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The epidemiology and prognosis of patients with massive burns: A multicenter study of 2483 cases

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ABSTRACT

Objective: Epidemiological features of massively burned patients in China remains unclear. This study was designed to investigate the epidemiological characteristics and evaluate the burn index (BI) and other risk factors associated with the prognosis of massively burned patients.

Methods: Data of patients with ≥30% total body surface area burned admitted in 2014 were retrieved from 106 burn centers in the mainland of China. Information of epidemiological features and the outcome were collected for retrospective analysis.

Results: A total of 2483 massively burned patients were included in this study, with a male-to-female ratio of 2.29:1, the mean age of 49.23±16.67 years, mean TBSA of 55.53±21.39% and the mean BI of 39.75±21.59. Scald accounted for 81.07% of the injuries in children, while flame accounted for 66.89% and 74.31% of the injuries in adults and seniors. Approximately 17.76% of the patients were admitted to the local burn center after 6h of injury, and the wound areas of 1154 (46.48%) patients were covered with folk remedies. The mortality was 9.79%, and the area under the receiver operating characteristic (ROC) curve for BI was 0.941 (95% CI, 0.929–0.954). When the value of BI was above a threshold of 29 in the 0–14 years age group, 43.5 in the 15–59 years age group and 35.5 in the 60 years or older age group, the mortality increased significantly. Multivariate logistic regression analyses showed that the odds ratio (OR) of death increased 6% with an increase in the BI of 1.0. Patients older than 60 years, the admission time longer than 6h after-injury (adjusted OR, 1.797; 95% CI, 1.179–2.740;

Abbreviations: BI, burn index; TBSA, total body surface area; ROC, receiver operating characteristic; OR, odds ratio; CI, confidence interval; AUC, area under the curve.

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adjusted $p<0.001$), and patients with a combined inhalation injury (adjusted OR, 6.649; 95% CI, 4.517–9.789; adjusted $p<0.000$), were at higher risk of death.

Conclusions: There are etiological characteristics of the different age groups that should be considered for prevention. BI can be a reliable index of prognosis in severely burned patients. The results of the study showed that a large BI, elderly age, delayed admission after injury and combined inhalation injury are the main risk factors for extensively burned patients.

1. Introduction

Modern developments in burn care have greatly decreased mortality caused by burn. However, the treatment of massively burned patients remains a global challenge due to the lack of autologous skin and the great risk of complications [1,2]. Although patients with burns covering 30% or more of their total body surface area (TBSA) compose only approximately 10% of the total burn injury patients, the mortality is substantially high in this group [3–5]. The 2012 American annual report of burns indicated a 34% mortality rate among patients with burns covering 30% or more of their TBSA [4]. However, death is only part of the problem for patients with large area burns. Indeed, most survivors are left with lifelong disabilities and disfigurements, which have far-reaching effects on family and society. It is therefore important to explore the epidemiological characteristics and identify the risk factors influencing the prognosis of patients with severe burns.

The past several decades have witnessed the rapid development of burn science with the efforts of nearly three generations in China. Our surgeons and scientists have explored many effective and useful methods and techniques in the diagnosis and therapy of burn injuries, but burn prevention remains a weak point in China [6]. To be effective in a particular area, burn prevention should be based on the sound knowledge of local epidemiological characteristics and associated risk factors [7]. Several studies on massive burn injuries have been conducted in different regions of Belgium, Spain, Turkey and the Netherlands [8–11]; however, no parallel study has been performed in China. The present study was designed to explore the epidemiological characteristics and risk factors associated with the prognosis of massively burned patients.

The prediction of the survival and outcomes of burn patients has always been an important goal of burn research. In 2012, Kraft et al. assessed burn size and survival probability in a sample of 952 severely burned pediatric patients treated between 1998 and 2008 and found that a burn size of 62% of the surface area of the body was a crucial risk factor for mortality [12]. However, the severity of burn injury was closely associated with both burn size and burn depth. Herein, we describe the severity of the burn injury by burn index (BI = full thickness TBSA + 1/2 partial thickness TBSA) [13] and explore the predictive value of BI using ROC analysis.

We hope that our investigation will provide useful information for the prevention and treatment of burns to help reduce the morbidity and mortality of burn injuries.

2. Methods

2.1. Patient selection

To conduct this retrospective observational multicenter study, a new database was initiated by the department of Burn and Plastic Surgery at the Burn Institute of the First Hospital Affiliated to the Chinese People's Liberation Army (PLA) General Hospital. This database used a standardized structured questionnaire that was designed by clinicians and epidemiologists and administered and checked by local investigators to collect data on patients with massive burns. Data on patients from 106 hospitals in 30 provinces across mainland China were included in the database (not including Tibet). Hospitals in China are organized according to a 3-tier system that recognizes a hospital's ability to provide medical care, medical education, and conduct medical research. Following each review, each hospital was assigned a grade of A, B, or C, Grade C hospitals serve township- level communities or countryside populations. Grade B hospitals serve county-level regions and cities, and accept referrals from Grade C hospitals. Grade A hospitals serve prefecture-level regions throughout the entire province, even nationwide, and accept referrals from Grade B hospitals. Each of the hospital was subdivided into three classes: 3A > 2A > A > 3B > 2B > B > 3C > 2C > C [14]. In this study, 79 burn units are affiliated to Grade 3A hospitals (71.70%), 18 burn units to Grade 2A hospitals (16.98%), and 7 burn units to Grade 3B hospitals (6.60%). The other 2 are private hospitals that are not classified by this 3-tire system. The geographic distribution of the 106 burn units was shown in Supplementary Material.

