

## Original Research

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# Comparative Analysis of Burn Injuries in Toddler and Preschool Children: Implications for Triage and Outcome Assessment

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## Abstract

**Objective:** This study aims to compare the demographic, clinical characteristics, and outcomes of burn injuries in toddler and preschool children, and to validate the American Burn Association (ABA) Burn Triage Decision Matrix in the Turkish pediatric population.

**Methods:** A retrospective analysis was conducted on 684 pediatric burn patients (494 toddlers, 190 preschoolers) admitted to our burn center over a 5-year period. Variables including gender, burn etiology, burn area, depth, treatment modalities, complications, length of hospital stay, and mortality were analyzed. The performance of the ABA Burn Triage Decision Matrix was evaluated in both groups.

**Results:** Scalding was the predominant cause of burns in both groups, with a significant difference in the involvement of anterior trunk ( $p = 0.027$ ). The mean Total Body Surface Area (TBSA) was comparable between the groups ( $p = 0.286$ ). There was no significant difference in mortality rates ( $p = 0.385$ ), treatment modalities, and complications. The ABA Burn Triage Decision Matrix demonstrated consistency in triaging the severity of burn injuries, with a notable discrepancy observed in the moderate risk category of toddler group.

**Conclusions:** This study highlights the distinct characteristics and outcomes of burn injuries in different pediatric age groups. The ABA Burn Triage Decision Matrix's validation suggests its utility in enhancing triage accuracy and resource allocation in pediatric populations, especially in disaster-prone regions.

The World Health Organization (WHO) defines a burn as an injury to the skin or other organic tissues primarily caused by heat, although other sources such as radiation, radioactivity, electricity, friction, or chemicals can also be the culprits. Global reports concerning burn victims depict it as a significant public health issue, attributing to around 180 000 deaths annually.<sup>1</sup> In managing burn injuries, three key factors play a pivotal role.<sup>2</sup> Building on the criteria of these critical factors, the American Burn Association (ABA) has formulated a guideline termed the Burn Triage Decision Matrix (BTDM) to effectively assess and treat burn patients in the aftermath of mass casualty incidents (MCI).<sup>3,4</sup> The BTDM aids in early assessment, triage, selection of the suitable treatment center, allocation of hospital resources, and discharge decisions, focusing exclusively on these three core factors.<sup>5</sup> A review of the BTDM reveals the existence of two distinct triage matrices. One notable factor differentiating these matrices is inhalation injury, referring to the damage in a burn patient's respiratory tract (including nasal passages, posterior oropharynx, larynx, trachea, bronchi) due to the burn.<sup>6</sup> Another major determinant is the patients' burn surface area.<sup>7</sup> The size of the burn, quantified as a percentage of the TBSA, correlates directly with survival, and accurately characterizing burn dimensions is crucial as it helps identify patients who could derive maximum benefit from personalized, experimental, or innovative treatments.<sup>8</sup> The third key factor is the age of the injured. Particularly in developing nations, children and the elderly are somewhat less at risk since many families continue to adopt a community-centered lifestyle, providing a degree of protection to these age groups.<sup>9</sup> However, when it comes to burn injuries, the distribution of risk and mortality rates is notably inverse: the mortality rate is higher in very young and elderly patients compared to other age groups. Hence, the age of the patient is a vital factor with a significant impact on burn outcomes.<sup>10,11</sup>

Burn research is formed through a body of literature encompassing studies conducted worldwide based on the experiences of injured individuals, enriched by a series of "experience" studies where researchers share their profound insights.<sup>12–14</sup> Numerous studies concerning the elderly patient group particularly emphasize that they have now become one of the most vulnerable segments to burn injuries.<sup>1,15</sup> In developing countries, child patients stand out as a group where burns are rare, but the mortality rates are high. This represents a domain within the literature where data is more scarce.

