


Epidemiological characteristics of paediatric burn patients in China from 2016 to 2019: a retrospective study

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ABSTRACT

Background Epidemiological characteristics of paediatric burn can help to protect children from burn injuries. Most of the previous studies have been conducted on small scale and single centre in China. This study analysed the epidemiological characteristics of paediatric burn using a large-scale and multicentre database from 23 children's hospitals in China to increase child protection against burn injuries, improve the quality of care and reduce hospitalisation costs.

Methods Excerpted information from medical records of 6741 paediatric burn cases was extracted from the Futang Research Center of Pediatric Development database from 2016 to 2019. The epidemiological characteristics of patients, including gender, age, cause of burn injuries, complication, the timing of hospitalisation (season and month) and hospitalisation length and cost, were collected.

Results Male gender (63.23%), aged 1–2 years (69.95%), and hydrothermal scald (80.57%) were significantly dominant among cases. Furthermore, complications were significantly different among groups with different age of patients. Pneumonia was the most common complication (21%). Meanwhile, most paediatric burn occurred in spring (26.73%), and hospitalisation length and cost significantly depended on the cause of the burn injuries and surgical intervention.

Conclusions This large-scale epidemiological study of paediatric burn in China revealed that boys aged 1–2 years with higher activity and lack of self-awareness are more likely to suffer from burn injuries by hydrothermal scald. In addition, complications, especially pneumonia, need attention and early prevention in paediatric burn.

BACKGROUND

Burn injuries are the major type of accidental injuries in children globally,¹ with heavy economic and psychological burdens for families and society.^{2,3} The children suffering from burn injuries in Asia account for more than half of paediatric burn cases worldwide, most of whom require hospitalisation.^{4,5} However, as a country with a huge number of children, China does not have adequate epidemiological information about the paediatric burn. Most of previous epidemiological reports on paediatric burn have been small-scale studies.^{6,7} A large-scale and multicentre

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Burn injuries are the main type of accidental injuries in children, and most of the epidemiological studies on this topic in China are small scale and single centre.

WHAT THIS STUDY ADDS

⇒ Scalds were the most frequent cause of burn injuries.
⇒ Toddlers aged 1–2 years were the most frequently affected group.
⇒ Pneumonia was the most frequent complication.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Education programmes for burn prevention targeting families, schools and child-care facilities are an important public health initiative to reduce the burn burden. According to the epidemiological information of paediatric burns, medical centres can devote intensive resources to prepare each patient and provide the best service. More effective evidence-based, individualised programmes should be developed to treat paediatric burn with high complication rates.

study can provide much more accurate information about paediatric burn, which can be used to promote care quality in paediatric burn. Therefore, it is necessary to retrospectively analyse the epidemiological characteristics of paediatric burn in a large-scale and multicentre study.

The Futang Research Center of Pediatric Development (FRCPD) is a large medical consortium and a non-profit social service organisation in China, greatly promoting research in the paediatric field.⁸ The FRCPD covers almost one-third of children's hospitals in China. In our prior studies, we reported that exposure to hot materials is the fifth cause of morbidity and mortality by analysing 122 284 medical records in the FRCPD database.⁹ Using the FRCPD database in this study, we retrospectively analysed the



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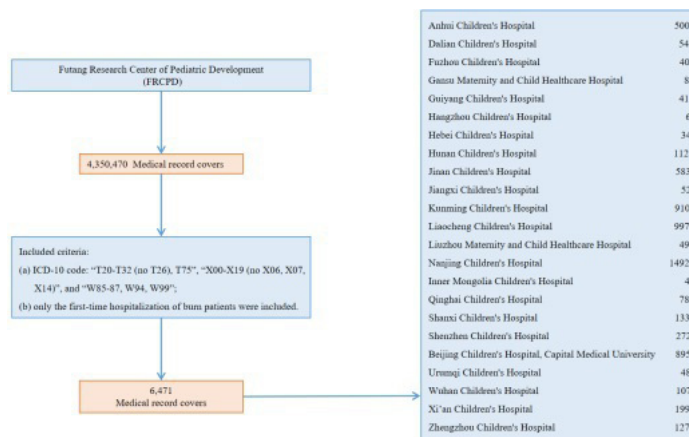


Figure 1 The flow diagram of the database search. ICD-10, the 10th revision of the International Classification of Diseases.

epidemiological characteristics of paediatric burn in a large-scale and multicentre study.