The study protocol was approved by the Ethics Committee of The Fourth Medical Center of Chinese PLA General Hospital, and all other participating hospitals provided a feasibility statement.

Massive burns were defined as a total burn area of 30% or greater of the TBSA. All patients admitted to the burn departments of the participating hospitals with massive burns between January 1, and December 31, 2014, were included in the database. Those who were transferred or discharged and stopped treatment within 24h after admission and patients with cutaneous injuries from traumatic sources other than burns were excluded.

2.2. Data collection and definitions

Information on the age, gender, time of the injury, admission time, prehospital emergency care, burn etiology, burn area (including second-degree burns and full-thickness burns), the presence of combined inhalation injury and the outcome were collected using a standardized and structured questionnaire for analysis.

The burn area was assessed according to the Chinese Rule of Nines, which was used to calculate the body surface area burned by dividing the full body surface area into eleven sections of 9% each. This rule was widely adopted after the 1970 National Burns Conference in China [15]. Inhalation injury was defined as airway edema and inflammation, mucosal necrosis and the presence of soot and charring in the airways on clinical inspection [2]. Each of the participating centers used standardized protocols for the treatment of massively burned patients on initial treatment, wound care, nutrition, metabolism and complications. The standardized protocols were mainly based on the national guidelines published by the Chinese Medical Association (CMA) in 2007 [16] and the *Practical Burn Surgery* in Chinese, edited by Chai JK, the former chief of the Chinese society of burns in 2014 [17]. With respect to the prehospital emergency care of the burn wounds, cooling, disinfection and dressing were considered rational remedies. Any external agents placed over the burns, including toothpaste, soy sauce, eggs, oil or other folk remedies, which may cause secondary infection, bacterial imbalance or resistance, or interfere with subsequent assessments of the burn depth, were considered improperly dispensed [18].

The patients were classified into three age groups: children (0–14 years), adults (15–59 years) and seniors (60 years or older) [2,18,19]. Based on BI, we further stratified the patients into seven groups to compare their background characteristics.

2.3. Statistical analysis

Continuous variables were compared using the chi-square test or the Mann–Whitney U test, whereas categorical variables were compared using the χ^2 test or Fisher's exact test in the different age or BI groups where appropriate. The BI and other risk factors were then assessed to determine whether they were associated with the prognosis of the patients.

To evaluate the predictive value of BI for prognosis, receiver operating characteristics curve (ROC) analysis was used to calculate the area under the curve (AUC). Youden's index was calculated to determine the optimal cut-off point. Following the univariate analyses, a forward stepwise logistic regression was performed using variables at a significance level of p-<0.1 to identify the independent predictors for prognosis. $p<0.05$ was considered statistically significant. All statistical analyses were performed using IBM SPSS version 20 (IBM Corp., Armonk, NY, USA).

3. Results

3.1. Age and gender of the patients

The mean age of the patients was 49.23 ± 16.67 years (range: 1–97 years). Children, adults and seniors represented 19.57%, 67.34% and 13.09% of the cases, respectively. Patients with the highest incidences of burns in the three age groups were children under the age of 3 (67.49%), adults aged 40–49 years (33.05%) and seniors aged 60–69 years (55.05%) (Fig. 1).

Males accounted for 69.59% of the 2,483 patients, and females accounted for 30.41%, corresponding to a male-to-female ratio of 2.29:1 (1728:755). This ratio was even higher in adults (3.04:1) and relatively low in the children (1.42:1) and senior groups (1.32:1). Gender difference in age distribution was statistically significant (<chi>2=77.944, $p<0.001$) (Table 1), and the male was dominant throughout the entire age group except that of age ≥70 years. (Table 1), (Fig. 1). The gender composition did not differ significantly in the BI groups (χ^2=5.230, p=0.515) (Table 2).

3.2. Seasonal distribution of burns

Massive burns occurred at almost any time of the year. Nonetheless, these injuries were more prevalent in April through August (57.47%). During this time period, 55.76% of children, 59.70% of adults and 48.62% of seniors were injured. These periods were thus identified as high-risk time periods for sustaining massive burn injuries.

3.3. Admission time after injury and prehospital emergency care

Nearly one-fifth of the patients (17.76%) were admitted 6 or more hours after the burn injury. The corresponding

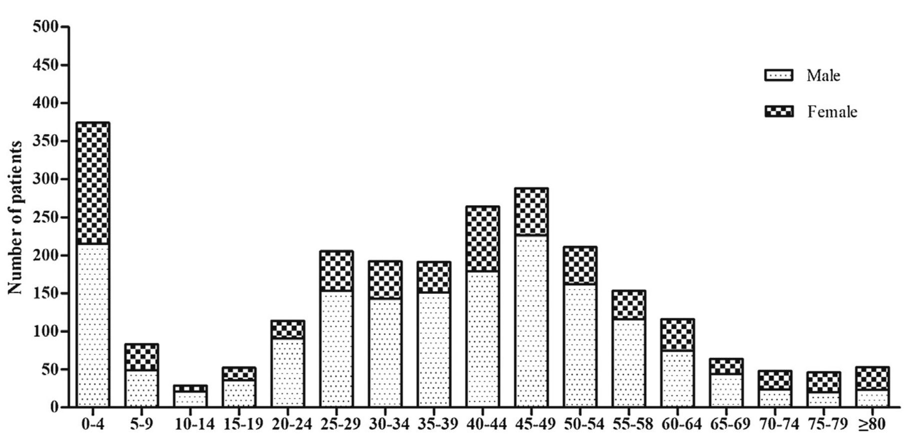

Fig. 1 – Age and gender distribution of massively burned patients.