Burn patients can emanate from minor domestic incidents affecting a few individuals to MCIs that trigger disaster scenarios. Consequently, numerous countries devise large-scale disaster plans to tackle burn cases. The cornerstone of disaster plans concerning burn cases is the determination of risk and severity levels of the injured individuals and forming patient management strategies based on this information.<sup>9</sup> Therefore, the triage and management of these patient groups are of vital importance not only for the treatment of burn patients but also for managing disasters originating from burns.

On February 6, 2023, a significant earthquake disaster, with magnitudes of 7.6 and 7.7, unfolded in Turkey and Syria, resulting in extensive destruction and over 50 000 fatalities.<sup>16</sup> Data released by UNICEF indicated that the earthquake impacted approximately 4.6 million children across ten provinces in Turkey and over 2.5 million children in Syria.<sup>17</sup> Turkey, known for its young population, experienced a substantial challenge in safeguarding children during this recent seismic event. This incident elucidated Turkey's susceptibility and vulnerability to disasters. Throughout our research, we encountered a lack of concrete data within the literature concerning the validation studies of the BTDM proposed by the ABA for the management of mass burn injuries in Turkey. This paucity of data accentuates the significance of the matrix, particularly in the context of managing pediatric patients, who represent one of the highly affected groups in disasters, aligning with the country's demographic profile.<sup>4,18</sup> The interconnection between burn patients and disasters highlights the imperative for the adoption of emergency measures.

This study was conducted in a burn center with a notably young population, examining the demographic data and management of burn patients over the past four years. The focus was on observing the management of burn patients without inhalation injuries. The main emphasis of this study was on evaluating the adaptation and validation of the BTDM proposed by the ABA, a framework not yet validated in Turkey. This effort is crucial for improving the management of burn patients and for better preparation for emergencies. Therefore, this study aims to provide significant contributions toward developing more effective strategies to protect children in burn incidents.

## Methods

### Data Procedure and Participants

This retrospective observational descriptive study was undertaken at a tertiary care hospital in the Southeastern Anatolia Region of Turkey. Presently, the Burn Treatment Center at our hospital accommodates 17 beds (12 ward beds, 5 intensive care unit beds) and manages a spectrum of burns, from second-degree superficial to full-thickness burns, induced by a variety of causes including boiling liquids, flames, electrical scalds, contact with hot objects, and chemicals. The center also addresses thermal burns leading to inhalation injuries and compartment syndromes stemming from burns. Adhering to a standardized protocol, our Burn Treatment Center extends services encompassing first aid, fluid resuscitation, burn wound assessment and care, infection control, and diagnosis and management of burn-related complications. A review was conducted on the medical records of 684 pediatric patients aged 1-5 years who were admitted to the burn center via the emergency department between January 1, 2018, and November 1, 2022. Patients with substantial gaps in their medical records were

excluded from the study, as were those transferred to other hospitals or those who left the burn center prior to completing the treatment process.

For the purposes of this study, patients were segregated into two age-based groups: toddlers (1–2 years of age) and preschoolers (3–5 years of age). The medical records furnished data regarding the patient's age, gender, time of admission, length of stay, anatomical location of the injury, degree of burn, TBSA affected, causative agent of the burn, treatment administered (including skin grafting and debridement), mortality, wound infections, and in-hospital mortality. Burns were classified based on their depth as superficial, partial-thickness, and full-thickness.

### Statistics

Statistical analyses were conducted using the Statistical Package for Social Sciences (v29.). The conformity to normal distribution was checked with the Shapiro-Wilk test and histogram. Data description was defined as frequency and percentage for categorical data and mean  $\pm$  standard deviation or median (IQR 25th–75th) for continuous variables. The chi-square test and Fisher's exact test were employed for comparing categorical variables of independent groups, whereas the student's *t*-test or Mann-Whitney-U test was utilized for comparing continuous variables. All tests were performed two-tailed, and a *p*-value of  $< 0.05$  was considered statistically significant.

The comparison of burn thickness between groups could not be conducted, as the chi-square conditions were not met.

