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Research Article

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Epidemiological and clinical characteristics of burns in the older person: a seven-year retrospective analysis of 693 cases at a burn center in south-west China

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Abstract

Background: Burns are one of the major traumas that may affect older individuals. The purpose of this study was to investigate the epidemiological and clinical characteristics of geriatric burns at a major center in south-west China.

Methods: This retrospective study was conducted at the Institute of Burn Research, Southwest Hospital of Army Medical University between 2010 and 2016, and the data collected from medical records included admission date, age, gender, premorbid disease, burn etiology, injured anatomical location, burn area and depth, inhalation injury, number of surgeries, length of stay (LOS), clinical outcome, and medical cost.

Results: Of the 693 older burn patients included, 60.75% were male and 56.85% were aged 60–69 years. Burns peaked in December–March and June. Flame was the most common cause of burns, making up 51.95% of all cases, and also dominated in the burn patients aged 60–69 years. Limbs were the most common anatomical sites of burns (69.41%), and the median total body surface area (TBSA) was 5% (interquartile range [IQR]: 2%–15%). The percentage of the patients who underwent surgeries and number of surgeries significantly increased in the cases of contact burns, younger age and full-thickness burns. Six deaths resulted in a mortality of 0.9%. The median LOS was 16 days (IQR: 8–29 days), and the main risk factors were more surgeries, better outcomes, and full-thickness burns. The median cost was 20,228 CNY (IQR: 10,457– 46,581.5 CNY), and major risk factors included longer LOS, larger TBSA, and more surgeries. Furthermore, compared to the earlier data from our center, the proportion of older adults among all burns (7.50% vs. 4.15%), proportion of flame burns (51.95% vs. 33.90%), and mean age (69.05 years vs. 65.10 years) were significantly higher, while the proportion of premorbidities (16.9% vs. 83.9%), mortality (0.9% vs. 7.5%) and median TBSA (5% vs. 21%) were significantly lower.

Conclusions: This study suggested that closer attention should be paid to prevent burn injuries in older people aged 60–69 years, especially males, regarding incidents in the summer and winter, and flame burns. Moreover, tailored intervention strategies based on related risk factors should be under special consideration.

Key words: Geriatric burns, Epidemiology, Outcome, Cost, Risk factors

Background

As living standards and medical levels improve gradually, the number of older people in China has been increasing continuously in recent years. The national population census in 2010 showed that individuals over 60 years of age composed 13.26% of the total population, whereas statistics in 2000 indicated a figure of 10.33% [1]. As the population grows older, an increasing number of aged people are being admitted to burn units [2, 3]. Burns are one of the major traumas that this population may encounter [4, 5]. Compared with younger groups with similar total body surface area (TBSA) burned, older patients frequently have a higher mortality and a worse outcome, most likely due to poor physiological and psychological tolerances (e.g., atrophic skin, reduced mobility, weakened organ function, and comorbid diseases) [4, 6, 7]. Burn management in older people tends to be far more challenging [8, 9]. Thus, burns in the older persons, as one of the tough public health problems, should deserve special attention.

Our burn center, at the Southwest Hospital of Army Medical University (AMU), admits an annual average of about 1300 burned patients from south-western China, including Chongqing, Sichuan, and Guizhou provinces [10]. It is one of the earliest burn centers in China and one of the largest burn centers worldwide, with 107 beds for common treatment and 18 beds for intensive care [10]. In 2009, Li et al. [4] investigated 280 older burn patients (aged 60 years and older) who were admitted to our burn center from 1999 to 2006, and reported the relevant epidemiologic characteristics. However, no updated epidemiological data for geriatric burns in our center after 2009 are available. Specific and timely epidemiological investigation can be beneficial to develop effective preventive strategies, improve treatment effects, and reduce the economic burden. Therefore, in the present study, we aimed to identify the epidemiological and clinical characteristics of older burn patients admitted to our burn center in south-western China from January 2010 to December 2016.

Methods

Data collection

This retrospective study included 693 burn patients aged 60 years and older who were in hospital between January 2010 and December 2016 among 9196 burn patients admitted to our burn center at Southwest Hospital of AMU.

All of the patients took the standard treatment plan: fluid resuscitation (Third Military MedicalUniversity [TMMU] formula [11]), burn wound assessment and management, infection control, diagnosis and treatment of inhalation injury, nutritional support, and rehabilitation.

The data included the admission date, age, gender, premorbid disease, burn etiology, injured anatomical location, burn area and depth, inhalation injury, number of surgeries, length of stay (LOS), clinical outcome, and medical cost. Considering wound healing and basic conditions when the patient discharged, we classified outcomes as died, invalid, improved, or cured as follows: if the patient reached the end of his or her life, the outcome was considered as "died"; if the wound area was not significantly reduced or worsened after treatment, the outcome was identified as "invalid"; if the wound area was decreased but not completely removed, the outcome was seen as "improved"; and if the wound had fully healed, and there was no residual wound, the outcome was regarded as "cured". The response rate was defined as the sum of the improving rate and the cure rate. The Abbreviated Burns Severity Index (ABSI) [12], modified Baux score [13] and Burn Index (BI) [14] were computed for all patients.

The present study was approved by the Ethics Review Committee of Southwest Hospital of AMU (Chongqing, China), and patient information resources were anonymized and de-identified before analysis. The informed consent requirement was not required due to the retrospective nature of this study.

Statistical analysis

Statistics analysis was conducted using GraphPad Prism 6 (GraphPad Software Inc., USA) and SPSS 20.0 (IBM SPSS Software, USA). Qualitative data were summarized as counts and relative frequency. Quantitative data were presented as mean, standard deviation, median and interquartile range (IQR). For categorical variables or quantitative variables following non-normal distribution, the comparison of two or more groups was conducted by chi-square test, Mann–Whitney *U* test or Kruskal–Wallis test, and Dunn's test was performed as a post-hoc test to compare two groups. For the chi-square test, Fisher's exact test should be performed for correction of continuity when the total sample size was less than 40 or the theoretical frequency is less than 5. For quantitative variables with normal distribution, *t*-test or one-way analysis of variance (ANOVA) was adopted to make a comparison between two or more groups, and Scheffe's test was performed as a post-hoc test to assess the difference between two groups. Multiple linear regression analysis was performed to find the risk factors for LOS and medical cost. The p values less than 0.05 were considered statistically significant.