Herein, we collected the medical records of 6741 paediatric burn cases from 23 Chinese provincial and municipal medical institutions in the FRCPD database. Excerpt epidemiological data from the medical records were retrieved and analysed. This large-scale, multicentre study can describe the epidemiological characteristics of paediatric burn in China, which can increase child protection against burn injuries, improve the quality of care and reduce hospitalisation costs.

METHODS

Data collection and inclusion criteria

In our study, 4350470 medical records were retrospectively investigated from the FRCPD database, and 6741 paediatric burn cases were extracted from 1 January 2016 to 31 December 2019 (figure 1). The following patients were included: (a) the 10th revision of the International Classification of Diseases (ICD-10 code): 'T20-T32 (no T26, T75', 'X00-X19 (no X06, X07, X14)' and 'W85-87, W94, W99'; (b) Only the first hospitalisation of burn children was included. The exclusion criteria were as follow: (a) patients aged >18 years who belonged to general hospitals with adult departments and (b) data of children who had unclear demographic characteristics. The epidemiological characteristics of patients, including gender, age, cause of burn injuries, complication, the timing of hospitalisation (season and month) and hospitalisation length and cost, were collected.

Based on their age, the patients were divided into four categories: <1 year old (infants), 1–2 years old (toddlers), 3–5 years old (preschoolers) and 6–15 years old (schoolchildren). In addition, the cause of burns was grouped into six categories based on the ICD-10 codes: hydrothermal scald (X10-19), flame (W34, W36, W38-40, W92, Y25, Y27, X00, X02, X04-06, X08, X09, X97), electric (W85-87, X33), chemical (X29, X44, X46, X47, X49, X69, Y19, Y41, Y43, Y45, Y46, Y50, Y54, Y55, Y57, Y63),

others (except for above four causes) and unknown (not described).

Fifteen common complications in paediatric burn patients were also collected, such as pneumonia, shock and electrolyte disturbance (the detailed classification is shown in online supplemental materials). According to the hospitalisation season, we divided hospitalisation timing into spring (March–May), summer (June–August), autumn (September–November) and winter (December–February) groups.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Statistical analysis

Categorical variables, including gender, age, cause of burn injuries, complication and the timing of hospitalisation, were expressed as numbers (N) and percentages (%) and were compared among different groups using Pearson χ^2 tests or when there were cells whose count was less than 5 and did not satisfy the requirements of Pearson χ^2 tests, Fisher's exact tests. Continuous variables included in this study, namely hospitalisation length and cost, were both non-normally distributed according to Shapiro-Wilk tests. Therefore, they were expressed as median and IQRs and compared using Kruskal-Wallis tests. Post-hoc tests were conducted using the Steel-Dwass method. P value < 0.05 was considered statistically significant. Statistical analyses were performed using JMP Pro V.15 software.

RESULTS

Gender and age of patients

A total of 6741 medical records were collected. Boys accounted for 63.23% and girls accounted for 36.77% (table 1), with a male-to-female ratio of 1.72:1. Our results showed that boys were markedly more than girls in all age groups and cause of burn injuries groups (figure 2A,B

Table 1 The baseline characteristics of included paediatric burn patients

Characteristics	Paediatric inpatients (N)	Per cent
Gender		
Male	4262	63.23%
Female	2479	36.77%
Age		
<1 year old	366	5.43%
1–2 years old	4715	69.95%
3–5 years old	1158	17.18%
6–15 years old	502	7.45%
Cause of burn injuries		
Hydrothermal scald	5431	80.57%
Flame	206	3.06%
Electric	85	1.26%
Chemical	84	1.25%
Others	100	1.48%
Unknown	835	12.39%
Surgical intervention		
Yes	1090	16.17%
No	5651	83.83%

and online supplemental table 1, $p=0.048$ or $p=0.013$, respectively).

The age of patients ranged from 1 day to 15 years. As shown in table 1, patients aged 1–2 years were dominant (69.95%), while <1-year-old patients had the prevalence (5.43%).

