Int J Clin Exp Med 2018;11(9):9280-9287
www.ijcem.com /ISSN:1940-5901/IJCEM0079061

Original Article

Pediatric burns in South Central China: an epidemiological study

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Received May 5, 2018; Accepted July 26, 2018; Epub September 15, 2018; Published September 30, 2018

Abstract: Objective: The aim of this study was to explore the epidemiological characteristics of hospitalized pediatric burns in Hunan Province, summarize the regional regularity of burns in the pediatric population, and provide rationale for optimizing management protocols of pediatric burns. Methods: Clinical data were obtained from < 15-year-old pediatric burn patients hospitalized at the Department of Burns, between 2013-2017. Retrospective analysis was performed, including gender, distribution of age, place of injury, cause of burn, distribution of months, extent of burn, anatomical sites of burn, length of hospitalization, and number of operations. Furthermore, differences were analyzed in causes of burn at different places, among 4 intervals of age, seasons of burn occurrence, and weeks of hospitalization, respectively. Results: A total of 452 children were hospitalized, accounting for 57.07% of the total number of burn patients. Most were aged 1-3 years (69.03%). The ratio of boy-to-girl was 1.48. Indoors was a major occurrence place of burns (89.16%), while scalding with hot liquid was the most common cause of burns (77.21%). Differences among causes of burns and places of burns were statistically significant (X^2=173.13, P < 0.01). An overwhelming majority were scalded with hot liquids indoors (347/403, 86.10%), while flaming burns were a major reason for outdoor injuries (36/49, 73.47%). Differences were statistically significant among causes of burn during 4 intervals of age (X^2=62.52, P < 0.01). The proportion of flaming burns increased gradually in each age group, along with growing up. The months of February to April had a higher incidence of burns. Differences were statistically significant among causes of burn during different seasons (X^2=21.43, P < 0.01). Most burns were mild and moderate (69.61%). Trunk, head & neck area, and upper extremities were the most susceptible anatomical sites. More than half had 2 or more anatomic sites of burns (58.41%). Those injured within 2-12 hours accounted for 34.51% of the total and 39.38% were injured 24 hours earlier. Almost half of them demonstrated improvements or were cured within 2 weeks of hospitalization. Differences were statistically significant in length of hospitalization among causes of burn (X^2=9.65, P < 0.01). However, those injured by flames, electricity, and chemicals had longer hospital stays. Conclusion: Children aged < 3 years, boys, and players during Chinese Lunar New Year were particularly susceptible to burns. Scalds happen mostly indoors while flaming burns tend to occur outdoors. Multiple anatomic sites, including the trunk and head & neck area, are at greater risks for burn injuries. Pediatric burns should be recognized as a social problem. Through a family-school-hospital-government mode of preventive strategy, a personalized preventive system of pediatric burns should be established, effectively lowering the morbidity of burns.

Keywords: Burn, pediatric, epidemiology, prevention

Introduction

Growing up in a safe environment is vital for both psychological and physical development of children. Due to a lack of necessary self-control and protective awareness, a large variety of unintentional injuries may impair their well-being. In searching for subtypes of lethal injuries from Global Burden of Disease Study 2016 (GBD 2016) Data Resources [1], unintentional injuries accounted for 62% of all kinds of injuries for children aged < 15 years, in 2016. More specifically, fire-related burns were among the leading causes (8.8%) [1]. Unintentional injuries among children have remained a primary domestic cause of mortality over the last decade [2]. Despite declining incidence of pediatric burns recently, scalding burns still have a high incidence in China [3-5]. After examining the causes of unintentional injuries in 924 chil-

Table 1. Constituent ratios of gender in all age groups [n (%)]

Age (years)	Number of patients	Boy	Girl
≤1	123	67 (54.47)	56 (45.53)
2-3	189	114 (60.32)	75 (39.68)
3-7	101	65 (64.36)	36 (35.64)
7-14	39	24 (61.54)	15 (38.46)
Total	452	270 (59.73)	182 (40.27)

Table 2. Constituent ratios for causes of burns at different locations of injuries [n (%)]

Locations	N	Hot liquid scalds	Flaming burns	Other burns
Indoors	403	347 (86.10)	35 (8.68)	21 (5.21)
Outdoors	49	2 (4.08)	36 (73.47)	11 (22.45)
Total	452	349 (77.21)	71 (15.71)	32 (7.08)

dren, retrospective analysis revealed that fire and heat-related burns ranked second among various causes of injury, while fall/drop injuries came in third [6]. Avoiding unintentional injuries more effectively and providing optimal intervention after injuries have important implications for clinical practice [7].

