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Epidemiology and first aid measures in pediatric burn patients in northern China during 2016–2020: A single-center retrospective study

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Abstract

Background and Aims: Burn and scald injuries are the fourth most common type of trauma. Pediatric burns account for a high proportion of the total number of burn patients and impose a high burden on public health. Understanding the epidemiology of pediatric burns can help improve science education and reduce the incidence of burn injuries.

Methods: This study is a single-center retrospective study. One thousand five hundred and twenty-seven pediatric burn patients admitted to our burn center from January 2016 to December 2020 were included. Demographic and epidemiological data of included patients were extracted and analyzed. The correlations of categorical data were tested by the Chi-square tests, and differences of continuous data were tested by the Kruskal–Wallis tests. A p-value of less than 0.05 was considered to be statistically significant.

Results: The results showed that children under 3 years of age were most susceptible to burn and scald injuries. Burn injuries were most likely to occur in the season of winter and at the place of home. 56.6% of included patients did receive first aid measures, while 1.8% received gold-standard first aid. Clinical variables related to the severity of injuries were statistically different between patients with and without cooling measures in first aid. Linear regression models showed that emergency treatment of burns in children and adolescents was associated with outcome indicators, including number of operations, total operation duration per total burn surface area (TBSA), cost per TBSA, and length of stay per TBSA.

Conclusions: This study summarized the epidemiology and outcomes of pediatric burn patients admitted to a burn center in northern China. Adopting cooling measures in first aid can reduce the severity of injuries and reduce the burden on the

Tian Liu and Yirui Qu contributed equally to this study.

medical system. Education on burn prevention and first aid measures to caregivers of children, especially preschool children, should be strengthened.

KEYWORDS
burns, emergency treatment, epidemiology, first aid, pediatrics

1 | INTRODUCTION

Burns are one of the most common accidental injuries in daily production and life.[1–4] With the increasing economic level and safety awareness of residents brought about by social development, the proportion of burns and scalds caused by production accidents has been decreasing year by year,[5–7] and, relatively, the proportion of burns and scalds occurring in daily life has increased.[8,9] Pediatric burns account for a high proportion of the total number of burn patients and impose a high burden on public health.[10–15] According to a 10-year analysis of burn patients in mainland China, burn patients under 10 years of age account for the highest proportion of total burn patients.[16] The trend of US pediatric burn hospitalizations from 2003 to 2016 showed that although the rate of burn hospital admission in the US has decreased considerably, the proportion of burn admissions among children aged 1–4 years increased by 9.1% and among children aged 5–9 years by 9.9%.[17] Two other studies of the epidemiology of burns in children at the University of Zurich Children's Hospital in Switzerland suggest that burns in children are mainly associated with kitchen supplies, hot tea, and coffee, and 65% of children have received different forms of first aid before hospitalization.[7,18] These results are different from the data collected in our clinical work. We did not find increased rates of admissions in children aged 5–9 years, and the main cause of injury in children did not include hot coffee but did include burns caused by hot water baths. In addition, our data showed that the proportion of children receiving first aid in the prehospital setting was significantly less than 65%. These differences may be related to the geographical characteristics, resident composition, and living habits of China, and are also part of the analysis attempted in this paper.

Children and adolescents are in the stage of growth and development and, therefore, often require surgical interventions to correct scar contractures until adulthood.[13,19,20] The treatment process for burns is full of pain, and even if successfully cured, the subsequent formation of scars can affect the victim's appearance.[21–24] Severe scar contracture may lead to scar deformity, developmental limitation, and dysfunction in children.[25–27] Burns and subsequent scars also impose a huge human and financial burden on families.[28–31] It should be noted that the treatment process of burns and scars in children and adolescents can cause severe psychological trauma to children and even affect their long-term mental health.[32–35] Therefore, it is necessary to carry out epidemiological studies related to burns and scalds in children and adolescents, as well as guide the dissemination of information regarding effective burn and scald prevention and first aid measures.

Key points

- Understanding the epidemiology of pediatric burns can help improve science education and reduce the incidence of burn injuries.
- This study aimed to analyze epidemiological and clinical variables of pediatric burn patients in a burn center in northern China.
- Children under 3 years of age were most susceptible to burn and scald injuries.
- Burn injuries in pediatric patients were most likely to occur in the season of winter and at the place of home.
- Adopting cooling measures in first aid can reduce the severity of burn injuries.

Previous studies have confirmed that appropriate first aid measures taken immediately after burns can effectively reduce the severity of burns.[18,36,37] However, these results are based on patient data from other countries or other regions of China, and evidence on first aid measures and pediatric burns, particularly in our region, is currently lacking. This study aimed to analyze epidemiological and clinical variables of pediatric burn patients in our burn center to provide relevant information for the prevention of pediatric burns and the education of pediatric caregivers.

