



CHANGING PATTERNS IN PEDIATRIC BURNS IN CROATIA – DATA FROM THE NATIONAL REFERRAL CENTER DURING THE 2010-2019 PERIOD

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SUMMARY – The aim of this study was to assess changes during the past decade in the overall number, as well as patterns of burn injuries according to age at the time of injury, total body surface area (TBSA) affected, and burn injury mechanisms. We also wanted to evaluate the average length of stay to TBSA ratio and seasonal variations according to burn injury mechanism. We performed a review of 402 patients hospitalized at our institution during a 10-year period and divided them into subgroups as follows: scalds, contact burns, flame and electrical burns, and massive thermal injuries (>40% TBSA regardless of burn injury mechanism). The peak incidence of burn injuries was recorded between the first and second year of life, and scalds predominated as the burn injury mechanism. During the observed period, the average TBSA declined and scalds became even more dominant as the burn injury mechanism. Seasonal variations could be confirmed for contact burns which occurred most commonly during autumn and winter, and for flame and electrical burns that occurred most often during summer. Given the fact that we recorded a decline in the number of patients with burn injuries, we believe that it is of highest importance for the management of burn injury pathology to be concentrated in a center with greatest experience in the treatment of burn injuries in children. Based on the characteristics of patients with burn injuries, small children and preadolescents and young adolescents should be targets of prevention campaigns.

Key words: *Burns, pediatric; Epidemiology*

Introduction

In the last fifteen years, there have been diverse reports regarding trends in the hospitalization of children with burn injuries. Most authors report a decline in the overall number of burn injuries¹⁻³, while more patients, occasionally with less severe injuries, are being treated in specialized burn centers⁴⁻⁶. Our institution is the Referral Center for Pediatric Trauma of the Ministry of Health of Croatia, and as such has the

role of the national pediatric burn center. The purpose of this study was to get the big picture regarding the situation with pediatric burns in Croatia and to see if there was a significant change in the incidence, burn

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injury patterns and outcomes in the last decade. These data would be helpful in planning of resources for pediatric burn management at our institution, as well as in Croatia as a whole.

Materials and Methods

A review was performed of all patients with burn injuries that required inpatient treatment at the Department of Burns, Plastic and Reconstructive Surgery and Traumatology, Zagreb Children's Hospital during the period from January 1, 2010 until December 31, 2019. The aim of the study was to assess changes in the characteristics of burn injuries according to age at the time of injury, total body surface area (TBSA) affected, burn injury mechanisms, annual number of hospitalizations, average length of stay (LOS) to TBSA ratio, and seasonal variations according to burn injury mechanism during the study period. Data were obtained through our hospital computer database. The study was approved by the Ethics Committee of Zagreb Children's Hospital (no. 02-23/40-1-20). Patients were divided into subgroups according to burn injury mechanism as follows: contact burns, scalds, flame and electrical burns, and massive thermal injuries. As there is evidence that when a burn injury affects >40% of TBSA, there is an increase in mortality in pediatric patients⁷, we classified all burn injuries to more than 40% of TBSA as massive thermal injuries, regardless of the injury mechanism. Patient data were calculated

and analyzed using Microsoft Excel 365™ (Microsoft Corporation Inc., Redmond, VA, USA). The primary objective of the research was to analyze how the following parameters changed in the observed period: annual number of burns, average TBSA of hospitalized patients, LOS/TBSA ratio, distribution according to age, and burn injury mechanism. The secondary objective was to analyze different subgroups for mean age, gender, mean TBSA, mean proportion of a third degree injury, and mean LOS in the hospital, in the intensive care unit, and time spent on mechanical ventilation. We also analyzed the relationship between seasons and occurrence of different types of burn injuries. Patients whose treatment was not completed at our institution were excluded from the study.