Epidemiological data of pediatric burns may offer valuable rationale for developing strategies of lowering incidence of burn injuries and slashing the overall healthcare budget [8]. Although epidemiological characteristics of pediatric burns vary widely among regions and countries, some regular patterns may be present. As one of the largest burn care centers in South Central China, our department has extensive resources of instruments and specialists. Epidemiological data were collected for hospitalized pediatric burns over the last 4 years. A retrospective study was performed revealing the regional epidemiological characteristics of burns. Present results supplied convincing clinical evidence, offering great potentials for optimizing management protocol for pediatric burns in China.

Materials and methods

Clinical data and epidemiological characteristics

Relevant clinical data were collected from hospitalized burn children, aged under 15 years old, from January 1, 2013 to January 1, 2017. Epidemiological characteristics were analyzed, including gender, age, places of injury, causes of burn, length of injury time at admission, extent of burn, anatomical sites of burn, injury date, length of hospitalization, and number of operations.

Based upon age distribution, they were grouped into 4 intervals of infants (≤ 1 year), toddlers (2 to 3 years), preschoolers (4 to 7 years), and school-age youngsters (8 to 14 years) [9]. The months of injury fell into different seasons, spring (March to May), summer (June to August), autumn (September to November), and winter (December to February) [10]. Major causes of burns were summarized into three categories, scalding (hot water, steam & hot oil/soup), flaming (fireworks & flame), and others (contacts with chemicals & electricity). According to standards of care for pediatric burns of Chinese Burns Association, extent of pediatric burns was graded as mild (a total body surface area [TBSA] < 5% and no third degree burns), moderate (TBSA 6-15% or third degree burn with TBSA < 5%), extensive (TBSA 16-25% or third degree burn with a TBSA range of 6-10%), and critical (TBSA > 25% or third degree burn with TBSA > 10%). Extent of burns and TBSA were estimated by two attending physicians, according to the Rules of Nines & Rules of Palms [11].

Furthermore, differences were analyzed among causes of burn, places of burns, intervals of age, seasons of burns, and length of hospitalization. Incidence of burns was compared for boys versus girls with regards to different extents of burn, with correlation detected between extent of burns and length of injury times after admission. This study also analyzed differences in the distribution of weeks of hospitalization between genders and among causes of burns. Correlation between length of hospital stays and intervals of age was also analyzed.

Statistical analyses

Continuous variables are presented as mean with standard deviation while categorical data are presented as constituent ratios or percentages. Pearson's X^2 test was performed on a contingency table containing two unordered categorical variables. Mann-Whitney U-test was used for examining inter-group differences for

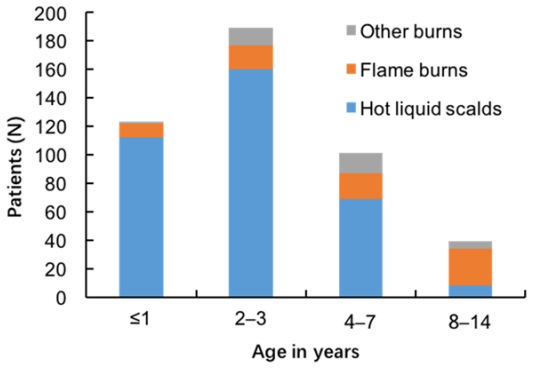

Figure 1. Distribution for causes of burns in all age groups.

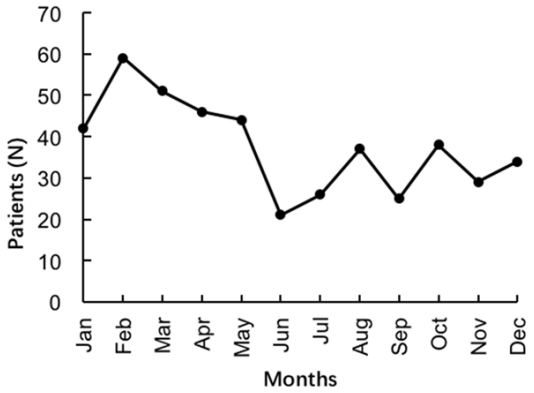

Figure 2. Cumulative frequencies for pediatric burns monthly over the past 4 years.

one variable in another ordered categorical variable. Kruskal-Wallis test was employed to detect differences among three or more groups of one variable in another ordered categorical variable. Spearman's rank correlation coefficient was used to detect correlation between two ordered categorical variables with different attributes. All statistical analyses were performed with Statistical Package for the Social Science (SPSS) version 19.0 for Windows (SPSS Inc., Chicago, IL, USA). $P < 0.05$ is deemed as statistically significant.