2 | MATERIALS AND METHODS

2.1 | Study setting

This study was performed in the burn center of the Fourth Medical Center of PLA General Hospital. Our burn center is in Beijing, the capital of China, and it is one of the largest burn centers in northern China. Beijing has a temperate semihumid semiarid monsoon climate with four distinct seasons. According to the most recent hospital specialty reputation ranking in China, our burn center ranked the first burn specialty in Beijing and the third in China. The average number of patients admitted to our burn center with a diagnosis of burns or burn scars from 2016 to 2020 was 2410 patients per year, and most of these patients are from Beijing and surrounding areas.

2.2 | Design of study

The medical records of 4137 burn patients admitted to our burn center from January 2016 to December 2020 were screened. According to the following inclusion and exclusion criteria, 1527 hospitalized burn patients were finally included. The medical records of the included patients were summarized and analyzed. This study was approved by the Institutional Review Board of the Fourth Medical Center of PLA General Hospital (Approval number: 2021KY033-KS001). The subjects of this study were anonymized, and the informed consent was waived by the Institutional Review Board (Institutional Review Board of the Fourth Medical Center of PLA General Hospital).

2.3 | Inclusion criteria

(1) Patients admitted to our center from January 2016 to December 2020, including patients who were cured and died, (2) the first diagnosis was burn or scald, (3) under the age of 18 years old, (4) the medical records had a high rate of integrity (less than 5% of items per variable were missing).

2.4 | Exclusion criteria

(1) Patients with burns in the diagnosis, but the first diagnosis is not burn (not admitted with burns as the primary cause), (2) have been hospitalized in other hospitals before being admitted to our center, (3) previous burns and hospitalized due to burn-related wounds or scars, (4) interrupted treatment due to special reasons, (5) incomplete epidemiological data.

2.5 | Data collection and process

First, we searched the hospital database of this burn center for patients with a primary diagnosis of burns, scalds, thermal injuries, hot crush injuries, or burn-blast injuries. Data screening and extraction were performed by two independent reviewers. One reviewer was responsible for extracting data from medical records, and the other reviewer was responsible for verifying the data to ensure the accuracy of the data. Data extracted from medical records included demographic data (gender, date of birth), hospitalization data, injury-related data (burn depth, burn area, burn site, inhalation injury, first aid after injury), infection-related data (results of bacteria and fungus culture, antibiotic use), and first aid measures (cooling methods and duration, folk prescription, burn ointment). The population of included patients was subdivided into four subsets: preschool group (under 3 years of age), kindergarten group (3–5 years old), elementary school group (6–11 years old), and middle school group (12–17 years old). Segmented epidemiological data were compared and analyzed. The Baux score, Abbreviated Burn Severity Index (ABSI), Burn Index, and Prognostic Burn Index were calculated by equations.[38–40] The calculation of length of stay (LOS) was obtained by subtracting the discharge date from the admission date.

2.6 | Statistical analysis

Data were collected and processed using Microsoft Excel 2016. The statistical analysis was performed using SPSS Statistics (version 26.0) and GraphPad Prism (version 9.0). Categorical variables were presented as frequencies and percentages. The correlation of clinical variables with age and gender was tested by Chi-square tests. Because some of the clinical indicators, such as burn area, were not evenly distributed, Kolmogorov–Smirnov tests were performed to test the distribution of continuous variables. Continuous variables with a non-normal distribution were presented as the median and interquartile range (IQR), and group comparisons were performed using the Mann–Whitney *U* test. Linear regression models were used to assess the associations between clinical outcome variables and the implementation of cooling measures during first aid. Additional covariates of interest adjusted in the linear regression models included age, gender, total burn surface area (TBSA), depth, number of specimens with bacteria or fungi detected, number of bacterial species detected, number of fungal species detected, number of antibacterial drugs used, and number of antifungal drugs used. The effect size, confidence intervals, and *p*-value of regression models were presented. All the statistical tests performed in this study were two-tailed, and a *p*-value of less than 0.05 was considered to be statistically significant.

3 | RESULTS

In this study, we collected the medical records of patients under 18 years of age who were hospitalized in our burn center from January 2016 to December 2020. According to strict inclusion and exclusion criteria and after consideration of the completeness of medical records, a total of 1527 patients were included in this study. Demographic data and clinical data of the included patients were collected and analyzed, and the specific processes and results are presented below.