## Results

The study encompassed 684 patients with burn injuries. Among them, 72.2% ( $n = 494$ ) were categorized as toddlers, whereas 27.8% ( $n = 190$ ) were preschoolers. Gender ratios between the groups revealed no statistically significant variation ( $p = 0.257$ ). Upon evaluating burns based on their etiology, scalding emerged as the most prevalent type, accounting for 86.4% ( $n = 591$ ) of cases. Other noted causes included flame burns in 20 patients (2.9%), contact burns in 27 patients (3.9%), electrical burns in 2 patients (0.3%), and chemical burns in 2 patients (0.3%). An additional 42 patients (6.14%) had burns attributed to other causes. In the toddler group, the left lower extremity (38.5%,  $n = 190$ ) and the right lower extremity (38.1%,  $n = 188$ ) were the most frequently injured areas; similarly, in the preschooler group, injuries were most common in the right lower extremity (42.1%,  $n = 80$ ) and the left lower extremity (33.7%,  $n = 64$ ). Front torso injuries were statistically significantly higher in the toddler group (31.8%,  $n = 157$ ) compared to the preschooler group (23.2%,  $n = 44$ ) ( $p = 0.027$ ). No statistically significant difference was identified between the groups concerning head-neck, back-torso, upper extremities, lower extremities, and genital area injury rates ( $p > 0.05$ ).

When evaluated based on burn thickness, the toddler group presented a superficial burn rate of 0.2% ( $n = 1$ ), and the preschooler group had a rate of 1.6% ( $n = 3$ ). Partial-thickness burns were seen at a rate of 93.5% ( $n = 462$ ) in the toddler group and 87.9% ( $n = 167$ ) in the preschooler group. Full-thickness burns were observed at a rate of 6.3% ( $n = 31$ ) in the toddler group and 10.5% ( $n = 20$ ) in the preschooler group. The average burn percentage was calculated as 11.35%  $\pm$  9.8% in the toddler group, and 11.44%  $\pm$  10.4% in the preschooler group, with no statistically significant difference observed between the groups ( $p = 0.286$ ) (Table 1).

**Table 1.** Comparison of demographic and burn injury characteristics between groups

		Toddler ( <i>n</i> = 494)	Preschooler ( <i>n</i> = 190)	<i>p</i>
Sex	Male	294 (59.5%)	104 (54.7%)	0.257
Burn etiology	Flame	13 (2.6%)	7 (3.7%)	0.464
	Scald	429 (86.8%)	162 (85.3%)	0.589
	Contact	20 (4%)	7 (3.7%)	0.826
Burn area	Head-neck	124 (25.1%)	47 (24.7%)	0.921
	Anterior trunk	157 (31.8%)	44 (23.2%)	0.027
	Posterior trunk	79 (16%)	34 (17.9%)	0.548
	Right arm	171 (34.6%)	61 (32.1%)	0.535
	Left arm	153 (31%)	57 (30%)	0.805
	Right leg	188 (38.1%)	80 (42.1%)	0.331
	Left leg	190 (38.5%)	64 (33.7%)	0.247
	Genitalia	44 (8.9%)	24 (12.6%)	0.145
Burn thickness	Superficial	1 (0.2%)	3 (1.6%)	
	Profundus	462 (93.5%)	167 (87.9%)	
	Deep tissue	31 (6.3%)	20 (10.5%)	
Burn (%)	11.35±9.8	11.44±10.4	0.286	

**Table 2.** Comparison of treatment and outcome data

		Toddler ( <i>n</i> = 494)	Preschooler ( <i>n</i> = 190)	<i>p</i> value
Treatment method	Debridement	66 (13.4%)	31 (16.3%)	0.321
	Skin grafting	48 (9.7%)	23 (12.1%)	0.359
Complications	Wound site infection	35 (7.1%)	13 (6.8%)	0.911
Hospital stay (days)		7 (5–11)	7 (4.75–16)	0.148
Mortality		8 (1.6%)	5 (2.6%)	0.385