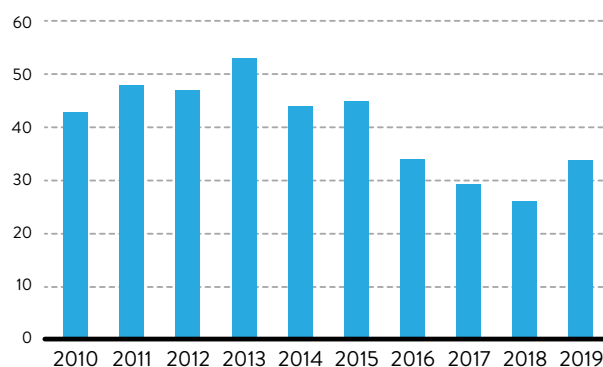


Fig. 1. Annual number of hospitalized pediatric burn patients.

Table 1. Baseline characteristics of patients with burn injuries hospitalized in Zagreb Children's Hospital from January 1, 2010 until December 31, 2019

	Contact burns	Scalds	Flame and electrical burns	Massive thermal injuries
Number of patients (%)	63 (16%)	257 (64%)	60 (15%)	22 (5%)
Average age of patients	1 yr 6 mo	3 yrs 5 mo	9 yrs 9 mo	8 yrs 2 mo
Gender (F female, M male) (%)	F 22 (35%) M 41 (65%)	F 100 (39%) M 157 (61%)	F 6 (10%) M 54 (90%)	F 17 (77%) M 5 (23%)
Average TBSA (%)	2	10	12	62
Affected body parts (H head and neck, T trunk, U upper extremities, L lower extremities) (%)	H 13 (21%) T 4 (6%) U 58 (92%) L 2 (3%)	H 70 (27%) T 133 (52%) U 143 (56%) L 85 (33%)	H 25 (42%) T 17 (28%) U 38 (63%) L 33 (55%)	H 16 (73%) T 22 (100%) U 22 (100%) L 22 (100%)

TBSA = total body surface area

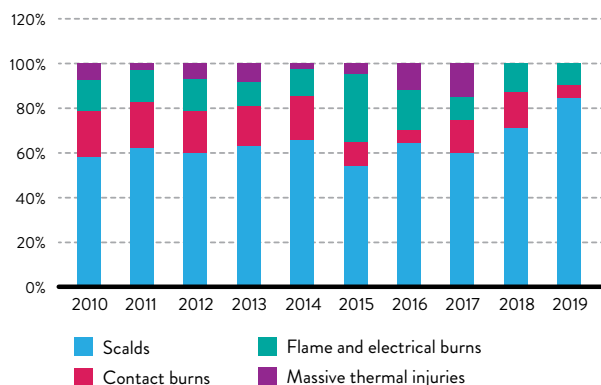


Fig. 2. Distribution according to burn injury mechanisms in the 2010–2019 period.

Results

In the past decade, there were 402 inpatients treated for burn injuries with a trend toward lower numbers of hospitalizations as approaching the end of the decade (Fig. 1). Scalding was the most frequent mechanism of injury which occurred in 64% of our patients ($n=257$), followed by contact burns (16%, $n=63$), and flame and electrical burns (15%, $n=60$) which were almost equally represented (Table 1, Fig. 2). There were also 22 patients with massive thermal injuries (5%). Unfortunately, we had two fatalities in this period, yielding a mortality rate of 0.5%.

Patient characteristics according to burn injury mechanism

Scalds

The mean age of patients with scalds was 3 years and 5 months, while the median age was 2 years. Boys constituted 61% of the patient population and the average TBSA was 10%. Areas of full thickness burns were observed in 32% of our patients, while 4% ($n=8$) had exclusively full thickness burns. The mean LOS was a little more than 2 weeks (15.1 days). Intensive care was required in 16% of patients, where they spent 6.7 days on average. Four (1.5%) patients required mechanical ventilation, spending 3 days on average intubated. When analyzing the numbers of scald injuries according to periods of the year, we could not find a pattern apart from the fact that the highest number

of scald injuries was recorded during March, July and October.

