

Comprehensive Assessment of Pediatric Burn Injuries in Children Aged 0–5 Years: Key Predictors of Hospitalization and Outcomes

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Abstract

Objective: To describe the epidemiology of emergency department (ED) presentations for burns among children aged 0–5 years and to identify key predictors of hospitalization using a decision tree–based prediction framework.

Materials and Methods: This retrospective, single-center observational study included children aged 0–5 years who presented to the ED with burn injuries between July 2019 and July 2024. Demographic and clinical variables, including burn etiology, depth, anatomical location, percentage of total body surface area affected, and Abbreviated Burn Severity Index (ABSI), were analyzed. A decision tree model was developed using SHapley Additive exPlanations (SHAP)–guided variable ranking and selection, and its performance was evaluated on a held-out test set.

Results: Among 329 patients, 47.7% were hospitalized (including those transferred for inpatient care). Scald burns were the predominant etiology (87.8%). Hospitalization was most strongly associated with second-degree burns, head and neck involvement, and an ABSI score ≥ 3 . The decision tree model demonstrated good discrimination for hospitalization (area under the receiver operating characteristic curve [AUC], 0.841).

Conclusion: In early childhood burns, second-degree burn depth, head and neck involvement, and higher ABSI scores were the most influential factors associated with hospitalization decisions. This classification and regression tree (CART)–based model provides explicit decision rules derived from routinely available variables; however, its clinical utility and net benefit require external validation and prospective impact assessment.

Keywords: ABSI score, decision tree model, emergency care, hospitalization predictors, pediatric burns, scald injuries

Introduction

Burn injury remains a pervasive and largely preventable cause of pediatric morbidity, disproportionately affecting early childhood and exerting a sustained burden on emergency care systems. Globally, children continue to carry a substantial share of burn-related disability and health-care utilization, with particularly pronounced inequities in low- and middle-income settings where prevention strategies, first-aid knowledge, and access to specialized burn care may be heterogeneous [1,2]. Beyond its immediate tissue damage, burn trauma initiates a complex local

and systemic inflammatory response that can rapidly evolve, especially in younger children with limited physiological reserve, thereby amplifying the clinical stakes of early assessment and timely disposition decisions [3].

Epidemiologic evidence consistently demonstrates that the highest risk concentrates in the 0–4-year age band, shaped by developmentally mediated exposure patterns and household-level hazards [4]. Although the majority of pediatric burn presentations are ultimately managed without admission, the absolute volume of emergency department (ED) encounters is considerable, and a



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clinically meaningful minority require hospitalization for analgesia, wound management, operative planning, or monitoring of complications [5]. In parallel, hospitalization patterns have evolved over time, reflecting changes in referral pathways, regionalization of burn care, and broader health-system dynamics [6]. Importantly, the downstream economic impact is non-trivial; even “small-area” burns can generate disproportionate costs at the population level when incidence is high and recurrent ED use occurs [7].

Accordingly, children aged 0–5 years were selected because early childhood consistently represents the peak-incidence period for burn-related ED presentations, largely reflecting developmentally mediated household exposures and limited self-protective capacity. In addition, disposition decisions in this age band are clinically distinct given lower physiological reserve and greater reliance on caregiver-dependent outpatient wound care and follow-up.

Disposition decisions in the ED require multidimensional risk appraisal, integrating burn depth and extent (e.g., % total body surface area [TBSA]), anatomical location, suspected inhalation injury, analgesic needs, and the feasibility of safe outpatient wound care and follow-up. Prognostic indices such as the Abbreviated Burn Severity Index (ABSI) are widely recognized and have been revalidated for severe-burn outcomes; however, many traditional tools were primarily optimized for mortality or inpatient prognostication rather than the immediate ED decision of admission versus discharge in very young children [8]. Consequently, there remains a pragmatic need for disposition-focused approaches that are clinically intelligible, explicitly reportable, and able to accommodate non-linear interactions among routinely available presentation-level features.

Therefore, using a high-volume ED cohort of children aged 0–5 years, we aimed (i) to describe the epidemiologic characteristics of burn presentations and (ii) to identify key predictors associated with hospitalization versus discharge in routine practice. To address this aim, we developed a decision-tree model based on Classification and Regression Trees (CART) methodology, with SHapley Additive exPlanations (SHAP) used to rank and prioritize candidate predictors, and evaluated its discriminative performance on a held-out test set. By formalizing commonly assessed bedside variables into explicit decision logic, this work seeks to support more consistent triage and resource planning while recognizing that external validation is necessary before broader implementation.