Upon comparing treatment methods between the groups, debridement was performed in 13.4% (*n* = 66) of the toddler group and skin grafting in 9.7% (*n* = 48); in the preschooler group, debridement was performed in 16.3% (*n* = 31) and skin grafting in 12.1% (*n* = 23), with no statistically significant difference found between the groups (respectively; *p* = 0.321, *p* = 0.359). Similar wound site infection rates were observed in both groups (toddler 7.1%, preschooler 6.8%, *p* = 0.911). The median length of hospital stay was 7 days (IQR 5 – 11 days) in the toddler group and 7 days (IQR 4.75 – 16 days) in the preschooler group, with no statistically significant difference observed between the groups. In-hospital mortality was observed at a rate of 1.6% (*n* = 8) in the toddler group and 2.6% (*n* = 5) in the preschooler group, with no statistically significant difference observed between the groups (*p* = 0.385) (Table 2).

For individuals under 2 years of age with a high survival expectation, 2 mortalities were observed among 441 individuals (survival 99.5%); in the medium survival expectation group of 44 individuals, 5 mortalities were observed (survival 89.8%); in the low survival expectation group of 2 individuals, 1 mortality was observed (survival 50%). No patients were observed in the expectant group. Among 125 patients aged 2–5 years where admission was not recommended, no mortality was observed (survival 100%); in the

high survival expectation group of 57 patients, no mortality was observed (survival 100%); in the medium survival expectation group of 8 individuals, 5 mortalities were observed (survival 37.5%), and no patients with low survival expectation were observed in this group (Table 3).

### Limitations

This study harbors several limitations. First, it employed the BTDM as proposed by the ABA for patients devoid of inhalation injuries. The nature of disasters necessitated a retrospective examination of the included patients, with a subsequent retrospective review of the decisions made. Hence, the evaluations based on this matrix were conducted irrespective of whether the injuries were sustained post-MCIs or as individual injuries at home. Second, the study utilized a voluntary registry with constrained data auditing. The data were retrospectively amassed from patient registries and individual documentation. As a result, issues related to data entry and the presence of missing data could potentially induce data bias. Third, the allocation and outcomes associated with resource utilization could exhibit variations in a disaster scenario. For example, children aged below 1 year are classified as “very high” primarily as a significant number are currently being admitted and are

**Table 3.** Validation of groups according to American Burn Association Triage Decision Matrix

Burn Size (%TBSA)										
age/years	0–10%	11–20%	21–30%	31–40%	41–50%	51–60%	61–70%	71–80%	81–90%	91+%
0–2	2/441 99.5%		5/44 89.8%			1/2 50%			0	
2–5	0/125	0/57 100%		5/8 37.5%			0			

utilizing hospital resources. This classification might not hold in a disaster context. As the fourth limitation, the focus of this study is the BTDM proposed by ABA. This scoring system primarily concentrates on the mortality status of the patient. However, it is not a prognostic predictor for the patient's treatment needs and potential complications, such as the need for surgery, airway issues, or chemical and radiologic problems. Last, the outcomes pertaining to burns in disaster situations may not correspond to those under "normal" circumstances, and the prognostication of these outcomes may not accurately reflect the actual resource requisites.