3.1 | Study population

Based on the search of primary diagnosis, 4418 burn patients were identified in the hospital database. After deleting duplicates and screening patients by inclusion criteria, 1527 patients under 18 years of age were included for further analysis. The characteristics of the included patients are presented in Figure 1. The average age of the pediatric burn patients included in this study was 2.83 years (3.635) years, and 57.17% (873) of the included patients were male. The counts of male and female patients of different ages are presented in Figure 1A. The data reveal that children less than 3 years old,

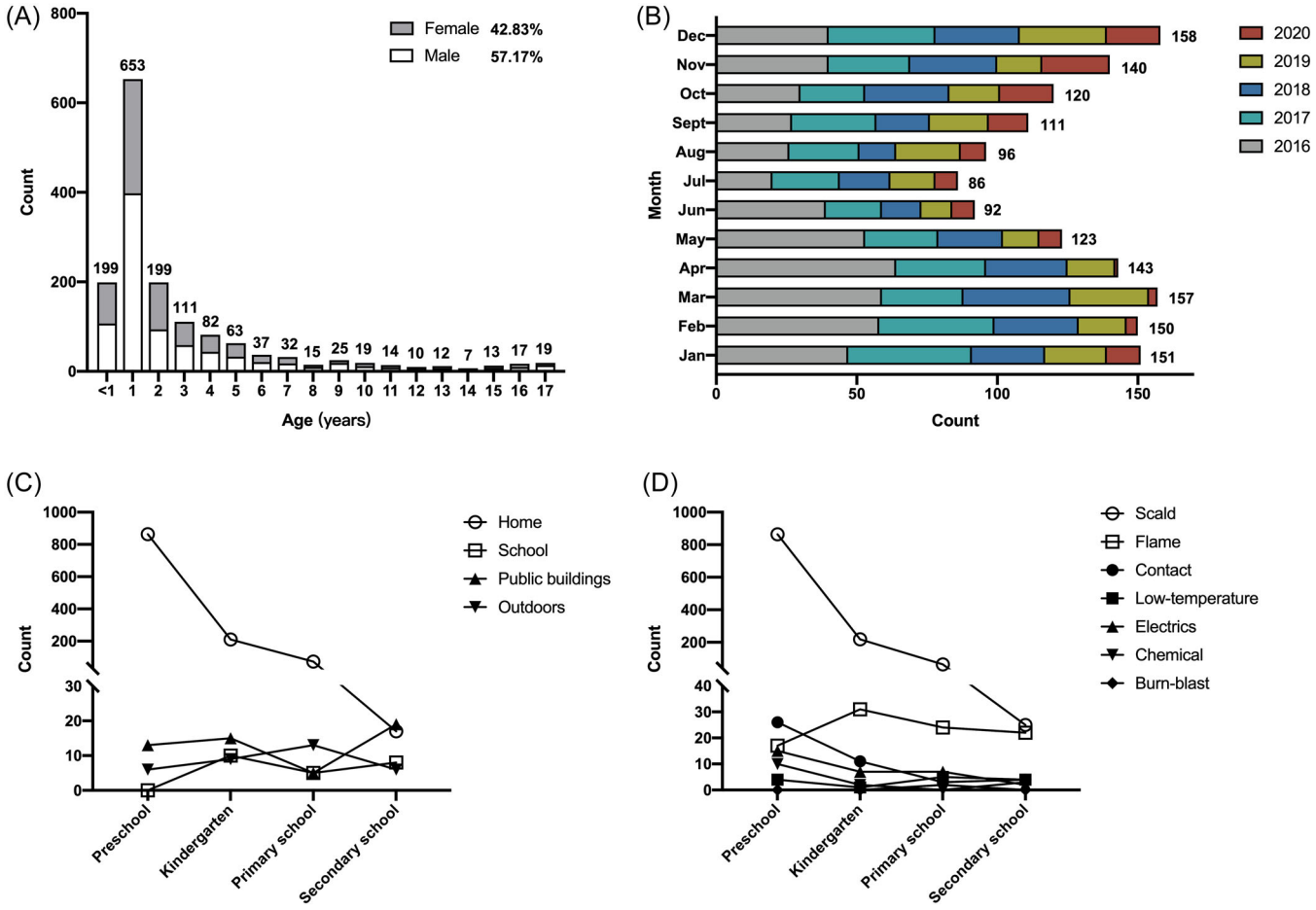

FIGURE 1 Distribution of demographic and epidemiological data. (A) Distribution of male and female patients in different age groups. Numbers of burn cases of each age are marked on the top of the bars. (B) Distribution of pediatric burn patients in different months and years. Numbers of burn cases of each month are marked on the right of the bars. (C) Distribution of place of occurrence of burns by age groups. (D) Distribution of burn causes by age groups.

especially those 1–2 years old, were most susceptible to burn and scald injuries.

3.2 | Epidemiological variables

The number of admissions by year and month is presented in Figure 1B. Burn admissions showed a decreasing trend year by year. It was observed that children and adolescents are more vulnerable to burn injuries from November to March of each year, with a peak in December. The most common reason for burns was scald, while the most common place of occurrence of burns was at home (Figure 1C,D). The distributions of place of injuries and burn causes by months are presented in Supporting Information: Figure S1.

3.3 | Clinical variables

The distributions of clinical variables by age and gender are presented in Table 1. TBSA, burn depth, and inhalation injury were statistically different among different age groups but not in separate gender groups. The most vulnerable site of burn injuries in children and adolescents was the extremities (37.73%), followed by the trunk (19%) and head/face/neck (19.2%) (Supporting Information: Figure S2). Additionally, 74.72% of the admitted pediatric patients did not undergo surgery, and 80.29% were treated with antibiotics (Supporting Information: Figure S3).