Table 1 – Epidemiological characteristics of patients in different age groups.

Patient characteristics	All patients $n=2483$	0–14 years $n=486$	15–59 years $n=1670$	60 years and older $n=327$	P[a]
Gender, n (%)					<0.001
Male	1728 (69.59)	285 (58.64)	1257 (75.27)	186 (56.88)	
Female	755 (30.41)	201 (41.36)	413 (24.73)	141 (43.12)	
Admission time after injury, n (%)[b]					<0.001
0–6h	1957 (78.82)	435 (89.51)	1289 (77.19)	233 (71.25)	
Over 6h	411 (17.76)	42 (8.64)	318 (19.04)	81 (24.77)	
Prehospital emergency care of burn wound, n (%)[c]					<0.001
Rational remedy[d]	417 (16.79)	57 (11.72)	312 (18.68)	48 (14.68)	
Improperly disposed[e]	1154 (46.48)	236 (48.56)	769 (46.05)	149 (45.57)	
Without treatment	810 (32.62)	164 (33.74)	533 (31.92)	113 (34.56)	
Etiology of burns, n (%)					<0.001
Flame	1431 (57.63)	71 (14.61)	1117 (66.89)	243 (74.31)	
Scalds	776 (31.25)	394 (81.07)	314 (18.80)	68 (20.80)	
Others[f]	276 (11.12)	21 (4.32)	239 (14.31)	16 (4.89)	
Burn index, mean (SD)	39.75 (21.59)	27.69 (15.18)	43.98 (22.69)	40.81 (18.45)	<0.001
Inhalation injury, n (%)	804 (32.38)	43 (8.85)	614 (36.76)	147 (44.95)	<0.001
Outcome, n (%)					<0.001
Survived	1887 (76.00)	402 (82.72)	1332 (79.76)	153 (46.79)	
Transferred	165 (6.65)	61 (12.55)	76 (4.55)	28 (8.56)	
Gave up treatment	188 (7.57)	3 (0.62)	103 (6.17)	82 (25.08)	
Died	243 (9.79)	20 (4.12)	159 (9.52)	64 (19.57)	

[a] P value was estimated by the chi-square test, Kruskal–Wallis H test or Fischer's exact test as appropriate.
[b] $n=2398$ patients, with 85 missing.
[c] $n=2381$ patients, with 102 missing.
[d] Rational remedy indicates that the wound received proper disinfection and dressing.
[e] Any external agents, including toothpaste, soy sauce, eggs, oil or other folk remedies, which may cause secondary infection, bacterial imbalance or resistance, or interfere with subsequent assessments of the burn depth, used to cover the wound were considered improperly dispensed treatments.
[f] Causes of burn injury other than flames and scald.

percentages in children, adults and seniors were 8.64%, 19.04% and 24.77%, respectively, and there were statistically significant differences in the admission time among the different age groups ($\chi^2=42.769$, $p<0.001$) (Table 1). However, no significant differences were found among the different BI groups ($\chi^2=8.829$, $p=0.183$) (Table 2).

With respect to the prehospital emergency management of burn wounds, only 417 patients (16.79%) received proper disinfection and dressing. Conversely, 810 patients (32.62%) did not receive any drug or wound dressings. The wound areas of 1154 (46.48%) patients were covered with folk remedies such as toothpaste, soy sauce, eggs or other substances that could hamper the healing or evaluation of the wound. There were significant differences in the prehospital emergency management of burn wound patients among the age groups ($\chi^2=255.044$, $p<0.001$) and BI groups ($\chi^2=27.822$, $p=0.006$) (Table 1 & 2). Additionally, in patients that were admitted after 6 or more hours, 37 patients (8.39%) received proper disinfection and dressing, 132 patients (29.93%) did not receive any prehospital wound treatment, and 251 (52.92%) patients were covered improperly with folk remedies. However, in patients that were admitted within 6h, 374 patients (19.11%) received proper disinfection and dressing, 637 patients (32.55%) did not receive any prehospital wound treatment, and 867 (44.30%) patients were covered improperly with folk remedies. There were significant differences in the prehospital emergency management of burn wound among the admission time groups ($\chi^2=37.345$, $p<0.001$).

3.4. *Etiology of burn injuries*

Flames caused the highest proportion of massive burns (57.63%), followed by scalds (31.25%), electrical burns (4.47%) and chemical burns (2.98%). Scald injuries were most prevalent in children (81.07%), whereas flame injuries accounted for 66.89% and 75.84% of the injuries in adults and seniors, respectively. The etiology of burns differed significantly among age groups ($\chi^2=727.78$, $p<0.01$) (Table 1). There were significant differences in the burn etiology among BI groups ($\chi^2=277.452$, $p<0.01$) (Table 2). The proportion of burns caused by flames increased as BI increased; when the BI reached 75 or higher, flames alone caused 81.73% of the burns.