Contact burns

The majority (86%) of patients with contact burns were toddlers, and 92% of these patients had a burn injury of upper extremity (Table 1). The majority of these injuries happened when small children came in contact with a stove or heating device with the palms of their hands. The mean age of this patient population was roughly 2 years and 1 month, while the median age was 1 year. Half of these patients had areas of third degree burns, whereas 17% had exclusively third degree burns. Boys constituted 65% of all patients. The mean LOS was 9.8 days. One patient, a 5 month old toddler who sustained a contact burn to the face while falling asleep next to a radiator, required mechanical ventilation and intensive care for 4 days. Contact burns occurred more often during the autumn and winter months with a peak incidence in September.

Flame and electrical burns

The mean age in this group was 9 years and 9 months while the median age was 10 years. Boys constituted 90% of the patient population. The mean TBSA was 13%. Burns with areas of full thickness injuries were observed in 48% of patients and 10% had exclusively full thickness burns. Patients with electrical burns constituted 6% ($n=4$) of the subgroup. The mean LOS was 28.7 days, 25% of these patients required intensive care and 8% required mechanical ventilation, with a mean of 9.2 days being intubated. Flame and electrical burns occurred more often during the spring and summer with a peak incidence in May.

Massive thermal injuries

The mean age of patients with massive thermal injuries was 8 years and 2 months while the median of age was 7 years. Boys accounted for 77% of these patients. When we included only children who had inflicted the injury by themselves (exclusively electrical or flame injuries), the mean age was 12.2 years. The mean TBSA was 62% and 91% of these patients had areas with full thickness burns while 5% had exclusively full thickness burns. Unfortunately, we had one fatality in the observed period, a 7-year-old boy

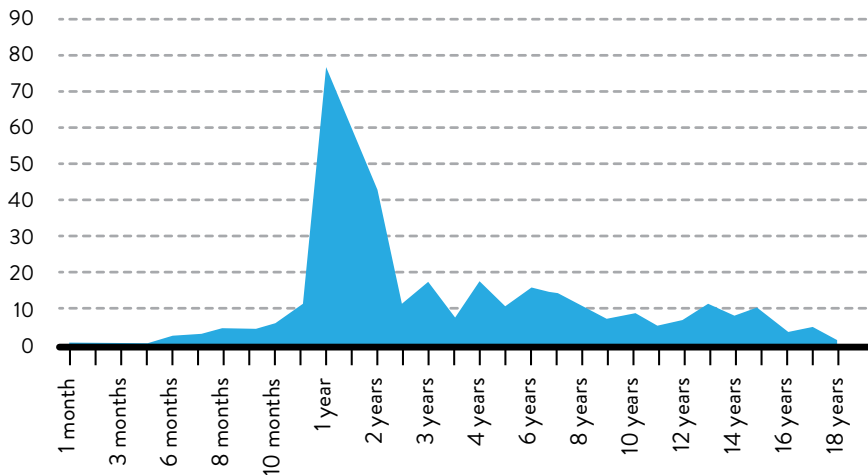


Fig. 3. Distribution according to age at injury.

who succumbed to a flame burn on 95% of his TBSA. He spent 193 days in the intensive care where he was intubated most of the time. When we excluded him, the mean LOS was 157 days. All patients required intensive care where they spent 31 days on average. Mechanical ventilation was required by 68% of these patients, who spent a mean of 5.7 days intubated. The highest percentage (36%, $n=8$) of these patients sustained electrical burns while an equal number sustained flame burns and scalds (32%, $n=7$). As the overall numbers were low and the mechanisms of massive thermal injuries were diverse, no seasonal pattern could be identified.

General considerations

Age at injury

According to age, 43% of our patients were in the preschool age group (6 years of age and younger) and 19% were younger than 2 years of age (Fig. 3). The distribution of patients according to age remained similar throughout the study period (Fig. 4).