Results

General characteristics and premorbid diseases

As shown in Table 1 and Fig. 1, 693 patients were aged 60 years and older, accounting for 7.5% of the 9196 total burn patients admitted from 2010 to 2016. Overall, the annual incidence of older people (aged 60 years and older) among admitted burns showed a significantly increasing trend. The average age of the 693 older burn patients was 69.05 ± 7.58 years, ranging from 60 to 94 years. Among the 693 older burn patients, the two most affected age groups were 60–69 years (56.85%, 394/693) and 70–79 years (30.74%, 213/693), and most patients were younger than

80 years (Fig. 1a). The occurrence of burns reached its peaks in December–March and June, and hit lows in October–November and April (Fig. 1b). The rate of male versus female was 1.5:1. Inhalation injury was observed in 42 (6.1%) patients, with the highest proportion in 2014 and 2015. The overall surgery rate of the patients was 49.6%, and the highest percentage was found in 2015 (64.9%). The median LOS was 16 days. The total response rate and cure rate was 95.1% and 51.5%, respectively. The overall mortality was 0.9%. Moreover, the most frequent preinjury morbidities included hypertension (3.6%), diabetes (2.2%), and cerebral infarction (1.4%) (Table S1). One death was related to hypertension, causing a mortality rate of 0.14%, in comparison with a mortality rate of 0.72% in those without any previous illness. However, no significant association was found between premorbid disease and mortality in the patients ($p = 1.000$).

Etiologies

Flame was the most common cause, with a proportion of 51.95%, and the next most common cause was scald, accounting for 36.22% of all patients. Electricity, chemical, and contact burns accounted for 9.24%, 2.02%, and 0.58%, respectively (Fig. 2a). Among the 64 electrical burn patients, 38 (59.38%) were injured by current, and 26 (40.63%) were injured by an arc. From 2010 to 2016, flame burns showed a strong increasing trend. The number of scald burns fluctuated. Geriatric burns caused by the other etiologies showed steady trends (Fig. 2b). The prevalence of burns caused by different etiologies reached the peak at different times. August and September were the peak times of electrical burns, whereas summer (May–September) and winter (December–February) were the two peaks for flame burns. Moreover, March, June, and December were found to be the peak times of scald burns (Fig. 2c). Flame and scald were the major causes of burns at all ages (Fig. 2d). The ratios of male to female were also different according to the causes. The highest ratio was 7.0:1.0 for electrical burns, followed by moderate ratios for contact (3.0:1.0), flame (1.6:1.0), and chemical (1.3:1.0) burns, and the lowest ratio was observed for scald burns (1.1:1.0) (Fig. 2e).

Burn sites

As shown in Table S2, the limbs were the most commonly injured anatomical location, accounting for 69.41% (481/693) of the 693 patients. The second most common site was the trunk (28.14%, 195/693), followed by the head, face, and neck region (27.13%, 188/693). Different

Table 1. General characteristics of the older burn patients

Years	Geriatrics n (%)	Male/female	Age median (IQR), year	Inhalation n (%)	Surgery n (%)	LOS median (IQR), year	Response rate n (%)	Cure rate n (%)	Mortality n (%)
2010	69 (5.4)	1.2:1	66 (61–75.5)	2 (2.9)	24 (34.8)	18 (8–34)	68 (98.6)	35 (50.7)	0 (0)
2011	95 (6.1)	1.7:1	71 (65–77)	6 (6.3)	38 (40.0)	15 (10–27)	88 (92.6)	39 (41.1)	3 (3.2)
2012	80 (6.3)	1.1:1	67 (63–74)	2 (2.5)	35 (43.8)	19 (10.25–37)	80 (100)	44 (55.0)	0 (0)
2013	134 (8.9)	1.4:1	68 (63–73)	10 (7.5)	57 (42.5)	17 (8–29)	131 (97.8)	75 (56.0)	0 (0)
2014	99 (7.1)	2.1:1	66 (62–74)	10 (10.1)	55 (55.6)	17 (9–26)	95 (96.0)	55 (55.6)	1 (1.0)
2015	114 (10.2)	1.5:1	66 (62.75–75)	9 (7.9)	74 (64.9)	14 (8–30.25)	109 (95.6)	65 (57.0)	0 (0)
2016	102 (9.8)	2.1:1	67.5 (62–75.25)	3 (2.9)	61 (59.8)	15.5 (9.5–24.25)	88 (86.3)	44 (43.1)	2 (2.0)
Total	693 (7.5)	1.5:1	67 (63–74)	42 (6.1)	344 (49.6)	16 (8–29)	659 (95.1)	357 (51.5)	6 (0.9)
P value	<0.001†	0.195†	0.06‡	0.19†	<0.001†	0.612‡	<0.001†	0.104†	0.07†

IQR interquartile range, *LOS* length of stay
$p<0.05$ were considered statistically significant
†determined by chi-square test, ‡determined by Kruskal-Wallis test

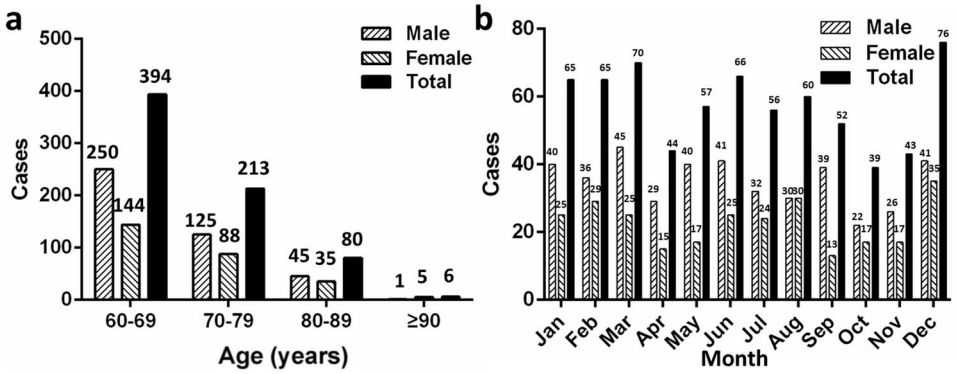

Figure 1. Age (**a**) and month (**b**) distribution of geriatric burns ($n = 693$). The patients were also divided by gender