Cause of paediatric burn

Among the 6741 hospitalised cases (table 1), the most common cause of burn injuries was hydrothermal scald (80.57%), followed by flame (3.06%), electricity (1.26%), chemicals (1.25%), others (1.48%) and

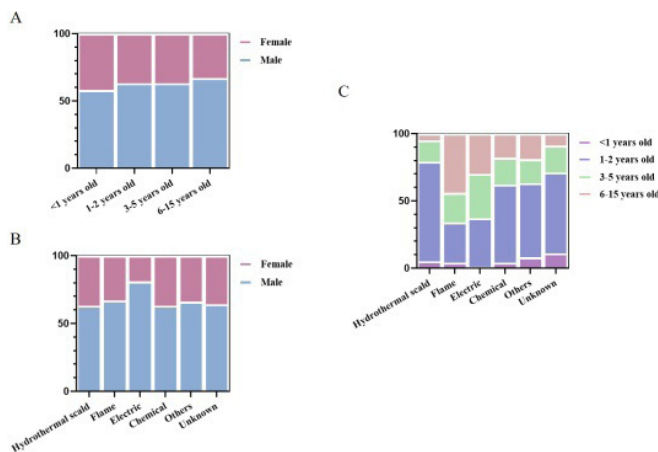


Figure 2 The distributions of the hospitalised cases of burn injuries based on the age and gender (A), gender and causes (B) and age and causes (C) of the inpatients, respectively.

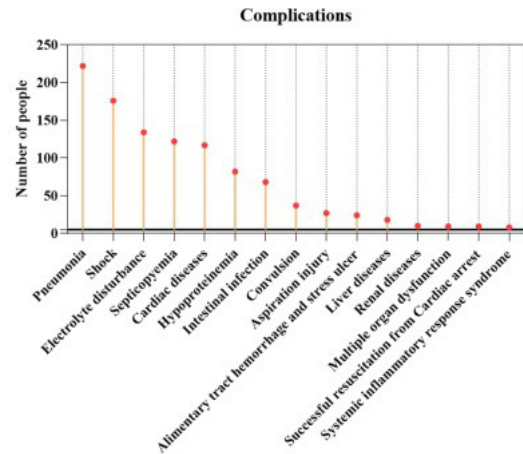


Figure 3 The proportion of common complications in paediatric burn patients.

unknown (12.39%). As shown in online supplemental table 2, the percentage of burn caused by hydrothermal scald was over 50% in different age groups, especially in children aged 1–2 years (85.24%). Thus, the cause distribution was significantly differed with age of the patients ($p<0.001$, online supplemental table 2). Moreover, we have drawn the mosaic plot for the age distribution of paediatric burn patients with different causes of burn injuries (figure 2C).

The complications of paediatric burn

The complications of burn injuries had a great impact on disease prognosis, and many patients suffered from more than one complication. The 15 most common complications were summarised in figure 3. Pneumonia (21%), shock (17%) and electrolyte disturbance (13%) were the top 3 complications of paediatric burn. In addition, table 2 reveals that the age of patients was significantly different with electrolyte disturbance ($p=0.003$), cardiovascular complications ($p=0.017$), hypoproteinaemia ($p=0.014$), intestinal infection ($p=0.002$), aspiration injury ($p<0.001$), hepatic complications ($p=0.047$) and renal complications ($p<0.001$).

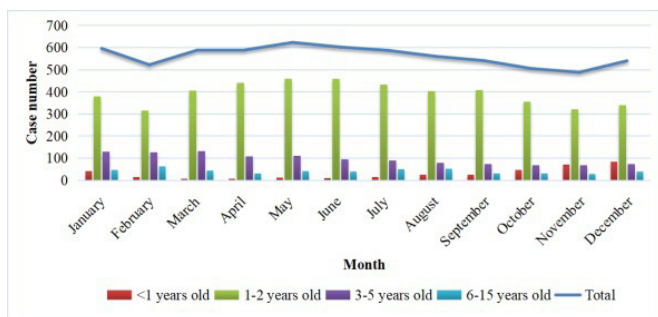
The timing, length and cost of paediatric burn in different age, cause of burn injuries and surgical intervention groups

Regarding the hospitalisation season, our study found that children were mostly admitted to the hospital during spring (26.73%), summer (25.69%), autumn (22.10%) and winter (25.47%), respectively. In particular, the number of paediatric burn patients was minimum in November (7.24%) and maximum in May (9.24%, figure 4 and online supplemental table 3). In the present study, the hospitalisation season distribution was significantly different among the groups of different cause of burn injuries ($p<0.001$, online supplemental table 1). Furthermore, the incidence of burn injuries caused by hydrothermal scald was maximum in spring (26.90%), while the flame was more in summer (39.32%), the electric burn was in winter (44.71%) and chemical burn in autumn (32.14%).