Materials and Methods

Study Design and Setting

This retrospective, single-center, observational cross-sectional study was conducted in the ED of a university-affiliated training

and research hospital located in Muğla, Türkiye. We retrospectively reviewed consecutive pediatric patients aged 0–5 years (from neonates to preschool-aged children) who presented to the ED with burn injuries between July 1, 2019, and July 1, 2024. The institution is a tertiary referral center serving Southwest Türkiye, with a capacity exceeding 600 beds and an on-site specialized burn unit.

The study was conducted in accordance with the Declaration of Helsinki. This study was approved by the Muğla Sıtkı Koçman University (Date: 05.11.2024, Decision no: 141). Given the retrospective nature of the study, the requirement for written informed consent was waived.

Selection of Participants and Data Collection

This study included consecutive pediatric patients aged 0–5 years who presented to the ED with burn injuries during the study period (July 1, 2019–July 1, 2024), regardless of arrival mode (walk-in or ambulance). A retrospective review of electronic medical records was performed to identify all eligible cases within this age range. For consistent age stratification, the Munich Age Classification System was applied [9], categorizing patients as neonate/infant (birth–12 months), toddler (13 months–2 years), and early childhood (3–5 years).

Data were abstracted from the hospital’s electronic medical records using a standardized spreadsheet to support structured and reproducible extraction. Collected variables comprised demographics (age, sex), arrival characteristics (mode of arrival), temporal variables (day of week and season), and burn-related clinical features (etiology/type of injury, burn degree, TBSA, anatomical location, and inhalation injury when present). ED disposition outcomes were recorded, including discharge, hospital admission (ward or intensive care unit), and all-cause ED mortality. For the purposes of this study, the primary endpoint was operationalized as need for inpatient care, defined as inpatient admission at our center or transfer to an advanced care facility for inpatient management. Injury severity was additionally summarized using the Abbreviated Burn Severity Index (ABSI), calculated for each patient as a standardized severity indicator incorporating age, sex, inhalation injury, TBSA, and full-thickness burn status [10]. TBSA was used as a continuous predictor in the decision-tree model, whereas it was categorized for descriptive group comparisons (0–10% vs. >10%) to align with Table 1 reporting.

Statistical Analysis

The normality of data distribution was evaluated using the Kolmogorov-Smirnov test. Comparisons of demographic, and

Table 1. Clinical and demographic characteristics of hospitalized and discharged pediatric burn patients

	Hospitalized (n=154)	Discharged from ED (n=175)	Test value (χ ² /Z)	p
Age (years), median (25-75)	1 (1-2)	2 (1-3)	-2.180	0.029
Sex, n (%)				
Male	85 (55.2)	93 (53.1)	0.139	0.709
Female	69 (44.8)	82 (46.9)		
Burn Grade, n (%)				
First-Grade	120 (77.9) ^a	171(97.7) ^b	35.991	<0.001
Second-Grade	33 (21.4) ^a	3 (1.7) ^b		
Third-Grade	1 (0.6) ^a	1 (0.6) ^a		
Etiology				
Scald	145 (94.2) ^a	144 (82.3) ^b	11.030	0.002
Flame or fire	1 (0.6) ^a	3 (1.7) ^a		
Contact burns	8 (5.2) ^a	28 (16) ^b		
Total Body Surface Area				
0-10%	96 (62.3)	158 (90.3)	36.355	<0.001
>10%	58 (37.7)	17 (9.7)		
Seasons				
Autumn	32 (20.8) ^a	41 (23.4) ^a	10.740	0.013
Winter	31 (29.1) ^a	57 (32.6) ^b		
Spring	48 (31.2) ^a	32 (18.3) ^b		
Summer	43 (27.9) ^a	45 (25.7) ^a		
Day of The Week				
Monday	22 (14.3)	24 (13.7)	6.598	0.360
Tuesday	18 (11.7)	34 (19.4)		
Wednesday	23 (14.9)	25 (14.3)		
Thursday	31 (20.1)	28 (16)		
Friday	23 (14.9)	25 (14.3)		
Saturday	20 (13)	14 (8)		
Sunday	17 (11)	25 (14.3)		
Abbreviated Burn Severity Index Score				
ABSI, median (25-75)	3 (2-3)	2 (2-3)	-2.609	0.009

