68%) by etiology. Scalds had the lowest mortality rate (1.08%) compared with those of electrical and chemical burns. Mortality was found to have a significant association with large-area burns. Our results showed that all deaths occurred from injuries with a burn size over 40% TBSA, accounting for 83.22% of the mean TBSA. Similar to other reports [21,22], mortality rates increased with inhalation injury; 24 of the 40 deaths in this study involved inhalation injury. The overall mean LOS was 25.8 days, which was longer than that of other studies in Taiwan [23] and Calgary [20]. This could be a consequence of a greater number of burns with larger TBSA, as the study site was a major burn center in Sichuan Province, with more severely burned patients admitted. Compared with LOS for scald injury, we found that electrical, flame, and chemical burns had longer LOS owing to more severe burn injuries that required lengthy hospital treatment. Therefore, further improvements in burn management and prevention measures by etiology are crucial to decrease the mortality and economic burden caused by severe burn injury.

As in our previous studies, education level was correlated with socioeconomic status. In the present study, we surveyed adult patients aged 15–60 years and found a considerably higher level of education among patients from urban areas than among those from rural areas; this difference was also seen with respect to knowledge about burns. Rural and urban patients had little knowledge about first aid, which may explain, to some extent, the greater severity of burns in our study compared with reports from other countries [24]. We further investigated knowledge about work safety in this age group and found that the majority of patients had no vocational education or training, especially rural residents who are more likely to be engaged in high-risk work under poor working conditions. This situation probably contributed to the high incidence of burn injuries at work in the present study. Education about burn prevention is critical among adult populations. In addition, the Chinese government should require companies to implement mandatory vocational education and training for their workers, especially those from rural areas, to reduce the incidence of burns.

As a consequence of increased socioeconomic development, there has been a decreasing trend in burn incidence in Sichuan Province, especially among children, which may also be attributed to our successful educational prevention programs, such as disseminating knowledge of burn prevention and first aid to patients or guardians by posters in our department, giving

lectures on burn prevention and first aid in kindergartens, schools, and community centers, as well as working with the media, particularly TV and radio stations, to educate the public about burn prevention and first aid in the form of interviews or health reports. Education on burn prevention and first aid is always a particularly effective part of prevention programs in all age groups. Patterns of injury differed by age and etiology in this study; therefore, it is necessary to develop age- and etiology-based burn prevention programs. As the primary cause of injury in our study, flame should be highlighted in prevention and treatment education. The majority of burn injuries occurred among adults in the workplace. Thus, it is imperative to improve the safety of equipment and the working environment and to provide compulsory education and professional training. Fire safety protection devices, such as smoke alarms and sprinkler systems, should be installed compulsorily in residential housing to lower the incidence and severity of flame burns that occur at home. Hospital admissions for burns only reflect the actual burn incidence rate to a certain extent. Further epidemiological studies based on more extensive, large-scale hospital registration networks are needed to more accurately assess the true incidence of burns. However, this study, which was based on hospital statistics, highlights concerns that should prove valuable for making recommendations on the focus of future preventive measures.

Conclusions

Our study revealed that the number of burn patients admitted to our burn center had decreased substantially, especially among children. On the whole, flame was the predominant cause of burns in this study. There was a high proportion of adult male patients hospitalized with flame burns, which mostly occurred in the workplace. In addition, burn injuries were more prevalent among patients from rural areas. Burn prevention strategies should focus on improvement of working conditions and compulsory vocational education. Education on burn prevention should be provided to all age groups, including adults engaged in high-risk occupations, to reduce the likelihood of burn injury. Most burns among pediatric and elderly patients occurred at home, mainly due to scalds and flame. Housing protection measures, particularly fire safety regulations, should be reviewed and improved.

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Conflict of interest

None.

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