## Discussion

The literature illuminates that scald injuries prevail as the predominant form of thermal injury in children under 5, accounting for over 65% of cases, whereas fire injuries trend toward older children, constituting over 56% of instances.<sup>19,20</sup> In alignment with existing literature, our study delineates a significantly higher occurrence of scalds in toddlers in comparison to preschool children, albeit with a continued prevalence in preschoolers though at a diminished rate. The World Health Organization's (WHO) 1985 delineation of child abuse encompasses any adverse impact on a child's health, physical, and psychosocial development instigated by an adult, community, or country, whether knowingly or unknowingly.<sup>21</sup> This study encompasses children from the neonatal stage to 6 years of age, marking both groups as inherently high-risk.<sup>20</sup> Post-trauma, the manifestation of burn injuries within this age bracket could be construed as abuse by WHO standards. Our demographic data resonates with prior research, indicating a heightened risk for toddlers as compared to preschool children.<sup>22</sup> According to WHO data, in the region of our study, the fatality risk for male children under 5 due to burns is nearly double compared to their counterparts in the WHO European Region.<sup>1</sup> A notable observation in our study was the predominance of male casualties in both groups. Previous studies underscore the potential of disasters to precipitate abuse, particularly in children; the demographic data and injury types in our study, analogous to child abuse scenarios, suggest that disasters might engender similar outcomes to abuse scenarios.<sup>23</sup> For this study, data were collected in one of the provinces affected by the February 6 earthquake, which had been collected prior to the earthquake and comprised data on children who had experienced abuse according to WHO criteria (age and trauma). The important point to emphasize is that, due to the demographic conditions of the children, even if burn injuries occur as accidents, regardless of their etiology, they may be termed as abuse. In this context, considering the impact of disasters on child abuse, it should be borne in mind that the risk of abuse for children, who are vulnerable groups in disaster areas, may increase further, and special policies should be developed to protect them.

The magnitude, area, and depth of burns are pivotal determinants that influence treatment and outcomes. The TBSA

measurement is invaluable for patient management, albeit challenging in terms of standardization.<sup>24</sup> Children exhibit a body surface area to body mass ratio approximately threefold that of adults, amplifying the ramifications of inaccuracies on patient management. Hence, precision in measurements is paramount. Lower extremity burn injuries predominantly contribute to the percentage calculations, a trend observed in both groups in our study. Common methodologies for gauging burned surface area encompass the Rule of Nines, Lund and Browder Chart, and Palmar Surface, all highlighting that, relative to other anatomical regions, lower extremity injuries contribute a larger percentage due to surface area.<sup>25</sup> Our study observed a high incidence of lower extremity injuries in both groups.

Another cardinal parameter in ascertaining burn severity and orchestrating patient management is the depth of the burn.<sup>26</sup> Our study observed a preponderance of deep injuries in both groups. With decreasing age, children possess thinner skin layers and less subcutaneous insulation compared to older children and adults, rendering what may initially appear as a partial-thickness burn in a child as potentially a full-thickness deep burn.<sup>27</sup> Furthermore, ascertaining burn depth is crucial since it stipulates the probable healing timeline, with delayed healing culminating in pain, elevated infection rates, and increased mortality.<sup>28</sup> The akin predominance of deep burns in both groups corroborates the observed similarities in hospital stay durations.

No significant disparities were observed between the groups concerning surgical interventions; however, a heightened surgical necessity was noted in the preschool group. Literature avers that age does not detrimentally affect clinical outcomes concerning early excision and grafting, harmonizing with the surgical needs of our research groups.<sup>29</sup> A formidable challenge in managing burn injuries in a fragile demographic like children emerges from the sheer number of casualties, as burns can manifest post-disasters and MCIs, intensifying the chaotic essence of management. According to the ABA, around 25 to 30% of casualties in such scenarios suffer from moderate to severe burn injuries.<sup>30</sup> Typically, civilian mishaps resulting in burns (e.g., house fires) afflict a limited number of individuals. However, the magnitude and repercussions of burns affiliated with a massive disaster can be cataclysmic, affecting numerous individuals concurrently, and potentially surpassing the capacity to furnish optimal burn care (beds, surgeons, nurses, operating rooms, equipment, materials). Hence, meticulous triage in both adult and pediatric patients is imperative. Although the ABA has delineated comprehensive burn care protocols, many nations would benefit from validating these protocols through the adaptation and implementation of their own local plans.<sup>30</sup>