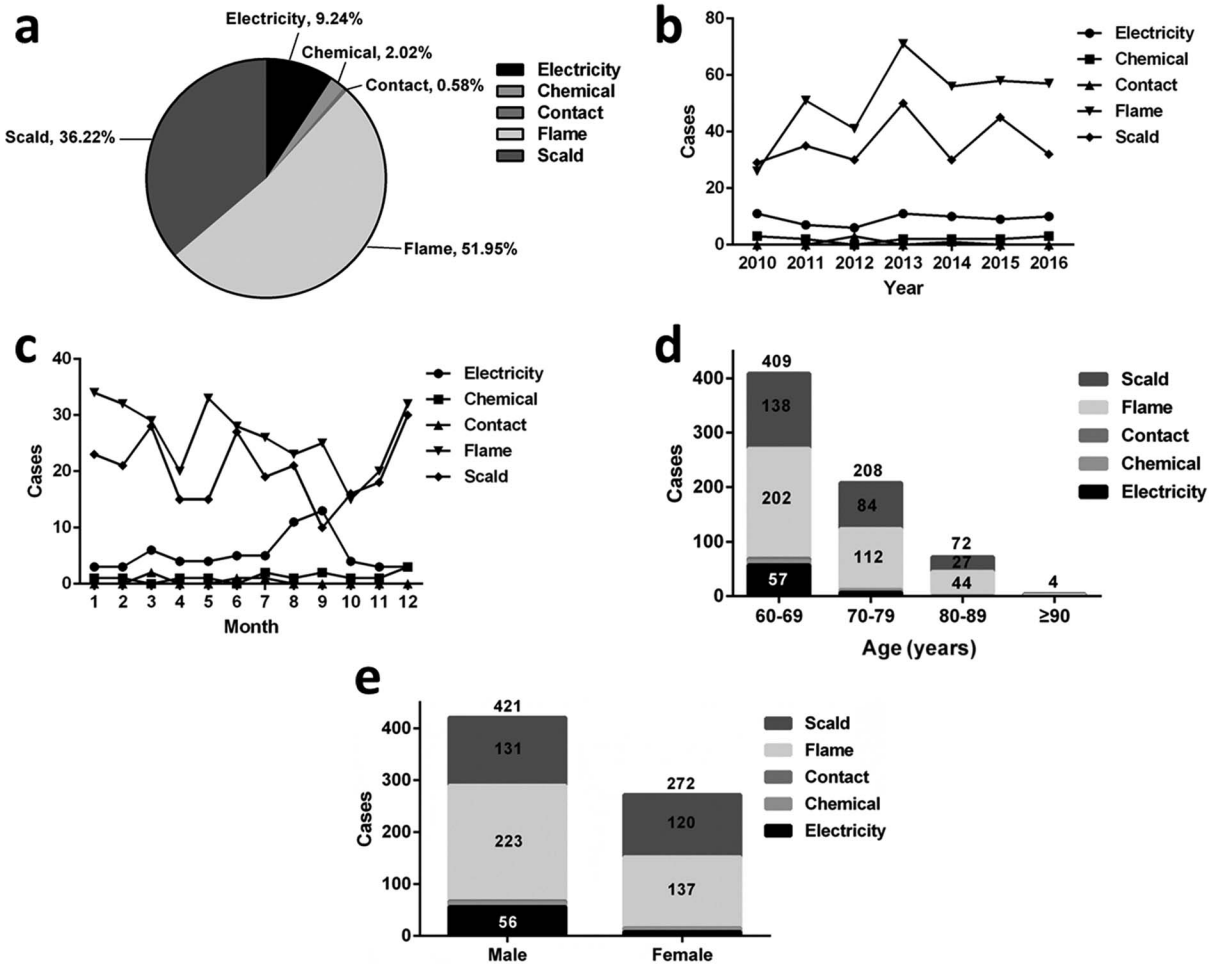

Figure 2. Etiology analysis-proportions and distributions. (**a**) Proportions of different causes. (**b**) Distribution of etiology by year. (**c**) Distribution of etiology by month. (**d**) Distribution of etiology by age. (**e**) Distribution of etiology by gender

causes tended to significantly affect different body sites ($p < 0.001$). Electricity was more likely to injure limbs and hands. Chemicals could easily result in burns to the limbs. Contact burns tended to occur on the hands. Flame and scald mainly led to limb and trunk burns. Moreover, flame was also prone to involve head/face/neck burns, whereas scald also frequently occurred on the feet.

Burn severity

The median TBSA was 5% (IQR: 2–15%). Patients with TBSAs of 0–10% and 11–20% comprised 67.97% and 14.72% of all cases, respectively (Fig. 3a). The distribution of TBSA exhibited remarkably different depending on the etiologies (Table 2). Contact burns had the lowest TBSA among all burns caused by different etiologies. Regarding the maximum burn depth, most patients had full-thickness burns (64.79%) and deep partial-thickness burns (34.49%) (Fig. 3b).

The median ABSI was 6 (IQR: 6–7) with a range from 4 to 17. The burn patients with ABSIs of 4–5, 6–7, and 8–9 accounted for 14.14% (98/693), 64.65% (448/693), and 12.70% (88/693) of all cases (Fig. 3c), respectively, predicting survival probabilities of 98%, 80–90%, and 50–70%, respectively. The median Baux score was 77 (IQR: 69–87), within the range of 61–186. Most patients (602/693, 86.87%) had a Baux score less than 100 (Fig. 3d), which predicted a mortality less than 25%. The median BI was 3 (IQR: 1–7) with a range from 0 to 62. The patients with BIs less than 10 and 10 or more accounted for 80.23% (556/693) and 19.77% (137/693) of all cases, respectively (Fig. 3e). A significant correlation was found between the etiologies and burn severity scores ($p < 0.001$; Table 2). The ABSI, Baux score, and BI of flame burns were all markedly higher than those of other burns ($p < 0.001$; Table 2). The ABSI of males was obviously lower than that of females ($p < 0.001$; Table 2). The ABSI and Baux score in patients aged 80 years and older were evidently higher than those of other age groups ($p < 0.001$; Table 2).