Results

Demographic characteristics

A total of 792 hospitalized burn were recorded during a 4-year period. Of these, 452 (57.07%) were aged under 15 years, with an average of 113 patients admitted annually.

Distribution of age had an average of 3.17 years with a standard deviation of 2.52 years. Toddlers (2 to 3 years) were the largest population with burns (41.81%), followed by infants (≤ 1 year) with an incidence of 27.21%. The ratio of boy-to-girl was 1.48. Constituent ratio of genders (unordered categorical variable) was compared among intervals of age (ordered categorical variable). Mann-Whitney U-test revealed no significant differences (**Table 1**).

Locations and causes of burns

In the present study, 403 burns occurred indoors (89.16%) while 49 children were burned outdoors (10.84%). Among causes of burns, scalding was the most common type (349/452, 77.21%), in which boiling water and hot oil constituted a large majority of injuries. Flaming ranked second (71/452, 15.71%), in which fireworks accounted for 26.76%. The group of other burns had 32 patients (7.08%). Differences were compared between locations of burns in the groups of causes of burns using Pearson's X^2 test. Statistically significant differences existed ($X^2=173.13$, $P < 0.01$). Scalding patients accounted for a large majority of indoor injuries (347/403, 86.10%), whereas flaming burns tended to occur more frequently outdoors (36/49, 73.47%). Constituent ratios for causes of burns at different locations are shown in **Table 2**.

Furthermore, differences were detected by Kruskal-Wallis rank-sum test among intervals of age (ordered variable) in causes of burns (unordered variable). Differences were statistically significant ($X^2=62.52$, $P < 0.01$). The proportion of scalding injuries decreased while that of flaming burns increased gradually, along with growing up (**Figure 1**).

Distribution of burns by month and season

Pediatric burn patients were grouped into each month, according to dates of admission. When distributed from beginning to end of the year, they were more likely to be injured in February (59/452, 13.05%) and March (51/452, 11.28%). Compared with adjoining months, pediatric burns occurred more frequently in August (8.19%) and October (8.41%). Cumulative frequencies of monthly pediatric burns over the last 4 years are shown in **Figure 2**. Furthermore, all months were grouped into 4 seasons. Results showed that spring (141/452, 31.19%) and winter (135/452, 29.87%) had a higher occurrence rate of burns. A total of

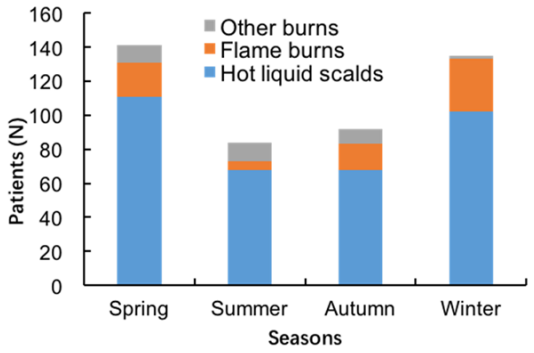

Figure 3. Distribution for causes of burns during different seasons.

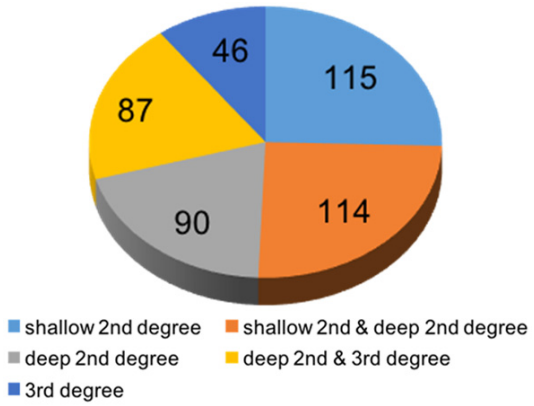

Figure 4. Distribution of pediatric burns in different depth of surface of burns.

92 children were injured in autumn (20.35%) and there was a lower risk of injuries in summer (84/452, 18.58%).