3.4 | First aid measures

The first aid measures taken by pediatric patients are listed in Table 2. More than half of pediatric burn patients (56.6%) did not receive any kind of first aid measures after being injured. Although 27.5% of patients received cooling measures, including cool running water and cool towels, only 1.8% received gold-standard first aid (application of cool running water to the burn site for at least 20 min). The most commonly used folk prescriptions were toothpaste, soy sauce, and sesame oil. Other first aid measures taken by pediatric patients or their guardians included

TABLE 1 Distribution of clinical variables by age and gender.

Variable	Total *n* (%)	Age					Gender		
		Preschool *n* (%)	Kindergarten *n* (%)	Primary school *n* (%)	Secondary school *n* (%)	*p* Value	Male *n* (%)	Female *n* (%)	*p* Value
The site of injuries									
Head/face/neck									
Yes	536 (35.1)	376 (24.6)	98 (6.4)	35 (2.3)	27 (1.8)	0.51	327 (21.4)	209 (13.7)	0.03
No	991 (64.9)	675 (44.2)	195 (12.8)	80 (5.2)	41 (2.7)		546 (35.8)	445 (29.1)	
Extremities									
Yes	1053 (69.0)	728 (47.7)	193 (12.6)	81 (5.3)	51 (3.3)	0.45	582 (38.1)	471 (30.8)	0.03
No	474 (31.0)	323 (21.2)	100 (6.5)	34 (2.2)	17 (1.1)		291 (19.1)	183 (12.0)	
Trunk									
Yes	683 (44.7)	504 (33.0)	132 (8.6)	32 (2.1)	15 (1.0)	<0.001	395 (25.9)	288 (18.9)	0.64
No	844 (55.3)	547 (35.8)	161 (10.5)	83 (5.4)	53 (3.5)		478 (31.3)	366 (24.0)	
Perineum									
Yes	119 (7.8)	74 (4.8)	28 (1.8)	13 (0.9)	4 (0.3)	0.22	75 (4.9)	44 (2.9)	0.18
No	1408 (92.2)	977 (64.0)	265 (17.4)	102 (6.7)	64 (4.2)		798 (52.3)	610 (39.9)	
Buttock									
Yes	129 (8.4)	79 (5.2)	34 (2.2)	9 (0.6)	7 (0.5)	0.15	69 (4.5)	60 (3.9)	0.38
No	1398 (91.6)	972 (63.7)	259 (17.0)	106 (6.9)	61 (4.0)		804 (52.7)	594 (38.9)	
Hand									
Yes	159 (10.4)	108 (7.1)	29 (1.9)	14 (0.9)	8 (0.5)	0.89	99 (6.5)	60 (3.9)	0.17
No	1368 (89.6)	943 (61.8)	264 (17.3)	101 (6.6)	60 (3.9)		774 (50.7)	594 (38.9)	
Foot									
Yes	112 (7.3)	73 (4.8)	18 (1.2)	15 (1.0)	6 (0.4)	0.09	77 (5.0)	35 (2.3)	0.01
No	1415 (92.7)	978 (64.0)	275 (18.0)	100 (6.5)	62 (4.1)		796 (52.1)	619 (40.5)	
TBSA									
0–5	701 (45.9)	441 (28.9)	154 (10.1)	63 (4.1)	43 (2.8)	<0.001	391 (25.6)	310 (20.3)	0.66
5.1–10	493 (32.3)	380 (24.9)	73 (4.8)	28 (1.8)	12 (0.8)		282 (18.5)	211 (13.8)	
10.1–20	212 (13.9)	159 (10.4)	42 (2.8)	7 (0.5)	4 (0.3)		127 (8.3)	85 (5.6)	
20.1–30	53 (3.5)	36 (2.4)	10 (0.7)	4 (0.3)	3 (0.2)		28 (1.8)	25 (1.6)	
30.1–50	18 (1.2)	9 (0.6)	5 (0.3)	4 (0.3)	0 (0)		12 (0.8)	6 (0.4)	
>50	18 (1.2)	6 (0.4)	2 (0.1)	5 (0.3)	5 (0.3)		11 (0.7)	7 (0.5)	
Uncertain	32 (2.1)	20 (1.3)	7 (0.5)	4 (0.3)	1 (0.1)		22 (1.4)	10 (0.7)	
Depth									
Superficial partial thickness burns	19 (1.2)	15 (1.0)	2 (0.1)	1 (0.1)	1 (0.1)	0.03	12 (0.8)	7 (0.5)	0.59
Deep partial thickness burns	819 (53.6)	583 (38.2)	157 (10.3)	54 (3.5)	25 (1.6)		467 (30.6)	352 (23.1)	
Full-thickness burns	629 (41.2)	417 (27.3)	119 (7.8)	52 (3.4)	41 (2.7)		355 (23.2)	274 (17.9)	
Uncertain	60 (3.9)	36 (2.4)	15 (1.0)	8 (0.5)	1 (0.1)		39 (2.6)	21 (1.4)	