3.5. *Burn severity*

The mean TBSA burn was 55.53 ± 21.39% (range: 30–100%). In total, 42.93% of the patients sustained burns ranging from 30 to 39% of their TBSA, and 19.81% of patients had burns that covered

Table 2 – Epidemiological characteristics of patients in different burn index groups.

Patient characteristics	All (n=2483)	15–24 (n=1136)	25–34 (n=586)	35–44 (n=294)	45–54 (n=191)	55–64 (n=109)	65–74 (n=63)	≥75 (n=104)	P[a]
Age, n (%)									<0.001
0–14 years	486 (19.57)	351 (30.90)	83 (14.16)	32 (10.88)	10 (5.24)	4 (3.67)	2 (3.17)	4 (3.85)	
15–59 years	1670 (67.26)	672 (59.15)	407 (69.45)	217 (73.81)	144 (75.39)	86 (78.90)	53 (84.13)	91 (87.50)	
≥60 years	327 (13.17)	113 (9.95)	96 (16.38)	45 (15.31)	37 (19.37)	19 (17.43)	8 (12.70)	9 (8.65)	
Gender, n (%)									
Male	1728 (69.59)	778 (68.49)	401 (68.43)	208 (70.75)	140 (73.30)	75 (68.81)	47 (74.60)	79 (75.96)	
Female	755 (30.41)	358 (31.51)	185 (31.57)	86 (29.25)	51 (26.70)	34 (31.19)	16 (25.40)	25 (24.04)	
Admission time after injury, n (%)[b]									0.183
0–6 h	1957 (78.82)	894 (78.70)	453 (77.30)	227 (77.21)	152 (79.58)	87 (79.82)	53 (84.13)	91 (87.50)	
Over 6 h	441 (17.76)	187 (16.46)	117 (19.97)	61 (20.75)	37 (19.37)	19 (17.43)	9 (14.29)	11 (10.58)	
Prehospital emergency care of burn wounds, n (%)[c]									0.006
Rational remedy[d]	417 (16.79)	214 (18.84)	98 (16.72)	42 (14.29)	29 (15.18)	15 (13.76)	6 (9.52)	13 (12.50)	
Improperly disposed[e]	1154 (46.48)	539 (47.45)	278 (47.44)	139 (47.28)	75 (39.27)	41 (37.61)	24 (38.10)	58 (55.77)	
Without treatment	810 (32.62)	340 (29.93)	189 (32.25)	102 (34.69)	72 (37.70)	48 (44.04)	29 (46.03)	30 (28.85)	
Etiology of burns, n (%)									<0.001
Flame	1431 (57.63)	493(43.40)	374 (63.82)	202 (68.71)	139 (72.77)	87 (79.82)	51(80.95)	85 (81.73)	
Scalds	776 (31.25)	537 (47.27)	131 (22.35)	52 (17.69)	25 (13.09)	14 (12.84)	7 (11.11)	10 (9.62)	
Others[f]	276 (11.12)	106 (9.33)	81 (13.82)	40 (13.61)	27 (14.14)	8 (7.34)	5 (7.94)	9 (8.65)	
Inhalation injury, n (%)	804 (32.38)	147 (12.94)	176 (30.03)	135 (45.92)	119 (62.30)	82 (75.23)	56 (88.89)	89 (86.58)	<0.001
Outcome, n (%)									<0.001
Survived	1887 (76.00)	1006 (88.56)	457 (77.99)	208 (70.75)	121 (63.35)	53 (48.62)	22 (34.92)	20 (19.23)	
Transferred	165 (6.65)	69 (6.07)	48 (8.19)	23 (7.82)	14 (7.33)	5 (4.59)	2 (3.17)	44 (3.85)	
Give up treatment	188 (7.57)	59 (5.19)	67 (11.43)	36 (12.24)	13 (6.81)	4 (3.67)	3 (4.76)	6 (5.77)	
Died	243 (9.79)	2 (0.18)	14 (2.39)	27 (9.18)	43 (22.51)	47 (43.12)	36 (57.14)	74 (71.15)	

[a] P value was estimated by the chi-square test, Kruskal–Wallis H test or Fischer's exact test as appropriate.
[b] n=2398 patients, with 85 missing.
[c] n=2381 patients, with 102 missing.
[d] Rational remedy indicates that the wound received proper disinfection and dressing.
[e] Any external agents, including toothpaste, soy sauce, eggs, oil or other folk remedies, which may cause secondary infection, bacterial imbalance or resistance, or interfere with subsequent assessments of the burn depth, used to cover the wound were considered improperly dispensed treatments.
[f] Causes of burn injury other than flames and scald.

40–49% of their TBSA. Additionally, 37.25% of the patients had burns covering ≥50% of their TBSA, among which 152 patients (6.12%) suffered a burn area of 90% or more of their TBSA. The mean BI was 39.75±21.59 (range: 15–98), and the BI was significantly higher in adults (43.98±22.69) and seniors (40.81 ±18.45) than in children (27.69±15.18) (χ^2=224.747, $p<0.01$).

A total of 1702 patients suffered full-thickness burns (68.55%), and the incidence of full-thickness burns increased from 50.82% in children to 70.79% in adults. In seniors, this percentage was even higher (83.48%) (χ^2=108.517, p-<0.001). In addition, the incidence of full-thickness burns increased significantly with increases in the BI (χ^2=544.951, $p<0.001$).