X^2 test was performed, comparing the constituent ratios for causes of burns among different seasons, with significant statistic differences existing (X^2=21.43, P < 0.01). Analyzing seasonal causes of burns, patients in spring and summer were burned by similar objects. Scalding and group of other burns were the major causes of burns in the summer, whereas flaming burns were more likely to occur in winter than other seasons (**Figure 3**).

Extent of burns and anatomical sites of burns

TBSA of burns ranged from 0.1% to 90% for pediatric patients, with a mean of 12.80% and a standard deviation of 14.62%. Specifically, 184 children (40.71%) were injured with TBSA < 5%, 160 (35.40%) TBSA 6%-15%, 50 (11.06%) TBSA 16%-25%, and 58 (12.83%) TBSA > 25%.

The depth of surface of burns included 6 levels, but only 5 degrees are shown in **Figure 4** since none of them were injured with first degree burns. A total of 114/452 patients were injured with shallow second-degree burns (25.22%), 90 patients were injured with deep second-degree burns (19.91%), 115 children had multiple anatomical sites of burns with either shallow or deep second-degree burns (25.44%), 46 patients had third-degree burns (10.18%) and 87 patients of multi-site burns with either deep second-degree or third-degree burns (19.25%).

According to TBSA, as well as depth of surface of pediatric burns, different extents of burns were defined as mild, moderate, extensive, and critical. Mann-Whitney U test was performed for data in a contingency table (**Table 3**), comparing the constituent ratios of extent of burns (ordered categorical variable) between genders (unordered variable). There were no statistically significant differences (Z=-0.356, P > 0.05).

In this study, anatomical sites of burns were distributed throughout 8 body parts. Trunks were the most commonly involved site (199/452, 21.49%), followed by head & neck area (195/452, 21.06%), upper extremities (192/452, 20.73%), lower extremities (165/452, 17.82%), fingers (6.37%), hip area (5.94%), genital area (4.86%), and dorsum of the foot (1.73%). The total sum of patients distributed at each anatomical site of burns was larger than the total number of pediatric patients. This was because over half of them had more than one injury site (264/452, 58.41%). The number of burn sites was 2 (n=125), 3 (n=83), 4 (n=43), 5 (n=11), and 6 (n=2), respectively. An 8-year-old girl with a TBSA > 85% was injured by a flame at her home in August. Another 7-year-old boy had a critical burn from household liquor with a TBSA of 90%.

Injury time pre-admission

Pediatric patients admitted with burn injuries within 2 hours accounted for 11.28% (51/452) in total, while 156 patients were injured within 2-12 hours pre-admission (34.51%), 67 children within 12-24 hours pre-admission (14.82%), and 178 patients beyond 24 hours post-admission (39.38%). Correlation between the 4 intervals of injury time pre-admission

Table 3. Constituent ratios for extent of burn in different genders [n (%)]

Gender	N	Mild	Moderate	Extensive	Critical
Boy	270	77 (28.52)	115 (42.59)	25 (9.26)	53 (19.63)
Girl	182	52 (28.57)	72 (39.56)	20 (10.99)	38 (20.88)
Total	452	129 (28.54)	187 (41.37)	45 (9.96)	91 (20.13)

Table 4. Constituent ratios of extent of burn for different injury time pre-admission [n (%)]

Time[a]	N	Mild	Moderate	Extensive	Critical
≤ 2 h	51	11 (21.57)	27 (52.94)	5 (9.80)	8 (15.69)
2-12 h	156	43 (27.56)	70 (44.87)	17 (10.90)	26 (16.67)
12-24 h	67	22 (32.84)	26 (38.81)	5 (7.46)	14 (20.90)
> 24 h	178	53 (29.78)	64 (35.96)	18 (10.11)	43 (24.16)
Total	452	129 (28.54)	187 (41.37)	45 (9.96)	91 (20.13)

a: Length of injured time pre-admission.

(ordered categorical variable) and extent of burns was further analyzed (**Table 4**). No statistically significant differences existed (Spearman's rank r=0.023, P > 0.05).