Surgeries and outcomes

The proportion of burn patients who received surgery was 49.6% and was significantly correlated to factors such as etiology, age, and full-thickness burns (Table 3). The percentages of the patients who underwent surgery and the number

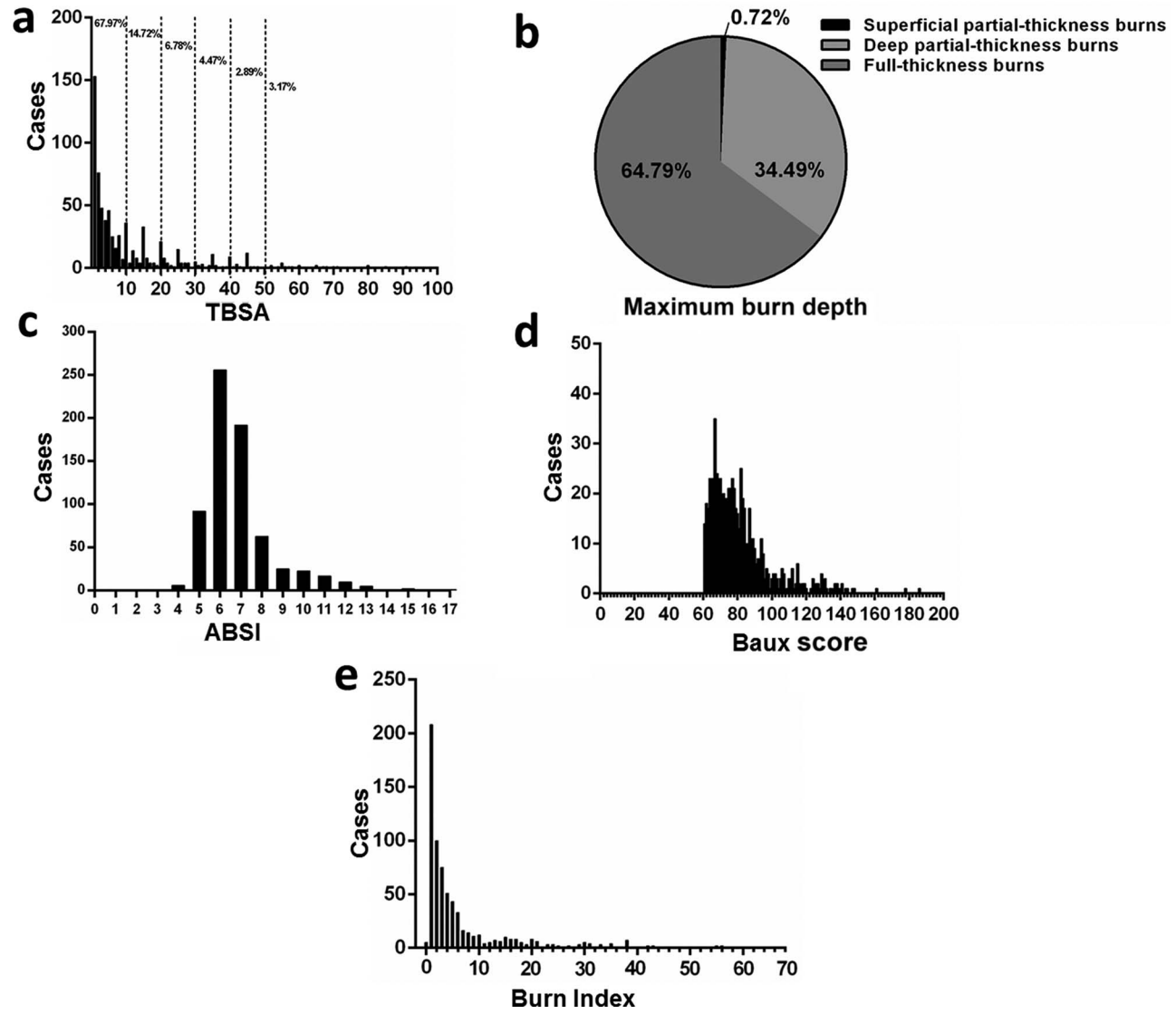

Figure 3. Burn severity distribution. (**a**) Distribution of total body surface area (TBSA). (**b**) Distribution of the maximum burn depth. (**c**) Distribution of Abbreviated Burns Severity Index (ABSI). (**d**) Distribution of the Baux score. (**e**) Distribution of the Burn Index

of surgeries were the highest for contact burns and lowest for chemical burns ($p < 0.01$). The number of surgeries for male patients was significantly greater than that for female patients ($p < 0.05$). The percentage of patients who underwent surgery and the number of surgeries showed a roughly decreasing trend as the age increased ($p < 0.05$). The percentage of surgeries and number of surgeries in patients with full-thickness burns were significantly higher than those in patients without full-thickness burns ($p < 0.001$).

The cure rate was obviously correlated with the etiology, full-thickness burns, and number of surgeries (Table 3, $p < 0.001$). The patients with contact burns, full-thickness burns and two surgeries had the highest cure rates, whereas the patients with flame burns, without full-thickness burns, and without surgery had the lowest cure rates. Among the 693 older burn patients, only six deaths were recorded. The mortality was extremely low (0.9%) and showed no significant difference among different etiologies, genders, ages, TBSAs, burn depth, and numbers of surgeries (Table 3).

Risk factors for LOS

The median LOS was 16 days (IQR: 8–29 days). The distributions of LOS and LOS/TBSA are illustrated in Table 3, and the multiple linear regression of factors associated to LOS is shown in Table 4. The age, gender, etiology, TBSA, full-thickness burns, inhalation injury, number of surgeries, outcome, and premorbid disease were incorporated into the regression model. Among these factors, more surgeries could result in the longest LOS (standardized coefficient = 0.355; $p < 0.001$), followed by better outcomes (standardized coefficient = 0.160; $p < 0.001$). According to the significant difference in the LOS and LOS/TBSA between different burn depths (with or without full-thickness burns), we could conclude that full-thickness burns were also likely to be a risk factor for LOS

Table 2. Burn severity analysis-distributions of total body surface area (TBSA), Abbreviated Burns Severity Index (ABSI), Baux score and Burn Index by etiology, gender, age and years