Total body surface area affected and length of stay

During the past decade, we also observed a decline in the mean TBSA of our patients (Fig. 5). When comparing the second and first half of the decade, the

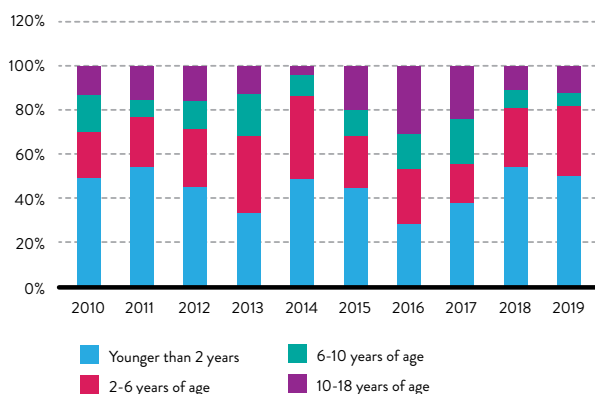


Fig. 4. Distribution of pediatric burn patients in the 2010–2019 period according to age groups.

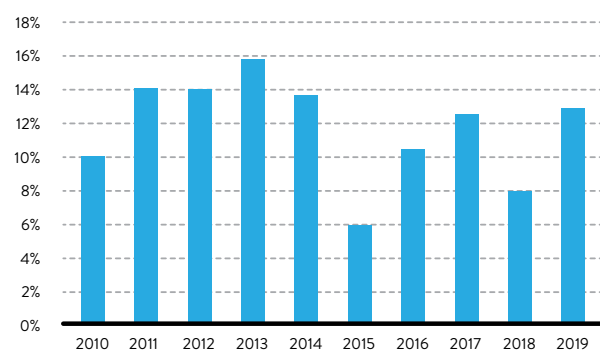


Fig. 5. Mean total body surface area (%) during the 2010–2019 period.

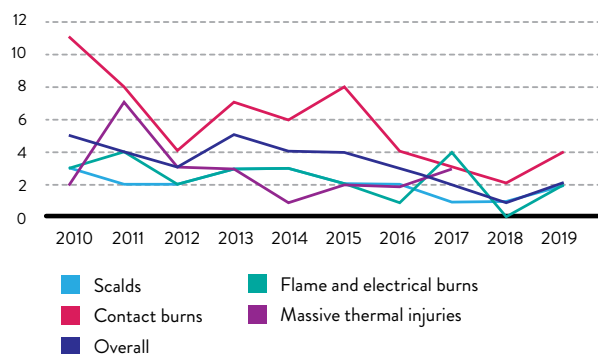


Fig. 6. The mean length of stay/total body surface area (%) ratio during the 2010–2019 period.

mean TBSA dropped by 26%. From 2010 until 2014, the mean TBSA was 13.6%, whereas from 2014 until 2019 it was 9.9%.

Another parameter that showed a decrease was the LOS to TBSA% ratio. This decline was mostly caused by marked reduction in the LOS/TBSA% ratio of contact burns and scalds (Fig. 6).

Seasonal variations

Analysis of seasonal variations showed that patterns could be found for contact burns, and flame and electrical burns (Fig. 3, Fig. 7). Contact burns most often occurred in winter months. As opposed to that, flame and electrical burns were most frequent in summer months. Scalds were equally distributed throughout the year.

Discussion

Our review showed that during the past decade, there was a notable decline in the overall number of hospitalized patients (Fig. 1), mean TBSA (Fig. 4), and LOS to TBSA ratio. The distribution according to age groups remained fairly consistent (Fig. 3), which means that decline in number was distributed evenly among age groups. Considering burn injury mechanisms, hot water scalds were the most common cause of injury, followed by contact burns and flame and electrical burns. These data are consistent with