(Continues)

TABLE 1 (Continued)

Variable	Total *n* (%)	Age					Gender		
		Preschool *n* (%)	Kindergarten *n* (%)	Primary school *n* (%)	Secondary school *n* (%)	*p* Value	Male *n* (%)	Female *n* (%)	*p* Value
Inhalation injury									
Yes	22 (1.4)	6 (0.4)	2 (0.1)	7 (0.5)	7 (0.5)	<0.001	10 (0.7)	12 (0.8)	0.26
No	1505 (98.6)	1045 (68.4)	291 (19.1)	108 (7.1)	61 (4.0)		863 (56.5)	642 (42.0)	
Total	1527 (100)	1051 (68.8)	293 (19.2)	115 (7.5)	68 (4.5)		873 (57.2)	654 (42.8)	

Abbreviation: TBSA, total burn surface area.

TABLE 2 First aid measures.

	Case	%
No first aid	865	56.6
First aid measures	509	33.3
Cool running water	398	26.1
<5 min	123	8.1
≥5 min but <20 min	88	5.8
≥20 min	28	1.8
Uncertain time	159	10.4
Other cooling measures	22	1.4
Cool towel	10	0.7
Others	12	0.8
Folk prescription	42	2.8
Toothpaste	7	0.5
Soy sauce	7	0.5
Sesame oil	4	0.3
Vinegar	3	0.2
Honey	3	0.2
Egg	2	0.1
Others	16	1.0
Burn ointment	36	2.4
Others	11	0.7
Uncertain	153	10.0

bandaging and disinfecting the burn area with iodophor or other disinfectants. The ratio of measures taken by the included patients and patients that received cooling measures are shown in Figure 2A,B, respectively. Compared with patients from other cities and rural areas, a slightly higher proportion of patients from Beijing implemented cool running water in burn first aid (25.6% vs. 37.7%, Figure 2C). Patients injured in summer were also more likely to apply cool running water than those injured in winter (38.3% vs. 27.0%, Figure 2E).

3.5 | Cooling measures and injury outcome

The comparison of clinical variables between patients with and without cooling measures in first aid is shown in Table 3. No statistical differences were observed in gender or age between the two groups. Other variables related to the severity of injuries, such as full-thickness burn area, burn depth, ABSI, bacterial or fungal infection, and operations, were statistically different between the two groups. Clinical variables, including application of antibiotics, number of operations, and total operation duration, were also different between the two groups, but the outcomes (cure, outpatient care, readmission, or death) of the patients in the two groups were not statistically different. Distinct multivariate linear regression models were formed to assess the correlation of cooling measures with clinical outcomes (Table 4) and potential confounders (age, gender, TBSA, depth, number of specimens with bacteria or fungi detected, number of bacterial species detected, number of fungal species detected, number of antibacterial drugs used, and number of antifungal drugs used) were adjusted. Linear regression analyses showed the number of operations, total operation duration per TBSA, cost per TBSA, and LOS per TBSA were reduced when adopting cooling measures in first aid.

4 | DISCUSSION

Our study demonstrated that children under 3 years of age were most susceptible to burn and scald injuries and that children aged 1–2 years were the most common. This is because children of this age can already act autonomously and have a strong desire to explore the unknown world but have not yet formed a sufficient awareness of risk avoidance. If guardians are negligent when caring for children in this age group, the chances of these children being burned or scalded significantly increase.[41] This phenomenon is consistent with the statistical results for the places where burns occur, as shown in Figure 1C. In China, it is common for children before the age of 3 to be cared for by their grandparents at home. Caregiving by grandparents leads to an increased rate of burns in families,[11,16] which is associated with low educational levels and poor safety awareness. Therefore, the home is the most likely place for children to suffer from burns or scalds.