	%TBSA median (IQR)	ABSI median (IQR)	Baux score median (IQR)	Burn Index median (IQR)
Etiology				
Electricity	5 (1–10.75)	6 (5–7)	69 (64.25–75.75)	3.5 (1–6.38)
Chemical	2.5 (1–6.5)	6 (5.75–7)	75 (68.75–80.75)	1.5 (1–3.5)
Contact	1.5 (1–2)	5.5 (5–6.75)	63.5 (61.5–68.5)	1.5 (0.63–2)
Flame	10 (4–23.75)	7 (6–8)	82 (73–97)	5 (2–14.5)
Scald	2 (1–6)	6 (6–7)	74 (67–81)	1.5 (1–3)
P value	<0.001†	<0.001†	<0.001†	<0.001†
Gender				
Male	5 (2–15)	6 (6–7)	76 (69–88)	3 (1–7)
Female	5 (2–15)	7 (7–8)	78 (68–87)	2 (1–6)
P value	0.175‡	<0.001‡	0.569‡	0.131‡
Age (years)				
60–69	5 (2–15)	6 (6–7)	70 (66–81)	3 (1–6.75)
70–79	5 (2–15)	6 (6–7)	80 (76–88.75)	3 (1–6)
≥80	5 (2–15)	7 (7–8)	90 (86.25–100)	3 (1–9.38)
P value	0.835†	<0.001†	<0.001†	0.948†
Years				
2010	5 (2–15)	6 (6–7)	77 (69–85)	2.5 (1–5.5)
2011	5 (2–15)	7 (6–7)	80 (70–87)	3 (1–7)
2012	5 (1–14.25)	7 (6–7)	74.5 (68–83)	2.75 (1–5.38)
2013	6 (2–20.25)	6 (6–7)	76 (68–92.25)	3 (1–8.25)
2014	5 (2–12)	6 (6–7)	75 (67–86)	3 (1–5.5)
2015	5.5 (1–15)	7 (6–8)	76 (69–89.25)	3 (1–8.5)
2016	5 (1–15)	6 (6–7)	78 (69.75–86.25)	3 (1–7.63)
P value	0.606†	0.241†	0.521†	0.801†

IQR interquartile range

$p<0.05$ were considered statistically significant

†determined by chi-square test, ‡determined by Kruskal-Wallis test

(Table 3; $p < 0.001$). Moreover, electrical burns and contact burns required the longest LOS and LOS/TBSA among all the burns, respectively (Table 3, $p < 0.001$). Male patients also had longer LOS than female patients (Table 3, $p = 0.001$).

Risk factors for medical cost

The median cost was 20,228 CNY (IQR: 10,457–46,581.5 CNY). The distributions of cost and cost/TBSA are illustrated in Table 3, and the multiple linear regression of factors related to cost is shown in Table 5. Longer LOS could lead to the highest medical cost (standardized regression coefficient = 0.409; $p < 0.001$), followed by larger TBSA (standardized regression coefficient = 0.402; $p < 0.001$), more surgeries (standardized regression coefficient = 0.374; $p < 0.001$), death (standardized regression coefficient = 0.063; $p = 0.004$), respiratory diseases (standardized regression coefficient = 0.055; $p = 0.01$), inhalation injury (standardized regression coefficient = 0.057; $p = 0.017$), and neurological diseases (standardized regression coefficient = 0.045; $p = 0.039$). Moreover, full-thickness burns required much higher expenses than no full-thickness burns (Table 3, $p < 0.001$). Thus, full-thickness burns could also be considered as a risk factor for medical cost. Furthermore, electrical burns and contact burns had the highest medical cost and cost/TBSA among all the burns, respectively (Table 3; $p < 0.001$). Male patients spent much more than female patients (Table 3; $p < 0.001$).

Comparison with previous studies

To better illustrate the new findings, the epidemiological and clinical characteristics between our current study and previous similar studies were carefully compared, and the results are shown in Table S3. Furthermore, the important data of our present study and the earlier study at our center were analyzed statistically. As shown in Table S4, compared to the earlier data, the proportion of older adults among all burns (7.5% vs. 4.15%), proportion of flame burns (51.95% vs. 33.9%), and mean age (69.05 years vs. 65.1 years) were significantly higher, while the proportion of premorbidities (16.9% vs. 83.9%), mortality (0.9% vs. 7.5%), and median TBSA (5% vs. 21%) were significantly lower.

Discussion

Burns are becoming more common in the older population, leading to a growing problem. This study mainly presented the epidemiological and clinical characteristics of geriatric burns at our burn center in south-western China from 2010 to 2016 to further improve and individualize burn-prevention strategies or programs. This study is different from the previous study from our center [4] for the following reasons. First, the number of cases in our study is much larger;

Table 3. Distributions of length of stay (LOS), surgery, outcome and cost by etiology, gender, age, total body surface area (TBSA), full-thickness burns and surgery numbers

	LOS (days) Median (IQR)	LOS/TBSA (days) Median (IQR)	Surgery n (%)	Surgery no. Median (IQR)	Cured n (%)	Died n (%)	Cost (CNY) Median (IQR)	Cost/TBSA (CNY) Median (IQR)
Etiology								
Electricity	31.5 (17–50)	7.3 (2.3–15.8)	44 (68.8)	1 (0–1)	45 (70.3)	1 (1.6)	36,106 (18,877–81,090)	8612 (3253–20,806)
Chemical	15.5 (8.75–32.5)	4.3 (2.8–14.4)	5 (35.7)	0 (0–1)	9 (64.3)	0 (0)	16,002 (8847–33,950)	6624 (2792–10,066)
Contact	28 (12.25–79)	21.8 (9.1–43.4)	4 (100)	1 (1–1)	3 (75.0)	0 (0)	33,508 (13,697–89,909)	23,344 (12,188–46,463)
Flame	16 (8–30)	1.7 (0.7–4.5)	178 (49.4)	0 (0–1)	161 (44.7)	5 (1.4)	26,015 (11,759–75,359)	3170 (1368–8689)
Scald	15 (8–22)	6 (1.8–14)	113 (45.0)	0 (0–1)	139 (55.4)	0 (0)	14,128 (9096–23,538)	6045 (1977–13,005)
P value	<0.001†	<0.001†	0.002‡	0.003†	<0.001‡	0.224‡	<0.001†	<0.001†
Gender								
Male	17 (10–33)	2.9 (1–10)	221 (52.5)	1 (0–1)	220 (52.3)	5 (1.2)	23,044 (11,728–53,504)	5022 (1960–13,161)
Female	14 (8–24.75)	2.8 (1.0–8.4)	123 (45.2)	0 (0–1)	137 (50.4)	1 (0.4)	16,052 (9412–33,874)	3776 (1734–10,109)
P value	0.001††	0.577††	0.061‡	0.042††	0.627‡	0.255‡	<0.001††	0.054††
Age (years)								
60–69	18 (10–36)	3 (1.2–10.5)	203 (53.3)	1 (0–1)	224 (54.8)	3 (0.7)	21,711 (10,518–48,733)	4651 (1936–12,959)
70–79	15 (7–23)	2.8 (0.9–8.2)	98 (47.1)	0 (0–1)	98 (47.1)	3 (1.4)	18,277 (9664–46,572)	4664 (1827–10,410)
≥80	12 (4.25–22.75)	2 (0.5–9.5)	28 (36.8)	0 (0–1)	35 (46.1)	0 (0)	17,287 (10,206–34,623)	3149 (1355–10,909)
P value	<0.001†	0.044†	0.022‡	0.021†	0.118‡	0.463‡	0.127†	0.226†
TBSA								
0–10	16 (8–30)	3 (1–9)	238 (50.5)	1 (0–1)	240 (51.0)	4 (0.8)	20,467 (10,577–49,101)	5142 (1943–12,096)
11–20	14 (8–24.25)	2.4 (0.6–10.1)	48 (47.1)	0 (0–1)	54 (52.9)	2 (2.0)	19,742 (9932–40,657)	3128 (1358–8535)
21–30	19 (6–35)	3.9 (1.3–12)	20 (42.6)	0 (0–1)	19 (40.4)	0 (0)	14,501 (6923–46,572)	4106 (1882–8954)
31–50	22 (11–34)	2.8 (1.1–7.6)	26 (51.0)	1 (0–1)	30 (58.8)	0 (0)	20,820 (11,704–53,469)	3795 (1576–9630)
51–100	17 (11–25)	5.3 (1.2–12.6)	12 (54.5)	1 (0–1)	14 (63.6)	0 (0)	21,351 (11,873–54,618)	4209 (2302–14,468)
P value	0.359†	0.431†	0.808‡	0.765†	0.305‡	0.704‡	0.496†	0.22†
Full-thickness burns								
With	18 (10.75–35.25)	5.5 (1.4–14)	332 (73.9)	1 (0–1)	258 (57.3)	4 (0.9)	27,510 (13,896–68,327)	8292 (3271–15,607)
Without	13 (7–21)	1.5 (0.8–3)	12 (4.9)	0 (0–0)	99 (40.7)	2 (0.8)	12,084 (8094–20,535)	1878 (927–3086)
P value	<0.001††	<0.001††	<0.001‡	<0.001††	<0.001‡	1‡	<0.001††	<0.001††
Surgery no.								
0	11 (6–19)	1.5 (0.7–4)	0 (0)	0 (0)	127 (36.4)	2 (0.6)	11,580 (7110–19,925)	1960 (954–3497)
1	21 (14–40)	7 (2.3–15.4)	329 (100)	1(1)	219 (66.6)	4 (1.2)	35,760 (20,325–81,892)	10,519 (5509–17,946)
2	33 (19–40)	7.6 (2.6–14)	15 (100)	2 (2)	11 (73.3)	0 (0)	41,305 (20,005–89,858)	12,961 (6668–15,184)
P value	<0.001†	<0.001†	–	–	<0.001‡	0.508‡	<0.001†	<0.001†