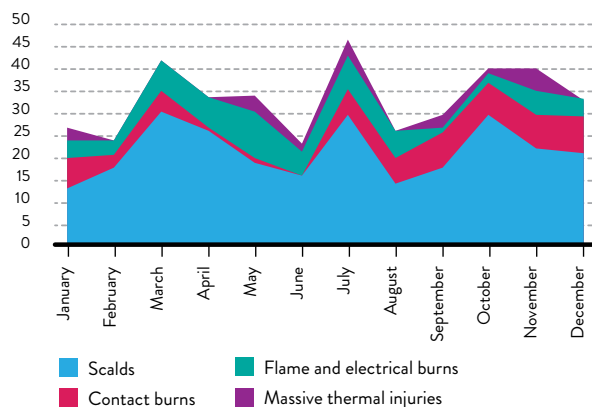


Fig. 7. Distribution of burn injury mechanisms according to seasons (months).

similar studies^{3,5,7-11}. We also found a shift to a higher percentage of scalds and lower percentage of contact burns, flame and electrical injuries, and massive thermal injuries as approaching the end of the decade. As Moehrlen *et al.*⁴ stated, this occurrence could be ascribed to the fact that children in modern societies less frequently come in contact with open fire and that electrical appliances had become safer.

Patients of preschool age (6 years of age and younger) accounted for 43% of our patients, while 19% were younger than 2 years of age, i.e., a little less than in comparable studies^{3,11-14}. These data are illustrated in Figure 2. Age at injury and the mechanism of injury are two parameters that are very strongly associated because, as seen in Table 1, children are prone to different types of burn injuries in different periods of childhood. When observing just the scald group, 83% of the patients were in the preschool age group; similar data have been reported by Moehrlen *et al.*⁴. A well-documented finding that contact burns mostly affect children under the age of 2^{3,4,15-17} was also confirmed in our study as this was the most common patient population (82%) suffering from contact burns. Electrical and flame burns most often occurred in older age group, with average age being 9 years and 9 months. These injuries resulted in larger TBSA affected than scalds and contact burns, a finding that also corresponds to the results of Moehrlen *et al.*⁴. Most of the patients in all the subgroups were boys but this ratio was most pronounced in the flame burn subgroup where boys

constituted 90% of the patient population. The mortality rate of 0.5% is comparable to mortality rates published recently in reports from pediatric burn centers in highly developed West European countries^{4,11} but much lower than in a report regarding pediatric patients hospitalized for burns in Canada³.

During the past decade, we also observed a decline in the average TBSA of our patients (Fig. 4). This decline did not have a steep curve but when comparing the second and first half of the decade, the average TBSA dropped by 26%. From 2010 until 2014, the average TBSA was 13.6%, whereas from 2014 until 2019 it was 9.9%. Authors of similar reports have described the same experience^{5,8,18}. This decline can, for the most part, be attributed to the fact that we did not have massive thermal injuries in 2018 and 2019.

As Lee *et al.* have previously pointed out¹⁹, the mean LOS to TBSA ratio is not a parameter that can be compared between burn centers because some of the centers, like our institution, have an integrated rehabilitation which automatically prolongs LOS. It is, however, a parameter that can be observed for a single institution and in that sense, we may point out that the LOS *per* TBSA% has notably shortened with time, as shown in Figure 5. A reduction in the LOS *per* TBSA% during the same period has also been reported by other authors^{8,11,20} and can be attributed to the availability of new wound dressings that allowed less frequent and painless dressing changes, which enables earlier discharge and outpatient treatment. Similar observations have been made by Baker *et al.*²¹.

The limitations of this study were that we analyzed data only for hospitalized patients and that, due to the fact that we do not have a nationwide burn register in Croatia, these data are representative for our institution only rather than the whole country.

The advantage of this study was that it was conducted in the Croatian national pediatric burn referral center over a relatively long period of 10 years, which makes these data applicable to the whole country to a certain degree.