This study endeavors not merely to share our experiences concerning the demographics, injury etiology, and management of pediatric patients at our burn center but also to validate the BTDM posited by the ABA, particularly for burns tethered to MCIs, in one of the regions bearing the highest disaster vulnerability. Our insights concerning burns indicate that children under 6 are affected by analogous mechanisms, burn incidence, and risk

factors. Nonetheless, upon scrutinizing the BTDM crafted by the ABA, different risks are ascribed to toddlers and preschoolers. For instance, there's no realm deemed safe for outpatient management in the toddler group, whereas in preschoolers, burns encompassing less than 10% TBSA are advocated for outpatient management. Our study buttresses the BTDM as none of the 125 patients in the preschooler group with burn percentages under 20% encountered mortality. Conversely, in the toddler group with burns under 10%, the survival rate was observed to be 99.5%, aligning with the BTDM. The discordance with BTDM in our study was observed in the toddler group with burns between 30–70% TBSA. According to the BTDM, this mid-risk group is anticipated to have over 50% survival; however, our study observed a survival rate of 37.5%. Although the primary factors impinging on mortality in burns are inhalation injury, age, and %TBSA, and these factors are enveloped in the burn triage matrix, other factors determined to affect mortality, such as burn depth which was akin in both groups in this study, could have possibly influenced these results.<sup>26</sup>

A recognized verity of disasters is the incapacity to provide optimal treatment to all due to resource constraints. Predetermining objective resource allocations pre-disaster enhances decision-making quality, mitigates stress for personnel during disasters, and assures the populace that organized plans are in place for MCIs. In this study, we interrogated the application of the ABA-recommended BTDM in one of the most vulnerable and disaster-prone regions and observed its successful utilization. Researchers querying the applicability of the BTDM across communities could further incentivize clinicians to adopt its use. The primary aim of the BTDM is to ensure accurate triage during mass MCIs; its successful validation in our study, even in scenarios devoid of mass admissions, is quite compelling. Although other models incorporating factors like burn depth, known to significantly affect mortality, are needed for higher prediction accuracy, determining burn depth—be it through histopathological examination lacking clinical equivalence or methods reliant on seasoned surgeons which present standardization challenges—could be attained through new methodologies.

The sudden onset and unique circumstances surrounding the occurrence of disasters pose the greatest limitation in research related to the utilization of patient management algorithms in disaster settings. This limitation becomes particularly complex and challenging when disasters involve specialized groups such as children. While providing detailed insights into the demographic, etiological, and management aspects of pediatric burn patients at our center, this comprehensive narrative has interrogated the validity and applicability of the BTDM, especially in MCIs in a region prone to disasters. Our observations underscore the critical role of accurate triage and suggest that further investigation and validation of the BTDM are warranted, thereby advocating for its broader adoption in clinical settings, particularly in disaster-prone areas.

## Conclusion

The management of burn patients and the protection of children during disasters emerge as pressing global public health issues. This research unveils significant findings on the demographic data, types of injuries, and management of burn patients, underscoring the paramount importance of safeguarding these vulnerable groups, particularly children and the elderly. Moreover, it delves into how burn patients could be impacted during disasters and the challenges inherent in managing burn-induced disasters. The necessity of adapting and examining the validity of the BTDM recommended by the ABA for patients without inhalation injury in Turkish

conditions is highlighted. This BTDM is perceived as a critical tool for the management of burn patients and the protection of children during disasters. In conclusion, this research accentuates the need to review and enhance current practices in the management of burn patients and protection of children, serving as a caution against the potential ramifications of burn-induced disasters. These findings could serve as a significant resource for public health officials, health care professionals, and disaster planners.

**Ethical Standard.** The study was carried out in alignment with the Declaration of Helsinki, with approval granted by an ethics committee on December 9, 2022 (approval number: 269).

**Author contribution.** SY, MO, RA, and ACT conceived the study and designed the trial. SY, MO, RA, and ACT supervised the conduct of the trial and data collection. SY, MO, RA, and ACT drafted the manuscript, and all authors contributed substantially to its revision. SY, MO, RA, and ACT take responsibility for the paper as a whole.

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