Table 2 The complication and comorbidity distribution of paediatric burn patients in different age groups

Complication and comorbidity	N	Yes or no	<1 year old (n, row per cent)	1–2 years old (n, row per cent)	3–5 years old (n, row per cent)	6–15 years old (n, row per cent)	χ^2	P value
Pneumonia	222	1	16, 7.21%	151, 68.02%	35, 15.76%	20, 9.01%	2.477	0.480
	6519	0	350, 5.37%	4564, 70.01%	1123, 17.23%	482, 7.39%		
Shock	176	1	12, 6.82%	125, 71.02%	29, 16.48%	10, 5.68%	1.480	0.687
	6565	0	354, 5.39%	4590, 69.92%	1129, 17.20%	492, 7.49%		
Electrolyte disturbance	134	1	15, 11.19%	83, 61.94%	20, 14.93%	16, 11.94%	13.731	0.003
	6607	0	351, 5.31%	4632, 70.11%	1138, 17.22%	486, 7.36%		
Septicopyaemia	122	1	13, 10.66%	79, 64.75%	22, 18.03%	8, 6.56%	6.914	0.075
	6619	0	353, 5.34%	4636, 70.04%	1136, 17.16%	494, 7.46%		
Cardiac diseases	117	1	7, 5.98%	70, 59.83%	23, 19.66%	17, 14.53%	10.257	0.017
	6624	0	359, 5.42%	4645, 70.12%	1135, 17.14%	485, 7.32%		
Hypoproteinaemia	82	1	10, 12.20%	49, 59.75%	19, 23.17%	4, 4.88%	10.701	0.014
	6659	0	356, 5.35%	4666, 70.07%	1139, 17.10%	498, 7.48%		
Intestinal infection	68	1	9, 13.24%	53, 77.94%	4, 5.88%	2, 2.94%	15.312	0.002
	6673	0	357, 5.35%	4662, 69.87%	1154, 17.29%	500, 7.49%		
Convulsion	37	1	0, 0.00%	30, 81.08%	5, 13.51%	2, 5.41%	Fisher	0.485
	6704	0	366, 5.46%	4685, 69.88%	1153, 17.20%	500, 7.46%		
Aspiration injury	27	1	3, 11.11%	9, 33.33%	5, 18.52%	10, 37.04%	Fisher	<0.001
	6714	0	363, 5.41%	4706, 70.09%	1153, 17.17%	492, 7.33%		
Alimentary tract haemorrhage and stress ulcer	24	1	1, 4.17%	13, 54.17%	5, 20.83%	5, 20.83%	Fisher	0.083
	6717	0	365, 5.43%	4702, 70.00%	1153, 17.17%	497, 7.40%		
Liver diseases	18	1	4, 22.22%	10, 55.55%	3, 16.67%	1, 5.56%	Fisher	0.047
	6723	0	362, 5.39%	4705, 69.98%	1155, 17.18%	501, 7.45%		
Renal diseases	10	1	1, 10.00%	2, 20.00%	3, 30.00%	4, 40.00%	Fisher	<0.001
	6731	0	365, 5.42%	4713, 70.02%	1155, 17.16%	498, 7.40%		
Multiple organ dysfunction	9	1	0, 0.00%	6, 66.67%	3, 33.33%	0, 0.00%	Fisher	0.629
	6732	0	366, 5.44%	4709, 69.95%	1155, 17.15%	502, 7.46%		
Successful resuscitation from Cardiac arrest	9	1	0, 0.00%	7, 77.78%	2, 22.22%	0, 0.00%	Fisher	0.912
	6732	0	366, 5.44%	4708, 69.93%	1156, 17.17%	502, 7.46%		
Systemic inflammatory response syndrome	8	1	1, 12.50%	7, 87.50%	0, 0.00%	0, 0.00%	Fisher	0.346
	6733	0	365, 5.42%	4708, 69.92%	1158, 17.20%	502, 7.46%		

Bold p values in the table indicate significant differences.

**Figure 4** The hospitalisation month distribution of paediatric burn patients in different age groups.

The median hospitalisation length was 8 days for paediatric burn in this study. There were no significant differences in age groups ($p=0.065$, table 3). Interestingly, our results showed that the hospitalisation days significantly differed based on the cause of burn injuries ($p<0.001$, table 3). The length of hospitalisation was the longest in patients burned by flame (the average was 10 days). In addition, surgical intervention significantly increased the length of hospital stay, and the median hospitalisation days was 15 days among those who underwent surgery ($p<0.001$, table 3).