IQR interquartile range

$p<0.05$ were considered statistically significant

†determined by chi-square test, ‡determined by Kruskal-Wallis test, ††determined by Mann-Whitney *U* test

Table 4. Multiple linear regression analysis of factors correlated to length of stay

	Unstandardized beta coefficients	Standardized beta coefficients	95% CI		*t*	*P* value
			Lower	Upper		
More surgeries	0.644	0.355	0.520	0.769	10.153	<0.001
Older ages	−0.023	−0.175	−0.031	−0.014	−5.233	<0.001
Better outcomes	0.314	0.160	0.180	0.448	4.594	<0.001
Female	−0.157	−0.078	−0.288	−0.025	−2.338	0.020

CI confidence interval

$p<0.05$ were considered statistically significant

thus, our investigation may be more representative. Second, the data obtained in our study are more comprehensive, possibly better reflecting the epidemiological and clinical characteristics of burns in the older persons. Finally, in this study, we used plentiful statistics, comparison of the data, charts, and graphic descriptions of methods to strengthen our conclusions.

In our present study, the older people comprised 7.5% of the total burn patients, which is higher than the proportions reported previously by our center [4] (7.5% vs. 4.15%, $p < 0.001$) and other Chinese centers [2, 15]. Moreover, the occurrence of geriatric burns increased annually, in contrast to the previous finding from our center [4]. These changes may be related to the increase in the older population in

Table 5. Multiple linear regression analysis of factors associated with total medical cost

	Unstandardized beta coefficients	Standardized beta coefficients	95% CI		*t*	*P* value
			Lower	Upper		
Longer LOS	0.019	0.409	0.017	0.021	17.438	<0.001
Larger TBSA	0.032	0.402	0.028	0.036	15.927	<0.001
More surgeries	0.814	0.374	0.715	0.912	16.25	<0.001
Death	0.800	0.063	0.264	1.336	2.93	0.004
Respiratory diseases	0.479	0.055	0.113	0.846	2.566	0.010
Cardiovascular diseases	−0.230	−0.050	−0.427	−0.033	−2.291	0.022
With inhalation injury	0.282	0.057	0.050	0.514	2.385	0.017
Neurological diseases	0.307	0.045	0.015	0.600	2.063	0.039

LOS length of stay, *TBSA* total body surface area, *CI* confidence interval
$p<0.05$ were considered statistically significant

south-western China in recent decades, who are always vulnerable to unintentional injuries (burns and trauma). Furthermore, the incidence of inhalation injury, LOS, response rate, and cure rate all fluctuated during the seven-year investigation. However, the male-to-female ratio and age distribution showed no remarkable changes. Thus, the current prevention and intervention of geriatric burns still need to be improved, deserving more attention and exploration.

Of the 693 older burn patients admitted, a male-to-female ratio of 1.5:1 was found, consistent with previous studies at our center and other Chinese burn centers [2, 4, 15]. By contrast, some studies in the other countries showed that women were dominant [6, 7, 16, 17]. Three potential explanations are proposed. First, the gender distribution of the older population varies in the different countries or regions. Second, in developing China, many retired older men are still engaged in dangerous fields such as construction and manufacturing with a high risk of occupational injuries (including burns). Finally, increasingly, more retired older men would like to participate in housework, and they are often subjected to unintentional burns by hot water or gas fires.