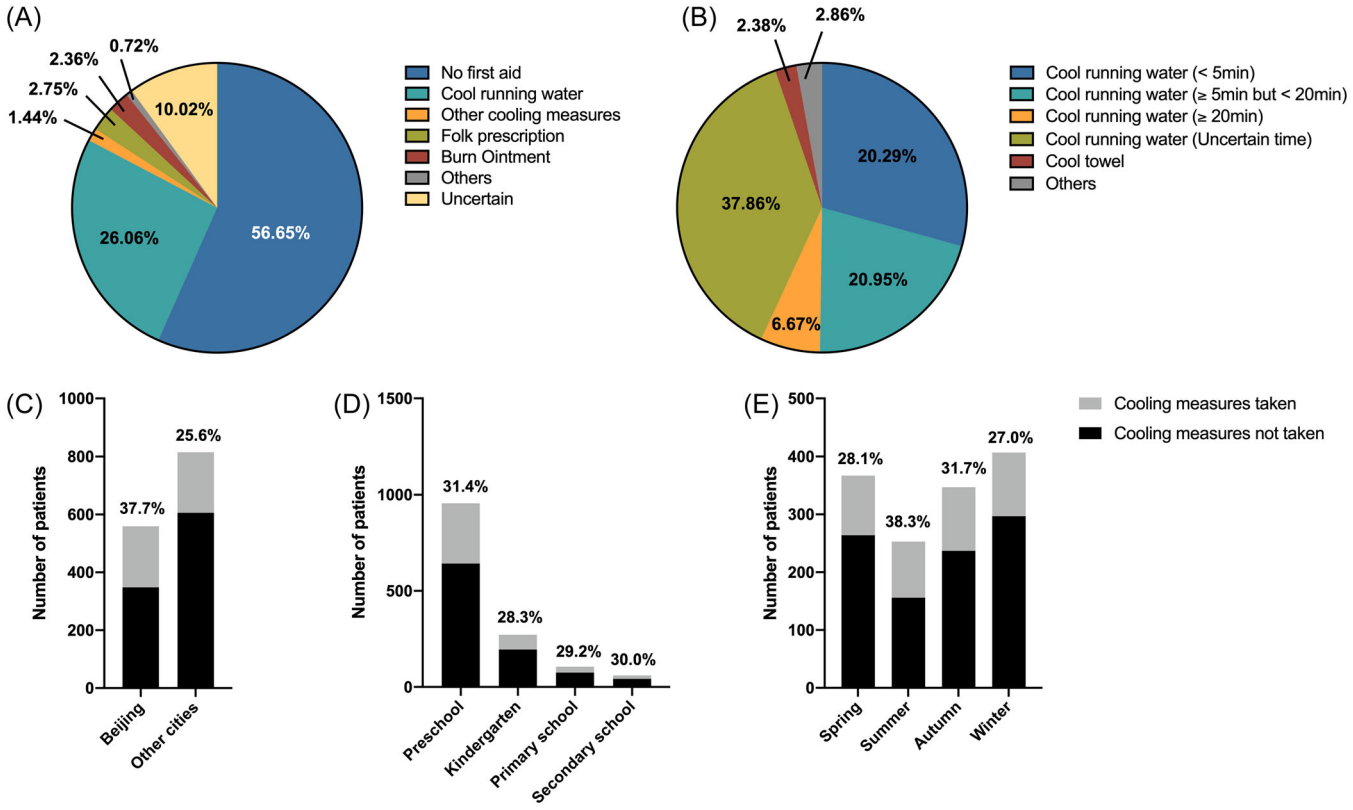

FIGURE 2 First aid measures and cooling measures. (A) Ratio of first aid measures adopted by included pediatric burn patients. (B) Ratio of cooling methods adopted by pediatric patients that received cooling measures. (C) Ratio of patients that received cooling measures in Beijing and other cities. (D) Ratio of patients that received cooling measures in different age groups. (E) Ratio of patients that received cooling measures in different seasons.

In the 5-year cases we studied, the number of burn and scald cases decreased significantly in 2020, most likely due to the effects of the COVID-19 pandemic and the fact that parents of juveniles spent more time working at home.[42] Parents more closely cared for preschool children, and the chance of accidents, such as burns and scalds, was correspondingly reduced. In addition, As one of the three centers in Beijing that can treat pediatric burn patients, our case is geographically representative. The results shown in this study were consistent with the epidemiological characteristics of large cities in northern China and their surrounding areas. At the same time, some of the results also differed from those of previous epidemiological studies.

Previous studies showed that summer was the season when burns and scalds were more likely to occur,[16,43] but our results showed that children and adolescents in Beijing and the surrounding areas were more likely to suffer from burns and scalds in winter (Figure 1B). The count curve of burn and scald cases in this population showed a significant peak from November to March, while the peak number of cases occurred in December. This has an obvious correlation with temperature changes in this region. Many families in northern China use heating equipment to drink hot water and hot tea in autumn and winter when the temperature drops. In addition, residents in northern China have a habit of soaking their feet in hot water and giving their children hot baths in autumn and winter. In using hot water, improper operation, such as adding hot water before cold water to the bathtub and placing hot tea in an easily accessible position, significantly increases the probability of burns and scalds in children aged 1–3 years. From these factors, it can be assumed that, in Beijing and surrounding areas, winter would be the season when pediatric burns and scalds were most likely to occur and that hydrothermal scald would be the most common cause of injuries. This is consistent with the statistical data shown in Figure 1D. This also presents a clear goal of science dissemination and local awareness campaigns.