Table 3 The hospitalisation days and expenses of paediatric burn patients in different age, cause of burn injuries and surgical intervention groups

	N	Hospitalisation days	χ^2	P value	Hospitalisation expense	χ^2	P value
Age			7.241	0.065		13.807	0.003
<1 year old	366	9 (5, 16)			8364.905 (4726.540, 15 865.008)		
1–2 years old	4715	8 (5, 13)			7651.290 (4340.300, 13 849.540)		
3–5 years old	1158	9 (6, 14)			8197.555 (4563.660, 15 960.208)		
6–15 years old	502	8 (5, 15)			7604.705 (4308.363, 16 412.910)		
Cause of burn injuries			84.825	<0.001		101.697	<0.001
Hydrothermal scald	5431	9 (6, 14)			8087.280 (4544.11, 14 745.15)		
Flame	206	10 (6, 22)			11 333.825 (5341.2275, 32 354.395)		
Electric	85	7 (3, 19)			8295.440 (4180.000, 20 183.535)		
Chemical	84	6 (3, 15)			7360.185 (2867.095, 23 227.935)		
Others	100	8 (4, 12)			6683.780 (3974.323, 11 361.275)		
Unknown	835	7 (5, 11)			5905.230 (3829.800, 10 576.620)		
Surgical intervention			552.466	<0.001		1375.611	<0.001
Yes	1090	15 (9, 26)			24 529.945 (12 745.078, 42 988.745)		
No	5651	8 (5, 12)			6647.910 (4026.300, 11 183.100)		

Bold p values in the table indicate significant differences.

The hospitalisation costs were considered the total expenses of inpatients, including treatment, medications, materials, lab tests, nursing care and additional expenses. **Table 3** revealed that the hospitalisation costs were significantly differed with age ($p=0.003$), cause of burn injuries ($p<0.001$) and surgical intervention ($p<0.001$) among all 6471 cases. The hospitalisation costs were highest in paediatric inpatients with <1 year old or burns caused by flame.

DISCUSSION

In the current study, we found that among paediatric burn patients, male gender, 1–2 years of age, and hydrothermal scald were more common. Pneumonia was the most common complication in paediatric burn, and the age of patients was significantly differed with burn complications, including electrolyte disturbance, cardiac complications, hypoproteinaemia, intestinal infection, aspiration injury, hepatic complications and renal complications. The number of paediatric burn

patients increased in spring, and the median hospitalisation length was 8 days. Furthermore, the hospitalisation length significantly differed according to surgical intervention and cause of burn injuries. The hospitalisation costs were significant difference with age, surgical intervention and cause of burn injuries.

Gender and age

Gender and age are significant risk factors for burn injuries. In most developing countries, burn injuries are more common among adult females due to cooking and heating fuels. In contrast, in developed countries, burn injuries are more common among adult males due to industrial accidents.¹ Previous reports revealed that boys are more susceptible to burn injuries because of impulsivity, curiosity, hyperactivity and lack of self-awareness.^{10–12} Consistent with these reports, the incidence of burn injuries was much higher in males than females in this study. Furthermore, the number of males who experienced burn injury was much higher than that of females in different age and cause of burn groups.



Paediatric burn primarily occurred in children younger than 5 years old,¹³ and our data also showed that children aged 1–2 years were more susceptible. Moreover, accidental burns were less common in infants (<1 year old) who did not walk, preschoolers (3–5 years old) and school children (6–15 years old) who recognised the danger. Given that the age distribution of burned children is wide ranging, education programmes for burn prevention targeting families, schools and child-care facilities are an important public health initiative to reduce the burn burden. For example, it is essential to remind and educate caretakers especially toddler (1–2 years old) caretakers, about burn prevention.¹⁴ Notably, we cannot assume that children aged 15–18 years do not suffer from burn injuries, because children over 14 years are often admitted to adult hospitals in China.

Cause of burn injuries

Children are susceptible to burn injuries, especially to hydrothermal scald. Various types of burn are related to eating or bathing habits, clothes and environmental temperature. Toddlers are often burned during bathing and eating. For instance, they are usually burned by boiling water, hot soup and hot milk,¹⁰ whereas burn injuries in young adults are often related to flame or electrical injuries.^{15–16} In our study, children aged 1–2 years are mainly burned by hydrothermal scald, and school-children aged 6–15 years are more likely burned by flames. Therefore, the necessary preventive measures, such as keeping hot water bottles out of sight of children, or testing the water temperature before bathing, could protect children from burns caused by hydrothermal scalds. In addition, the mental health of adolescents needs serious attention, although only three boys aged 6–15 years with burn injuries caused by intentional self-injury were identified among our cases.