3.6. Inhalation injuries

A total of 804 (32.38%) patients were complicated with inhalation injuries. The incidence of inhalation injuries was 8.85% in children, 36.76% in adults, and the percentage was even higher in seniors (44.95%), (χ^2=161.205, $p<0.01$) (Table 1). Moreover, the incidence of inhalation injuries increased significantly with an increasing BI (increasing from 12.94% in the 15–24 BI group to 86.58% in the 75 and above BI group, χ^2=617.964, p-<0.001) (Table 2). Patients with inhalation injuries had a significantly higher mortality rate than those without inhalation injuries (24.75 vs. 3.32%; $p<0.001$).

3.7. Outcomes and mortality

Among the 2483 admitted patients, 243 died, corresponding to a mortality rate of 9.79%, 165 patients were transferred before wound healing, whereas 188 patients stopped treatment mainly due to financial reasons. Seniors faced the highest risk of death (19.57%), followed by adults (9.52%) and children (4.12%). There was a statistically significant difference in the outcomes of the different age groups (χ^2=296.867, $p<0.01$) (Table 1). Furthermore, the mortality rate increased with increases in the BI (increasing from 0.18% in the 15–24 BI group to 71.15% in the 75 and above BI group).

3.8. Relationship between the burn index and the survival probability

Kaplan–Meier survival curves showed significant differences in the survival of different BI groups (log rank test $\chi^2 = 1097.430$, $p < 0.01$) (Fig. 2). The AUC of BI for survival prediction was.942 (95% CI, 0.929–0.954) (Fig. 3).

To further validate this finding, we performed an ROC analysis of the mortality to establish the critical value of BI for prognosis. The cutoff was identified as 29 in the 0–14 years age group: at this point, the Youden's index peaked at 0.82 (with a sensitivity and specificity of 1.00 and 0.82, respectively) (Fig. 4A). The cutoff was identified as 43.5 in the 15–59 years age group: at this point, the Youden's index peaked at 0.81 (with a sensitivity and specificity of 0.96 and 0.85, respectively) (Fig. 4B). The cutoff was identified as 35.5 in the 60 years or older age group: at this point, the Youden's index peaked at 0.70 (with a sensitivity and specificity of 0.87 and 0.82, respectively) (Fig. 4C).

3.9. Risk factors for death

To determine the key factors affecting the prognosis of patients with massive burns, a multiple logistic regression was performed. After adjustments for gender, age, admission time after injury, prehospital emergency care and inhalation injury, the results showed that when BI increased by 1, the OR of death increased by 6% (Table 3). This finding confirmed that BI was the main risk factor for the estimation of prognosis. Inhalation injury was associated with an OR of death that was 6.649 times higher ($p < 0.001$) than that for patients without inhalation injury.

Compared to children, mortality was higher in seniors (OR, 3.520 [95% CI, 1.879–6.594]; $p < 0.001$). The mortality was also higher in those who used "folk remedies" to treat the wound than those who received proper cleaning and dressing (OR, 2.947 [95% CI, 1.819–4.774]; $p < 0.001$). Patients who were admitted over 6 h after injury also faced a higher risk of death than did patients who arrived within 6 h after injury (OR, 1.797 [95% CI, 1.179–2.740]; $p < 0.001$). Although burn etiology was correlated with death in the univariate analysis, it was excluded in the multivariate logistic regression analysis due to a lack of statistical significance. Gender was not associated with mortality in this patient population (Table 3).

4. Discussion

Similar to previous findings, adults aged 15–60 were found to suffer the most frequent burn injuries in China [5,18]. Adults, the primary group that works in production lines, were the major group to suffer burn injuries in the Chinese population and face a higher exposure to danger than other age groups.

A retrospective multicenter study of pediatric burns in military hospitals of China from 2001 to 2007 showed that children compose 35.45% of the entire population of burn patients [20]. Another multicenter study of pediatric burns in northern China reported that children accounted for 43.57% of all patients hospitalized for burn treatment in the same period [21]. Several studies on elderly burn patients in different regions of China, such as Shanghai, Chongqing and Sichuan, reported that seniors account for 3.40–4.15% of the total burn patients [22–24]. However, in this study, children and seniors accounted for 19.57% and 13.09% of the severely burned patients, respectively, indicating that the percentage of children decreased, whereas the percentage of seniors increased in massive burn cases. This phenomenon may have occurred because many families have only one child due to the one-child policy; thus, parents are exceptionally scrupulous in keeping their only child safe from burns or other injuries. However, the prevention of burns in the elderly requires further attention.

Previous studies in different regions have demonstrated that the male-to-female ratio ranges from 2.00 to 3.00:1 in China [2,5,25,26]. In this study, the gender ratio was 2.29:1, and we found that males were more commonly burned in all age groups except for elderly patients over the age of 70. This finding is in accordance with the results of Tang K's study [19]. Females exceeded males in the 70 and older age group (the male-to-female ratio was 0.84); this might occur because after retirement, males are no longer at risk for workplace burns, and the majority of the household work is performed by women, exposing them to the risk of burns at home.

Consistent with the findings of previous studies, burn incidence was comparatively higher in April, May, June, July and August [5,26]. In most areas of China, this period corresponds to the summer, with higher temperatures and less protective clothing. In the summertime, people also bathe more frequently, increasing the risk of scalding injuries.