Our results showed that the most frequently occurring age group was 60–69 years, similar to the other report [2]. Furthermore, the percentage of victims aged 70–79 years had significantly increased compared with that previously reported by our center [4], suggesting that the age group of 60–79 years should be a primary target in the burn prevention programs. Correspondingly, the mean age of the older burn patients in our current study was also significantly older than that in the earlier study at our center (69.05 years vs. 65.1 years, $p < 0.001$) [4], mostly because human life expectancy has been getting longer in the past decade. Our results also demonstrated that the prevalence of burns decreased with age, while the burn severity scores, particularly the ABSI and Baux score, increased with age. In addition, the LOS, LOS/TBSA, and cure rate decreased with age. In China, the relatively young geriatric persons (aged 60–69 years) accounted for the highest proportion of the older population (aged 60 and older) [1]. Many of them still work in factories or outdoors, but they usually lack knowledge about safe operation and security defense. However, people older than 70 years are more likely to sustain burns or scalds in households [15]. Such people encounter many challenges of living alone, such as extinguishing fires, using stoves or ovens, managing a smoking habit, and operating electrical appliances [3]. Additionally, common geriatric conditions, including deteriorating health, reduced cognitive ability, and diminished mobility, all render them more vulnerable to severe burns [18]. Thus, burn prevention education should be tailored to age and working state. For the working older persons of relatively young ages, education should be emphasized to themselves and their employers. On the one hand, knowledge about burn injuries and awareness of self-protection should be enhanced via daily meetings and publicity materials. On the other hand, standardizing working rules and using personal protective equipment should be generalized and implemented across the fields. For the retired older persons at relatively advanced age, the target of the prevention project should be expanded to family members, maids, and carers. Identification of the at-risk location and activities plays a crucial role in older adult burn prevention. Prevention strategies should be focused on cooking, bathing, sleeping, and smoking. Moreover, rural and community doctors or workers should receive professional training and provide educational materials on geriatric burns to the older persons' families. However, any prevention program should be reviewed and repeated regularly to reinforce the messages.

The most common cause of burns in our study was flame, differing from previous reports from our center and others, where scald was the most common cause [4, 6, 19, 20]. Furthermore, the proportion of flame burns in our study was significantly higher than that in the earlier study at our center [4] (51.95% vs. 33.9%, $p < 0.001$). Moreover, scald was still the second most common cause of burns in our study, but had no significant difference as compared to that of the earlier study at our center [4] (36.22% vs. 36.1%, $p = 1.000$). Thus, we believed that the decrease in the incidence of other burns

(not scald) resulted in this change. Flames mainly arise from firewood, natural gas, fireworks, and alcohol. Scald burns are often caused by hot water, hot soup, and hot soil. Most of the above burns occurred in domestic activities [2, 15] and were caused by carelessness. These domestic burns in the older adults are preventable by educational programs based on causes. For example, the following preventive strategies could be adopted: cooking without wearing loose sleeves, testing water temperature prior to bathing, installing smoke detectors on all floors, and making regular quality control for construction or household maintenance. Furthermore, different preventive strategies should be implemented according to the time of injury. In our present study, flame burns often took place in the summer and winter, whereas scald burns were frequently found in the months of March, June, and December. The prime time of electrical burns was August and September, the hottest time in south-western China. The public health institutions and vulnerable population should emphasize the prevention of different types of burns in different months. However, all should consider that the peak time is only relative, and any type of burn could occur at any time. Therefore, burn prevention should also continue throughout the whole year.

In this study, the limbs were the most commonly injured site, followed by the trunk, head, face, and neck, similarly reported in other studies [2, 15, 20], usually resulting in physical and mental disability upon wound healing. Therefore, burn rehabilitation is very important to help older burn survivors improve life quality [9, 21]. Burn rehabilitation could be considered as a preventive strategy against adverse outcomes of burns [22]. A special team had been established for the early rehabilitation of hospitalized burn patients at our center since 2011, including two doctors, 10 rehabilitation therapists, two nurses, one psychological counsellor and one music therapist [23]. To enhance the doctors' awareness of rehabilitation in China, the experts from our center organized the guidelines for Chinese burn rehabilitation in 2015 [24]. However, the following still should be strengthened: investment for burn rehabilitation, education on burn rehabilitation, professional training, and long-term assessment.

Regarding the TBSA of burns, we found that most burns were smaller than 20% (0–10%: 67.79%; 11–20%: 14.72%), similar to other studies of older adult burns [2, 6, 15, 20, 25, 26]. However, in the previous report from our center [4], the burn patients with TBSAs of 0–10% made up only 28.9%, whereas burns of 11–30% and 31–50% TBSAs accounted for 43.57% and 21.07%, respectively. Accordingly, the median TBSA in our study was significantly lower than that in the earlier study at our center (5% vs. 21%, $p < 0.001$) [4]. The possible reasons are as follows. First, due to limited conditions, many burns with TBSA under 10% received treatment at community clinics or were treated by patients themselves at an earlier time. Second, the change in the etiologies in our present study may be associated with this discrepancy. Third, individual protection consciousness has grown in recent years, which is likely to reduce the number of extensive burns. Moreover, most of the older patients had full-thickness burns and deep partial-thickness burns. Based on the above findings, some older persons only suffered small burns, but these were always deep wounds and required surgical intervention. Some studies have shown that early surgery was beneficial for shortening healing time, reducing overall cost, and yielding better outcomes in burn patients [27–30]. In recent years, we have taken a positive attitude towards surgery for geriatric burns at our center over the centers from Sichuan [2] and Shanghai [15]. Our surgical and anesthetic teams are convinced that older people with burns should undergo surgery as soon as they are hemodynamically stable to reduce the risk of infection, functional disability, and aesthetic sequelae. Our results showed that the surgery rate has been increasing continuously. Moreover, the cure rate of the older persons who underwent surgery significantly increased by nearly 30% (66.86%, 230/344 vs. 36.40%, 127/349) compared to that of the older persons who did not receive surgery. Furthermore, in the present study, the number of surgeries and surgery rates differed significantly among etiologies, age, and burn depth. We found that more than half of the older adults aged 60–69 years underwent surgery, and the surgery rate was significantly decreased with increasing age. As traditionally reported [12, 31], age is a well-known adverse prognostic factor for burn patients. Of course, age should also be included in the considering factors for surgery in older adult burns. In the present study, the number of surgeries and surgery rates were comparably low in chemical and scald burns and were relatively high for contact and electrical burns, which could be due to different injury patterns and personal intentions of patients. Notably, a high proportion of chemical burns were caused by Chinese traditional medicines, resulting in initial hyperemia and delayed vascular damage, and resembling scald burns with an indeterminate depth. At our center, such burns initially undergo conservative therapy for 2 weeks unless full-thickness burns appear, which coincides with the ISBI practice guidelines [32]. Moreover, some older burn patients held the view that they were unable to tolerate surgery and would rather choose conservative treatments for deep wounds caused by strong acids, alkalis, or oxidizing solutions. Additionally, we found that 73.9% of the older persons with full-thickness burns and 5.0% of the older persons with deep partial-thickness burns underwent surgery, indicating that full-thickness burns were commonly treated with surgery and deep partial-thickness burns usually underwent conservative treatments. In fact, burn management, especially burn wound management in older people, is controversial [7, 33]. Surgery is a "double-edged" sword because it not only closes the burn wounds quickly but can also worsen medical conditions or cause death. Some researchers agreed that conservative protocols were less traumatic in older people, considering their frequent pre-existing comorbidities and poor tolerance of surgery [33, 34]. Therefore, evidence-based protocols for geriatric

burn treatment should be explored and adopted in the future.