Complications

In addition, more attention should be paid to complications during hospitalisation. Burn-related complications, such as abdominal compartment syndrome, acute respiratory distress syndrome, septic shock, acute kidney injury and pneumonia, were the leading causes of mortality in paediatric burn.¹⁷ Compared with burns in adults, burns in children aged less than 4 years were easily complicated due to weak skin barriers.¹⁸ Furthermore, severe burn injuries led to organ damage/failure in children.¹⁹ Among the observation in our study, the most common complications was pneumonia. Heat damage and irritants lead to the release of inflammatory mediators in the upper respiratory tract and increased vascular permeability leading to oedema.²⁰ Currently, the treatment of respiratory injury included antibiotics, airway control and mechanical ventilation. In addition, loss of circulating blood results in hypovolaemic shock, peripheral oedema, multiorgan failure and even death.²¹ Children are more susceptible to burn shock than adults due to lower circulating blood volume. According to

the epidemiological information of paediatric burns, medical centres can devote intensive resources to prepare each patient and provide the best service. More effective evidence-based, individualised programmes should be developed to treat paediatric burn with high complication rates.

Hospitalisation timing, length and cost

The seasonal variation, rather than the yearly variation, seems more statistically valuable in burn injuries. Summer was the peak of severe burn patients admitted to the eight public hospitals.¹⁸ Nevertheless, our study verified that the number of paediatric burn patients was higher in the spring. Most likely, the cold weather limits children's outdoor activities. Hydrothermal solutions and electric sockets are more accessible during indoor activities of children. Inversely, hydrothermal scald injuries are milder when children wear thick clothing, which may partly explain why November had the lowest number of paediatric burn hospitalisation.

Besides, a previous study showed that hospitalisation length is related to the extent of body surface area.²² A study found that the median hospitalisation length of burn patients increased to 14 days due to severe injury and prolonged rehabilitation.¹⁸ The median hospitalisation length was 8 days in this study. Furthermore, the hospitalisation length was significantly different among groups with different cause of burn and surgical intervention. Paediatric burn caused by flame or surgery may increase median hospitalisation length. Hospitalisation costs were significantly associated with age, surgical intervention and cause of burn injuries. A study found that medications, particularly antibiotics, were the leading cause of hospitalisation costs in paediatric burn.⁴ Similarly, treatment and medications were the main costs in this study, and hospitalisation expenses significantly increased in patients <1 year old or undergoing surgery. Our results also confirmed that hospitalisation length and costs of paediatric burn were higher when burn was caused by flame. Therefore, it is essential to reduce the incidence of flame injuries, considering the hospitalisation length and expenses of paediatric burn. Active intervention for flame burns, shortening the interval between two surgeries and increasing the treatment area of a single surgery may reduce the length of hospital stay.

Severity of burns is very important criteria in all type of burn injuries, ultimately affecting morbidity, mortality, complications, hospital stay, hospital expenses and surgical interventions etc. Unfortunately, severity of burns (% total body surface area and depth of burn injuries) in all participants were not analysed in the present study due to incomplete diagnosis of included homepage information. In addition, some children with mild burn injuries received only outpatient treatment, and this might exclude the number of mild burn cases, and influence the distribution of children patients.

CONCLUSION

Burn injuries are devastating in children, often leading to lifelong physical and psychological impairments. According to the FRCPD database, this large-scale and multi-centre study from 2016 to 2019 revealed the epidemiological characteristics of paediatric burn. Overactive boys aged 1–2 years who lack self-awareness are more likely to suffer from burn, and parents should pay more attention to preventing hydrothermal scald. Pneumonia was the most common complication of burn injuries, which needs more attention and early prevention. Herein, we recommended some measures to protect children from burn injuries, improve treatment and reduce hospitalisation costs in paediatric burn.

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Contributors The authors' contributions were as follows. YG and XN contributed to the conception and design of the study. KC, JL, XW contributed to acquisition, analysis and interpretation of the data. KC and JL wrote the manuscript. PC, GF, YZ, XX revised the manuscript. XN acted as a guarantor in the manuscript. All authors read and approved the final manuscript.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval All patient records were pseudonymised by the data providers through encryption of personal identifiers. Ethical approval to hold and analyse the data set was obtained from the ethics committee of Beijing Children's Hospital, Capital Medical University (Approval Number: 2020-k-10).

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