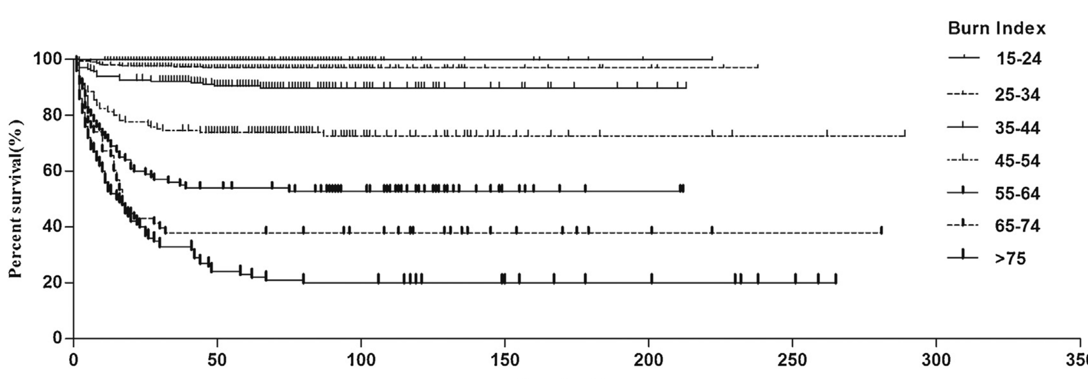

Fig. 2 – Kaplan–Meier survival curve of massively burned patients in different BI groups.

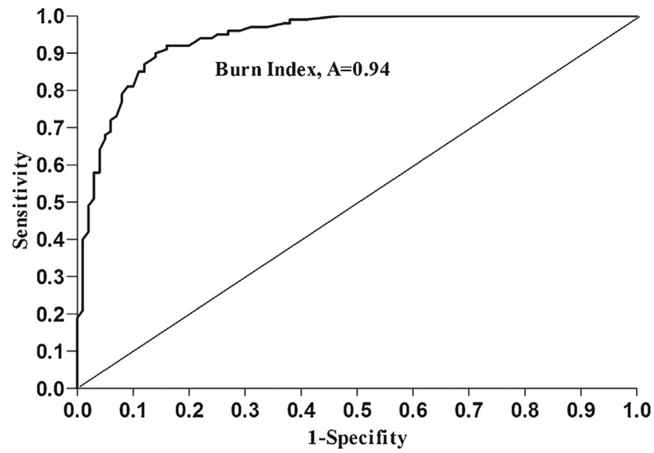

Fig. 3 – Receiver operating characteristic curve of BI to predict the outcomes of massively burned patients.

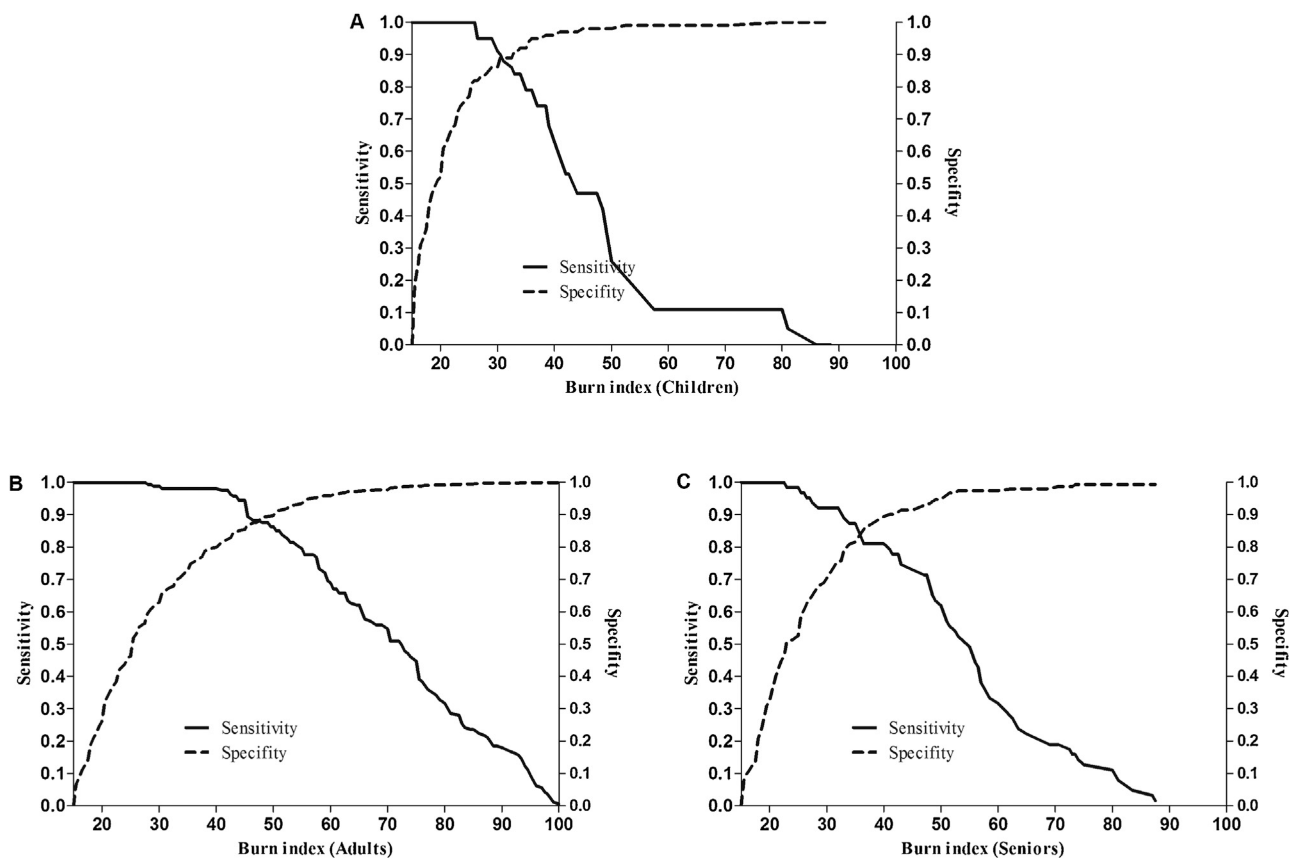

Fig. 4 – Cutoff determination of BI in different age groups.