Length of hospitalization and operation

Length of hospital stay was grouped into weeks of hospitalization since there was a large deviation from the average value (17.70±12.36 days) for pediatric burn patients. Specifically, 62 (13.72%) patients were discharged from the hospital within 1 week (< 7 days), 143 (31.64%) stayed for 1-2 weeks (7-13 days) pre-discharge, 98 (21.68%) had 2-3 weeks (14-20 days) hospitalization, and 71 (15.71%) stayed for > 1 month (≥ 30 days). Differences in weeks of hospitalization between genders were further analyzed by Mann-Whitney U-test, with no statistically significant differences detected (Z=-0.451, P > 0.05). This study characterized the correlation between weeks of hospitalization and 4 intervals of age using Spearman's rank correlation coefficient, finding no significant correlation (r=0.033, P > 0.05). This study also compared the constituent ratios for cause of burns during different weeks of hospitalization using the Kruskal-Wallis test (**Figure 5**). Statistically significant differences existed among them (X^2=9.648, P < 0.01). Although pediatric patients injured by scalds were the common population during different weeks of hospitalization, ratios of flaming burns increased for children hospitalized for over 1 month.

Of these, 289/452 patients (63.94%) were not operated on while another 163/452 children (36.06%) underwent one or more operation. There was one-time operation (n=113), re-operation (n=32), and repeated operation (n=18). For those with mild or moderate burns, only 31.78% (41/129) or 27.81% (52/187) underwent operations, respectively. For those with extensive or critical burns, 44.44% (20/45) or 56.04% (51/91) were operated on more than once.

Discussion

Epidemiological characteristic of pediatric burns

Children aged 14 years or under accounted for 57.07% of the total number of hospitalized burn patients over the last 4 years. The proportion of pediatric burn patients was in accord with figures reported from other studies [9-13]. The distribution for age had a mean of 3.17 years and a standard deviation of 2.52. Among 4 intervals of age, toddlers (aged 2-3 years) were the most common burn sufferers, followed by infants (≤ 1 year). Toddlers have just learned to walk and remain curious about their surroundings without awareness of danger. Thus, they deserve more attention from their parents or other supervisors. Incidence of burns was much higher in boys than in girls. The ratio of boy-to-girl achieved 1.8 for preschoolers (4-7 years). This may be because boys tend to be more active than girls, by nature, and there is a higher birth rate of boys in China.

Most burn injuries occurred indoors. Hot liquid scalding has been a major cause of indoor burns while flaming burns are more frequent outdoors. Present findings were consistent with other studies of pediatric burns [12-15]. As demonstrated by another study analyzing the causes of burns in 4 age groups, scalding was the most common cause of burns in children under 3 years (87.18%). While the proportion of flames and other causes of pediatric burns increased gradually with advancing age, the proportion of flames achieved 66.67% in children over 7 years. These results were in accord with other studies [16-18]. Children under 3 years tended to stay at home

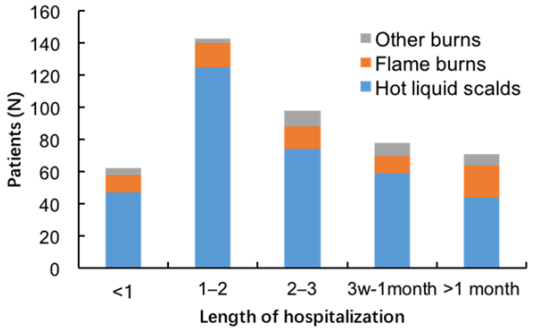

Figure 5. Distribution for causes of burns during different weeks of hospitalization.

and have higher possibilities of touching hot liquids. Preschoolers and school-age kids are generally more curious about household electrical equipment and are more likely to play with fire and fireworks or walk close to a high-voltage area outdoors. Thus, they have a higher probability of injury by flames, electricity, or high-temperature solids. As a result, different supervision schemes should be adopted for different ages of children. Caretakers should pay more attention to hot liquids at home and emphasize the risks of fire and electricity wherever children play.

The peak incidence of burns in winter appears in February, coinciding with the Spring Festival in China. Most people are accustomed to using water in winter in South Central China, indicating a higher probability of scalding for children. The constituent ratio of flames in winter was much higher than other seasons. Children prefer to play with fireworks outdoors without parental supervision during the period of Spring Festival in China [19]. A secondary peak of burns was seen in August and October (**Figure 2**). Analysis of causes of burns in these two months showed that scalding accounted for 86.49% and 68.42% in all kinds of burns. Burned toddlers were predominant over the last two months. Since August is one of the hottest months in China, children are bathed so frequently that they may be burned while their parents are preparing bath water. Furthermore, children that dressed lightly tended to expose directly their skin to the air. During the 7-day period of National Holiday each October in China, children have ample leisure time playing at home. Their parents may ignore the potential risks of burns while enjoying the holidays. In one report, incidence of pediatric burns in winter was higher than other seasons in Inner Mongolia Autonomous Region [20], while the period of April to August had a higher incidence of pediatric burns in Nanjing, Jiangsu Province [21]. Although occurrence of pediatric burns with high frequency was distributed in different periods in these studies, their distributions have some monthly or seasonal regularities. Residents living in Northern China have different living habits from those living in South China, due to considerable differences in climatic conditions and geographical locations.