These data show that there are two main groups on which we should focus when developing prevention strategies, i.e., families with small children, and preadolescents and young adolescents. Since scalds with hot liquids in children up to 2 years of age constitute

the majority of burn injuries (Fig. 2), families with small children should be a very important focus group. Fortunately, these injuries have a good prognosis but they nevertheless carry a lot of discomfort for the parents, as well as a financial burden for the health system. The other group should be preadolescents and young adolescents who are at the highest risk of massive burn injuries, either electrical or flame burns, which carry the worst prognosis. These are almost always acquired in the company of their peers, unattended by their parents.

Another thing that should be pointed out is that, given the fact that the numbers of burn patients are declining, there is a need of concentrating burn injury pathology at a single center. Some of these patients are vitally endangered and they need the best possible care in a center where all the resources are at hand. Patients who are not vitally endangered would still benefit from treatment in a burn center because in these patients the focus should be to provide an optimal treatment that would result in the best possible outcome in the sense of absence of hypertrophic scars while performing a minimal number of procedures in general anesthesia. We believe that this can be performed only in a center which has most experience in the treatment of burn injuries in children.

Conclusion

In general, we may say that we witnessed beneficial changes in burn injuries in children during the past decade. We recorded a progressive decline in the number of hospitalized patients, their affected TBSA and the LOS to TBSA ratio. Scald injuries, which carry the lowest risk of a full thickness burn, became even more prevalent among all burn injuries. Regarding prevention strategies, we can conclude that there are two main groups that should be the focus of prevention campaigns, i.e., small children, and preadolescents and young adolescents.

In conclusion, considering that the overall number of patients with burn injuries is declining, burn injury pathology should be concentrated at a center most experienced in the treatment of burn injuries in children.

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Sažetak

PROMJENE U OBRASCIMA OPEKLINSKIH OZLJEDA KOD DJECE U HRVATSKOJ –
PODACI NACIONALNOG REFERENTNOG CENTRA U RAZDOBLJU 2010.-2019.*R. Kralj, Z. Barčot, M. Kurtanjek, I. Petračić, K. Tadić, I. Bumči, S. Višnjić i R. Žic*

Cilj ove studije je bio utvrditi promjene u ukupnom broju i obrascima opekliniskih ozljeda tijekom razdoblja od 2010. do 2019. u Hrvatskoj. Analizirali smo ukupni broj, obrasce opekliniskih ozljeda prema dobi u vrijeme ozljede, ukupnoj površini tijela zahvaćenoj opeklinom i mehanizmima opekliniskih ozljeda. Također smo željeli procijeniti omjer prosječnog trajanja boravka u bolnici i ukupne površine tijela zahvaćene opeklinom te sezonske varijacije prema mehanizmu ozljede opeklinama. Analizirali smo rezultate kod 402 bolesnika hospitalizirana u našoj ustanovi tijekom 10-godišnjeg razdoblja i podijelili ih u podskupine na sljedeći način: opekline vrućom tekućinom, kontaktne opekline, opekline plamenom i električnom energijom te masivne termičke ozljede (>40% ukupne površine tijela neovisno o mehanizmu ozljede opeklinama). Vrhunac incidencije je zabilježen između prve i druge godine života, a opekline vrućom tekućinom su prevladavale kao mehanizam ozljede. Tijekom promatranog razdoblja prosječna ukupna površina tijela zahvaćena opeklinom se smanjila, a opekline vrućom tekućinom su postale još dominantnije kao mehanizam ozljede. Sezonske varijacije mogle su se potvrditi za kontaktne opekline, koje su se najčešće javljale tijekom jeseni i zime te za opekline plamenom i električnom energijom koje su se najčešće javljale tijekom ljeta. S obzirom na činjenicu da smo zabilježili pad broja bolesnika s opeklinama smatramo da je od najveće važnosti da se liječenje patologije opeklini koncentrira u centru s najvećim iskustvom u liječenju opeklini kod djece. Na temelju naših rezultata distribucije po dobi, mala djeca, predadolescenti i mladi adolescenti bi trebali biti meta preventivnih kampanja.

Ključne riječi: *Opekline; Pedijatrija; Epidemiologija*