Timely and reasonable prehospital emergency management plays an important role in effectively alleviating the severity of burn injuries and improving prognosis [18,27]. Most of the massively burned patients were sent to hospitals for consultation immediately, but the current level of emergency burn management is relatively low in China. A large proportion of patients knew nothing about prehospital first aid [18]. Worse still, many people believe that folk remedies, which are usually mixtures of herbal powders or household products, such as toothpaste, soy sauce, eggs, etc., are effective in prehospital burn care. In fact, previous research has shown that the folk remedies mentioned above cannot protect burn wounds; rather, they may induce or deepen burn injuries [18,28]. Furthermore, substances applied to the burned area may be potential causes of allergic reaction or even anaphylaxis [29]. The results of our investigation showed that most patients are likely to receive clinical treatment in time; however, the available prehospital emergency burn care is relatively unsatisfactory at present. Therefore, public education campaigns should be launched to remind people of the

Table 3 – Multivariate logistic regression analysis of risk factors for mortality in massively burned patients.

Items	r	Crude		Adjusted for case mix	
		OR	95% CI	OR 95%	CI
Gender	−0.050	0.969	0.721–1.303	–**	
Age	0.190				
0–14 year		1.000	–	–	–
15–59 year		2.399*	1.487–3.871	0.900	0.513–1.578
≥60 year		8.408*	4.922–14.363	3.520*	1.879–6.594
Admission time after injury	−0.037	1.677*	1.193–2.358	1.797*	1.179–2.740
Prehospital emergency care	0.016				
Cleaning and dressing		1.000	–	–	–
Folk remedies		1.882*	1.250–2.833	2.947*	1.819–4.774
Without treatment		1.439	0.931–2.223	0.344	0.196–0.603
Etiology	−0.126				
Flame	1.00		–	–	–
Scalds		0.213*	0.140–0.325	–**	
Others		0.775	0.513–1.172	–**	
Burn index	0.246	1.045*	1.038-1.052	1.060*	1.050–1.071
Inhalation injury	−0.327	9.584*	6.818–13.472	6.649*	4.517–9.789

r: Spearman contingency coefficient; OR: odds ratio; CI: confidence interval; gender was categorized as male or female; age was categorized as children (0–14 years); adolescents and adults (15–59 years) and seniors (60 years and above); admission time after injury was categorized as 0–6 h and over 6 h; prehospital emergency care of burn wound was categorized as cleaning and dressing; folk remedies and without treatment; etiology was categorized as flame, scalds and others. Burn index was used as a continuous variable.

* P value of less than 0.01.

** Eliminated from multiple logistic regression model with probability for rejection set at $P<0.1$.

profound damage that can result from burns and the preventability of most burn injuries. Education about prehospital emergency management as a long-term strategy must be intensified. We are glad to tell that the Burn Committee of the Chinese Medicine Education Association, a committee dedicated to burn-related education and research, was founded by our team, and we launched the Chinese Dream Health Dream Burn Prevention Special Public Project to promote burn-related education. We opened a public account on WeChat, China's most popular social media platform, and published the Burn Prevention Manual in Chinese in 2014 (edited by Chuanan Shen, ISBN: 9787509183818) to share the burn prevention knowledge, and deliver skills on how to provide effective first aid treatment and rescue the injured, as well as how to offer appropriate rehabilitation services and psychological support; we hope our effort will help to promote further development of burn prevention and care.

A retrospective multicenter study on burns in military hospitals of China from 2001 to 2007 with a sample size of 131,577 cases reported that scalds represented 80.5% of burn injuries [5]. However, our study showed that different etiologies peaked at different age groups in terms of massive burns. Scalds remain the leading cause of pediatric massive burns, whereas flames cause most burns in adults and seniors. Our investigation also found that the proportion of injuries caused by flames increased as BI increased. This suggests that the etiology of burns influences the severity of injuries. More importantly, different measures should be taken to prevent scald burns in children and prevent flame burns in adults and seniors.

In the present study, the percentage of patients decreased as the BI increased in all age groups. This trend was more obvious in children, for whom the percentage decreased sharply from 72.22% in the 15–24 BI group to 17.08% in the 25–34 BI group. Patients with a BI of 75 or higher accounted for only 0.82% of massive pediatric burns. This trend is similar to that in Dokter's study of severe burns in the Netherlands [11] and Xu's multicenter study of pediatric burn patients in China [20]. Hospitalized pediatric burn patients mainly suffered from scalds and usually had minor or moderate burns; severe burns accounted for only a small proportion of the study population.