In the present study, TBSA of pediatric burns ranged from 0.1% to 90%. TBSA < 15% accounted for 76.10%. Most children were injured with mild or moderate burns, similar to the results of Liu et al. [11]. The number of patients with critical burns was greater than those with extensive burns. If extensive burns were not treated timely and properly, wounds deteriorated into critical burns. Primary injured body sites in children were trunk, head & neck, and upper extremities. When children touched containers filled with hot liquids at the edge of a table due to curiosity, they would be easily scalded at the upper extremities and head & neck. More than half of the pediatric patients had two or more anatomical sites of burns. Thus, it is imperative for their parents or guardians to perform cooling treatment timely. By lowering the temperature of skin surface through cold water or cold compression for at least 20 minutes, they may avoid aggravation of the burns [22].

Most pediatric patients were hospitalized after burn injuries within 2-12 hours. Traffic conditions are terrible surrounding our hospital, due to its downtown location within an old neighborhood. Patients admitted within 2 hours after injuries were more likely to be residents not far away, while residents living in suburban districts or other downtown areas might be admitted within 12 hours. In addition, over one third of patients had burns > 24 hours at admission. Most of them came from other cities or remote villages, while some came from neighboring provinces.

In the present study, the average length of hospitalization was 2 weeks, a bit longer than values reported in other studies [10, 13, 23]. Mild burns were more likely to occur from injures from hot liquids. Most cases could be cured and discharged within one to two weeks after

non-surgical measures and optimal treatments. Although the proportion of patients with flaming burns and other burns was relatively low, patients from flaming burns accounted for a high proportion of 28.17% in patients hospitalized for over one month. It was higher than the average proportion 15.71% of flaming burns. Most patients of electric, chemical, and scalding burns stayed in the hospital for 3 weeks up to 1 month. Reports from other studies have also indicated that TSBA of burns were relatively large for these causes of burns. These pediatric patients were more susceptible to disabilities, malformations, amputation, or even death due to ineffective first-aid treatment after injuries [16, 24].

Preventive measures for pediatric burns

Although epidemiological characteristics are complicated for pediatric burns, the regularities of preventing pediatric burns can be summarized. Parents or supervisors should take meticulous caution to avoid various risk factors. Healthy growing up for children has been closely correlated with the development of human society. Not merely a disease caused by unintentional injury, pediatric burns should be treated as a social problem to be tackled by different departments in the whole country. The government should propagandize the knowledge of preventing burns to the public more frequently, enhancing the alertness of residents. Hospitals should expand the scope of community services and organize professional healthcare workers to spread the knowledge of prevention and first-aid for burns at communities, kindergartens, and primary schools. During this era of information, the government should organize local communities to cooperate with hospitals to implement safety education regarding burns through public electronic displays or internet postings. Local schools can also cooperate with hospitals, helping teachers and parents acquire more information on preventing burns by broadcasting on social networking platforms. Acting as primary supervisors of their children, parents should take more initiative to grasp relevant knowledge. If under the care of grandparents, their parents should communicate with elders more frequently to enhance security awareness. Most Chinese grandparents are accustomed to using traditional folk remedies for injuries. However, these folk remedies have unknown side effects. Thus, it is essential to remind grandparents to provide timely emergency measures.

In short, as a national social systematic project, prevention of burns requires pooling the resources of hospitals, government agencies, schools, and family members to construct a personalized prevention system for pediatric burns.

Acknowledgements

This work was supported by the Open Research Program of Hunan Provincial Key Laboratory for Germplasm Innovation and Utilization of Crop, China #15KFXM11, the Scientific Research Program of the Educational Department of Hunan Province of China #16C0776, and the Science Foundation for Young Scholar of Hunan Agricultural University of China #16QN33.

Disclosure of conflict of interest

None.

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