Based on the leading causes of injury, the clinical variables of hospitalization in children and adolescents showed characteristics that were consistent with the epidemiological characteristics of injury. As shown in Table 1, burns and scalds in children and adolescents in the studied area were mainly small-area superficial injuries, and no statistical difference was observed between males and females. Furthermore, 45.9% of the included patients had a burn area of less than 5% TBSA, while 78.2% of the included patients had a burn area of less than 10% TBSA. The burn depth statistics showed that 54.8% of the burns and scalds did not contain full-thickness burn wounds, and 30.0% of the burns and scalds had mixed partial-thickness and full-thickness

TABLE 3 Comparison of clinical variables of patients with and without cooling measures.

Variable	Yes, *n* = 420	No, *n* = 954	*p* Value
Age (median/IQR, year)	1/2	1/2	0.80
Gender (*n*/%, count)			0.78
Male	237/17.2	546/39.7	
Female	183/13.3	408/29.7	
TBSA (median/IQR, %)	6/6	6/7	0.12
Full-thickness burn area (median/IQR, %)	0/1	0/2	<0.001
Depth (*n*/%, count)			<0.001
Superficial partial thickness burns	4/0.3	12/0.9	
Deep partial thickness burns	264/19.2	473/34.4	
Full-thickness burns	142/10.3	429/31.2	
Uncertain	10/0.7	40/2.9	
Abbreviated burn severity index (median/IQR, score)	3/1	3/2	0.01
Baux score (median/IQR, score)	9/9	9/9	0.30
Burn Index (median/IQR, score)	4.00/3.50	3.50/4.43	0.49
Prognostic Burn Index (median/IQR, score)	6.00/6.00	6.00/6.00	0.84
Proportion of patients with positive specimens detected (*n*/%, count)	90/21.4	210/22.0	0.81
Proportion of patients with positive bacteria detected (*n*/%, count)	90/21.4	210/22.0	0.81
Proportion of patients with positive fungal detected (*n*/%, count)	4/1.0	20/2.1	0.14
Propotion of patients using antibacterial drugs (*n*/%, count)	327/77.9	778/81.6	0.11
Propotion of patients using antifungal drugs (*n*/%, count)	0/0	8/0.8	0.06
Number of operations (median/IQR, count)	0.26/0.612	0.51/1.108	<0.001
Total operation duration (median/IQR, h)	0/0	0/1.5	<0.001
Cost/TBSA (median/IQR, RMB)	2551.6458/ 2811.70	2873.851- 3/4114.40	0.02
LOS (median/IQR, day)	14/13	14/16	0.45
Outcome			0.33
Cure	99/7.2	233/17.0	
Outpatient care	305/22.2	663/48.3	
Readmission	15/1.1	51/3.7	
Death	0/0.0	5/0.4	
Uncertain	1/0.1	2/0.1	

Abbreviations: IQR, interquartile range; LOS, length of stay; RMB, renminbi; TBSA, total burn surface area.

wounds. The statistical results of area and depth were highly consistent with the epidemiological characteristics expected to lead to burn and scald outcomes. In addition, the vulnerable sites, ranked from highest to lowest frequency, were extremities (37.73%), trunk (19%), and head, face, and neck (19.2%), which was associated with the ranking of body mobility. The extremities, which exhibit the highest degree of mobility, were most susceptible to burns and scalds. However, based on the area and depth of injury, the surgical rate of hospitalized patients in this population was low, and most patients could be healed after repeated dressing changes. However, because pediatric patients might get more parental attention and pediatric burn wounds were more likely to lead to elevated body temperature, the use of antibiotics in hospitalized patients from this population was higher than in adult patients. The impact of social and humanistic factors on treatment cannot be neglected, particularly in the treatment of pediatric patients and antibiotic use, which we cannot avoid.[44,45]

TABLE 4 Linear regression analyses of the association of cooling measures with clinical outcomes.

Outcome	Effect size	95% Confidence interval	*p* Value
Number of operations	−0.083	−0.162 to −0.005	0.04
Total operation duration/TBSA (h)	−0.258	−0.495 to −0.021	0.03
Cost/TBSA (RMB)	−2143.737	−4069.205 to −218.269	0.03
LOS/TBSA (day)	−2.154	−4.255 to −0.054	0.04

Abbreviations: LOS, length of stay; RMB, renminbi; TBSA, total burn surface area.