With respect to full-thickness burns, the incidence increased from 50.82% in children to 70.79% in adults. In seniors, the percentage reached 83.48%. This increase occurred because seniors are more vulnerable to deep burns, given a variety of geriatric conditions, including atrophic skin, failing health, preexisting medical problems, diminished defense mechanisms and reduced mobility. In combination, these factors render the elderly population more likely to suffer from severe burns than other age groups suffering similar burn types.

In this study, 32.38% of the patients suffered from burns that were complicated by inhalation injury. This value is far greater than the incidence (6.9%) of the total admitted burn patients reported by Wang et al. [2]. Moreover, the inhalation injury incidence increased as the BI increased, suggesting that inhalation injury is positively correlated with burn severity.

The mortality rate of burns is an important indicator of the burn care level and is affected by many factors, including age, agents and severity of burns, rescue conditions before hospitalization, complications and state of health before injury [1]. The overall mortality rate among massive burn patients was 9.79% in this study. In fact, the real mortality rate must be higher because some patients gave up treatment for primarily financial reasons. Finances are thus an important factor in severe burn survival. Muangman et al. found that the degree of social support may affect patient survival, and survivors were more likely than non-survivors to have social support [30]. Additionally, there is no obligatory health insurance or form of social support in China [6,31].

In fact, there is a public insurance system, and nearly every citizen can be covered by this insurance system, which reduces the financial burden of burn patients to some extent. However, the coverage is far from sufficient to offset the expensive costs of treatment in extensive burn patients, and in most cases, only the basic treatment can be covered by the public medical insurance system. By far, there is no public fund or insurance for burns in China, some areas and organizations have been trying to launch special fund and help burn victims, offering the poverty-stricken injured necessary assistance, such as Chunmiao Aid Foundation established by the Southwest Hospital, the Third Military Medical University, Chongqing, China (Website: http://www.burncamp-china.com/); Central China Burn Women and Children Foundation established by Wuhan City Hospital No.3 & Tongren Hospital of Wuhan University, Wuhan, China (Website: http://www.hbcf.org.cn/FundShow/1154/2/62.html); and Burn Care Public Welfare Fund launched by Aiwuhen Burn Rehabilitation and Care Center (Website: http://www.aiwuhen.org). The domestic burn rescue funds are still in the initial stage, and the source of the funds mainly come from the unstable social donation. Moreover, the funds are mainly established and managed by the locally influential burn centers, without specialized management and full-time staff, the running and management are not yet standard. Therefore, a number of patients with massive burns might not be able to afford expensive hospital stays and thus may drop out of patient records. It is thus essential for the government to develop health insurance and social support systems for burn care to aid in both the resuscitative stage and later stages of recovery.

Previous literature has documented the age, total burn size and inhalation injury effects on burn mortality [1,12]. Yao et al. found that males with fire-related burns covering over 30% of their TBSA resulted in the greatest number of fatalities [5]. Muangman et al. concluded that a ≥80% TBSA full-thickness burn was uniformly fatal [30]. However, no published studies have simultaneously considered burn size and depth.

In our study, when the BI exceeded a threshold of 29 in the 0–14 years age group, 43.5 in the 15–59 years age group and 35.5 in the 60 years or older age group, the mortality rate increased significantly. Further logistic regression analysis revealed that patients older than 60, those whose burns were covered with “folk remedies” in prehospital emergency management, those who were admitted more than 6h post-burn, those with a BI exceeding the threshold and those with combined with inhalation injury were at a higher risk of death. By contrast, patient gender and burn etiology were not associated with an increased mortality. Based on these findings, we recommend that patients with a BI greater than 29 in the 0–14 years age group, 43.5 in the 15–59 years age group and 35.5 in the 60 years or older age group be immediately transferred to a specialized burn center. Furthermore, such patients should be treated with increased vigilance and improved therapies, in view of their increased risk of poor outcomes.

5. Limitations

The 106 hospitals that participated in this study did not include all of the hospitals in mainland China; therefore, this study did not include all hospitalized massive burn cases, and we could not report on the incidence of massive burns in our country. In addition, the prediction models used here do not consider factors assessed during treatment; thus, the relationship between treatment-related factors and mortality rates in this high-risk patient group must be assessed in further studies.

6. Conclusion

Our research demonstrated that adult males are the most high-risk population regarding massive burn injuries. Most patients are likely to receive clinical treatment in time; however, nearly half of the massively burned patients are porne to use folk remedies to cover burn wounds before admission, the current level of prehospital emergency burn care is relatively low in China. Scalds are the main cause of pediatric burns, whereas flames predominate in adult and senior burns. A BI of 29 in the 0–14 years age group, 43.5 in the 15–59 years age group and 35.5 in the 60 years or older age group are the crucial threshold for mortality in massively burned patients. Furthermore, more attention should be paid to patients in view of the increased risk of poor prognosis associated with patients older than 60, a history of covering the burn using a folk remedy, a hospital admission more than 6h post-burn, a BI exceeding the threshold and a combined inhalation injury.

Author contributions

Dr. Cheng had full access to all of the data in this study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Drs. Shen, Cheng and Zhao developed the study concept and design. Drs. Cheng, Zhang, Tu, Yuan, Song, Liu and Qin conducted the statistical collection and analysis, and all authors interpreted the data. Drs. Cheng, Zhao, Li, Shang, Liu and Shen drafted the article, and all authors provided critical revisions of the important intellectual content. This study was supervised by Dr. Shen.

Conflict of interest

There are no competing interests or conflicts in the present paper.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.burns.2018.08.008.

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