The clinical outcomes are associated with many factors [18, 31, 35–37]. Our results revealed that the patients with contact or electrical burns, younger age, full-thickness burns, and more surgeries had relatively high cure rates. It is possible that the older population at relatively young ages tend to have better health and are more alerted to burns, leading to mild or moderate burn severity and favorable healing. Furthermore, contact and electrical burns often result in deep partial-thickness or full-thickness wounds, which could be well closed by early excision and skin grafting or skin flap coverage [38, 39]. However, the mortality in our study showed no significant difference among the etiologies, genders, ages, TBSAs, burn depths (with or without full-thickness burns), and treatment modalities (with or without surgery). Furthermore, the mortality rate of 0.9% was much lower than those of the earlier study at our center (0.9% vs. 7.5%, $p < 0.001$) [4] and other similar studies [2, 3, 15, 20]. These findings could be explained by the following. First, in our current study, the low mortality rate may associate with a relatively low proportion of inhalation injury (6.1%) and a high percentage of patients (67.97%) with TBSA under 10%. Second, some rural patients were more likely to die due to inaccessible, inadequate, or delayed medical treatment. Third, based on the Chinese tradition, many older patients with severe burns chose to give up treatment and died at home. Fourth, the level of medical care for geriatric burns has been considerably improved at our center during this decade. Additionally, 117 (16.9%) of the older burn cases had premorbid diseases. Cardiovascular disease was the most common pre-injury condition (6.8%). This situation is similar to that in other studies [2, 7, 15], but the percentage of premorbidities is much lower than that of the earlier study at our center (16.9% vs. 83.9%, $p < 0.001$) [4]. There are two possible explanations for this. On one hand, in today's China, thanks to the unremitting efforts that have been made, medical and healthcare systems covering both urban and rural residents have taken shape, the capabilities of disease prevention and control have been enhanced, the coverage of medical insurance has been expanded, continuous progress has been made in medical science and technology, and the people have become healthier and long-lived. On the other hand, it's possible that many pre-injury diseases were not recorded or identified. Furthermore, no association was found between pre-injury diseases and death in the older burn patients, consistent with some studies at other centers in China [2, 15], but in stark contrast to the previous study at our center [4]. One possibility is that statistical errors happen due to the small size of premorbid diseases and deaths in our present study; another possibility is that there may be a lot of life-threatening pre-existing comorbidities in the previous study at our center.

Our results showed that the median LOS was 16 days (IQR: 8–29 days) (average: 23.68 ± 26.10 days), which was comparable with those in previous studies [6, 20]. Moreover, consistent with other studies [25, 40], we found that LOS was positively associated with many factors—e.g., number of surgeries, outcome, burn depth, etiology, and gender. Among these, the number of surgeries and outcome were the main influencing factors, which could be explained by the following. First, the postoperative recovery and interval between two surgeries were likely to delay discharge. Second, some family members preferred to let the older persons stay in the hospital until they were fully recovered. Third, to gain a better outcome, the treatment strategies were usually comprehensive and time-consuming. We also found that the median cost was 20,228 CNY (IQR: 10,457–46,581.5 CNY) (average: $51{,}673.3 \pm 100{,}405.2$ CNY), which was much higher than that obtained in a study undertaken in Shanghai [15]. The difference might be due to differences in the severity of burns, therapeutic method, and treatment expectance [41]. Similar to LOS, our results also showed that the LOS, TBSA, number of surgeries, death, some pre-existing comorbid disease, etiology, gender, and burn depth were related to the hospitalized cost. The potential reason may resemble the explanation provided above for the LOS. Although the national economy has developed rapidly, medical insurance coverage only includes emergency medical costs, not costly medicines/consumables and rehabilitation therapy, a cost which has to be borne by the patients. Additionally, with the rapid development of Chongqing, many rural older patients come to the city for medical care without health insurance, and medical costs have become a very serious problem they have to confront. Therefore, it is highly recommended for the government and society to set up special medical insurance or charity foundations to help older burn patients.

However, the findings of this study should be interpreted carefully due to the following limitations. First, our study did not contain patients who might have died at the scene of burns, on the way to our center, and in basic hospitals, those who received treatment as outpatients, and those who never sought medical care for social, economic, or other reasons; hence, we could not estimate the exact morbidity and mortality. Second, owing to the retrospective nature of this study, we could not assess the long-term morbidity, disabilities, pattern of rehabilitation, and social costs. Third, this study was carried out at a single burn center, which only partially reflected the epidemiology of geriatric burns in Southwestern China. Thus, it is recommended to perform further well-designed multicenter studies with a long-term follow-up to improve the limitations of the current study [42]. Fourth, in this study, there were only six deaths, which is insufficient to analyze the risk factors for mortality.

Conclusions

This study described the epidemiological and clinical characteristics of geriatric burns at a major center in south-west China from 2010 to 2016 and analyzed the risk factors for length of stay and medical cost. Our findings showed that

older people aged 60–69 years, males, incidents occurring in the summer (May–September) and winter (December–February), and flame burns should be considered as the key prevention targets. Furthermore, individualized intervention strategies based on related risk factors such as electrical burns, contact burns, full-thickness burns, burns with respiratory and neurological diseases, inhalation injury, larger TBSA, higher number of surgeries, and better outcomes should be taken.

Supplementary data

Supplementary data are available at *Burns & Trauma Journal* online.

Declarations

Not applicable.

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Availability of data and materials

Not applicable.

Authors' contributions

WQ and GL conceived, designed, drafted and revised the article; WQ, SW, YW, XZ, ML, RZ, YH, and WH were responsible for data analysis and interpretation, revision. All authors approved the final article.

Ethics approval and consent to participate

The prospective study was approved by the Ethics Review Committee of Southwest Hospital of Army Medical University. The informed consent requirement was not required due to the retrospective nature of this study.

Consent for publication

Not applicable.

Conflicts of interest

The authors have no conflicts of interest to declare.

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