Previous studies have shown associations between first aid and improved outcomes in burn and scald injuries.[18,36,46,47] Data from the Burn Registry of Australia and New Zealand showed that approximately 70% of children received good burn first aid in these countries.[48] A study from Germany also showed that about 50% (54.3% for scalds, 48.7% for chemical burns, and 70.7% for contact burns) of the population had appropriate first aid knowledge.[49] Another study from India reported that approximately two-thirds of caregivers were aware that cool running water should be applied to a burn.[50] A questionnaire analysis on burn first-aid knowledge among children's caregivers in China reported that 73.8% of caregivers chose the option of "immediately applying cold running water" during the first-aid process of burns.[51] The result is higher than our result, which is probably due to the educational level of included caregivers. 65.3% of investigated caregivers graduated from university or junior college, and 96.9% of investigated caregivers are parents. The percentage of caregivers knowing standardly first-aid measures was 26.2% and 33.2% when the caregivers graduated from primary school or junior high school. According to another research on pediatric burns from our burn center published in 2016, only 30.0% of male guardians and 29.5% of female guardians graduated from college.[52] The educational level of guardians of pediatric patients in our burn center is consistent with the results of first-aid measures in this study. According to our statistical results, only 27.5% of pediatric patients received cooling measures during first aid. The proportion of patients who adopted the gold-standard first aid measure (cool running water for at least 20 min) was only 1.8%. However, outpatients were not analyzed in this study. Because proper first aid could reduce burn injury severity, patients who adopted appropriate first aid measures may have recovered after outpatient treatment. Besides, a recent study from Ukraine demonstrated that first aid and prevention knowledge was poor among parents and daycare workers. After implementing active education and an information campaign, a statistically significant increase was observed in the score of knowledge in first aid among daycare workers.[53] These experiences can be referred to improve the knowledge of pediatric caregivers in our country.

To investigate the impact of first aid measures on the severity of burn injuries, we compared clinical variables between patients with and without cooling measures in first aid. Compared with patients without cooling measures, patients with cooling measures showed smaller full-thickness burn areas, shallower burn depths, and lower scores for burn severity. Cooling measures in first aid also reduced the frequencies of antibiotic use, operation duration, and hospitalization costs per TBSA. Interestingly, the outcomes were not statistically different between the two groups because the vast majority of these pediatric patients could eventually be cured. We also analyzed the clinical variables between patients who adopted gold-standard first aid and patients who adopted cool running water for less than 20 min. Statistically, differences can be observed in age and antibiotic use but not in other clinical variables (data not shown). A possible reason for this is that the sample size of patients who adopted gold-standard first aid was too small for further analysis.

Distinct multivariate linear regression models were formed to assess the correlation of cooling measures with clinical outcomes. The outcome indicators included in these models were important in clinical settings, and we would like to know whether cooling measures could affect these indicators. Linear regression models showed associations between adopting cooling measures in first aid with the number of operations, total operation duration per TBSA, cost per TBSA, and LOS per TBSA. The effect size of regression models indicated that implementing cooling measures can reduce the total operation duration per TBSA by about 15 min on average. Cooling measures can also reduce the cost per TBSA by 2144 RMB and shorten LOS per TBSA by 2.2 days, reducing the financial burden on the medical system. Although confounders were controlled when establishing regression models, conclusions drawn in these models can only be used as a reference since clinical practice is far more complicated.

This study has proved the importance of cooling measures in first aid of burns. However, there are certain limitations of this study. Although the number of included subjects was 1527, the number of patients adopting cooling measures was only 420. We tried to analyze the suitable time for applying running water to pediatric patients but failed due to the sample size. Besides, this is a single-center study, and most of the hospitalized patients in our center were from Beijing and surrounding areas. Furthermore, this study did not include outpatients, which are generally patients with a diagnosis of superficial partial thickness burns. Nevertheless, this study provides important information on the epidemiology of pediatric burn patients and the association of first aid measures with clinical outcomes.

5 | CONCLUSIONS

We aimed to analyze epidemiological characteristics data and emergency treatment of burns and scalds in children and adolescents to provide a strong reference for targeted popular science and education. According to our analysis, carrying out targeted burn and scald protection and emergency science education for home caregivers of children under the age of 3 may achieve the ideal results. According to China's social and family characteristics, this part of the population consists primarily of the grandparents of children. Television, community announcements, and other traditional media science and education publicity may be more popular and accepted. Propaganda films could be produced in the form of animations to allow children and adolescents to learn about prevention and immediate first aid measures for burns while watching. Relevant knowledge could be added to the publicity bar in the community so the caregivers could learn about the prevention and first aid measures of burns. Our work can help prevent and treat burns and scalds, improve science education, and serve as a reference for other researchers.

AUTHOR CONTRIBUTIONS

Tian Liu: Conceptualization; formal analysis; funding acquisition; investigation; resources; validation; writing—original draft. **Yirui Qu**: Data curation; formal analysis; investigation; resources; software; validation. **Jiake Chai**: Conceptualization; methodology; project administration; supervision; validation; writing—review & editing. **Xiangyu Liu**: Data curation; investigation; resources; validation. **Fangchao Hu**: Data curation; investigation; resources; validation. **Dongliang Zhang**: Formal analysis; methodology; software. **Hongjie Duan**: Conceptualization; methodology; supervision. **Yunfei Chi**: Conceptualization; funding acquisition; methodology; project administration; supervision; validation; writing—review & editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

TRANSPARENCY STATEMENT

The lead author Jiake Chai, Yunfei Chi affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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