Data are expressed as median (25%-75% percentile) or count (%) for categorical variables unless otherwise indicated. Similar letters in the same row indicate similarity between column ratios, and different letters indicate differences between column ratios. Z: Mann Whitney U test statistics, χ^2 : Chi-Square test statistics

clinical variables between hospitalized patients and those discharged from the ED were performed using the Mann-Whitney *U* test for continuous variables and the Chi-Square test for categorical variables. Continuous variables were presented as mean $\pm$ standard deviation (SD) or median (range), depending on their distribution. Categorical variables were expressed as frequencies and percentages. A p-value of <0.05 was considered

statistically significant for all tests. Statistical analyses were conducted using SPSS software (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp). Missingness was assessed for all candidate variables. Analyses were conducted using a complete-case approach; no imputation was performed.

Decision Tree Model with SHapley Additive exPlanations for Variable Selection

Hospitalization status (need for inpatient care status vs. discharged from the ED) was the dependent variable in this study. Independent variables included key clinical and demographic factors such as burn severity, anatomical location, total body surface area, presence of inhalation injury, burn etiology, season, day of the week, month, admission pathway, age, gender, and the ABSI.

The dataset was randomly partitioned into a training set (70%) and a test set (30%). SHAP values were computed for all independent variables to determine the most influential predictors of hospitalization. The top 10 variables, whose cumulative mean absolute SHAP values accounted for 95% of total importance, were selected for model construction. A decision tree model, based on the Classification and Regression Trees methodology, was developed to predict hospitalization outcomes using these high-ranking predictors [11].

To optimize model complexity, the grid search technique was applied, testing parameters between 0.001 and 0.5 with increments of 0.01. Model performance was evaluated on the test set using multiple metrics, including the area under the receiver operating characteristic curve (AUC), sensitivity, specificity, overall accuracy, and F1 score. The 95% confidence interval (CI) for the AUC was estimated using nonparametric bootstrap resampling of the held-out test set. Statistical analyses were conducted using R software (R Foundation for Statistical Computing, Version 4.2.0, Vienna, Austria) utilizing the rpart package for decision tree modeling and the SHAPforxgboost package for SHAP value computation.

Results

During the study period, 329 consecutive pediatric patients aged 0–5 years presented to the ED with burn injuries. The median age of the cohort was 2 years, and 175 patients (54.1%) were male. Overall, 154 patients (47.7%) required hospitalization or referral to advanced care centers. Among admitted patients, the mean length of hospital stay was 4.3 ± 3.5 days.

The temporal distribution of presentations was relatively balanced across seasons and weekdays. Specifically, cases were most frequent in summer and winter (26.7% each), followed by spring (24.3%) and autumn (22.2%). With respect to weekdays, the highest frequencies were observed on Thursdays (17.9%) and Tuesdays (15.8%), whereas Saturdays had the lowest frequency (10.3%). Regarding etiology, scald injuries accounted for 87.8% of cases; in addition, contact burns comprised 10.9%, and flame/fire burns accounted for 1.2%.

Baseline characteristics stratified by ED disposition are summarized in Table 1. Compared with discharged patients, hospitalized/referred patients had a lower median age (1 [1–2] vs. 2 [1–3] years; $p = 0.029$) and a different distribution of burn depth ($p < 0.001$). Moreover, the proportion of scald injuries differed between groups ($p = 0.002$), as did the distribution of TBSA category (0–10% vs. >10%; $p < 0.001$) and season ($p = 0.013$). ABSI scores also differed between groups (3 [2–3] vs. 2 [2–3]; $p = 0.009$). In contrast, sex ($p = 0.709$) and day of the week ($p = 0.360$) did not differ significantly between disposition groups.

According to the Munich Age Classification System, patients were categorized as neonate/infant ($n = 149$; 45.3%), toddler ($n = 100$; 30.5%), and early childhood ($n = 80$; 24.3%). Notably, the distribution of hospitalization across these age strata differed significantly ($p = 0.012$). In absolute numbers, hospitalizations comprised 78 neonate/infant patients (50.6% of all hospitalizations), 50 toddlers (32.5%), and 26 early-childhood patients (16.9%).

The anatomical distribution of burns is presented in Figure 1 (multiple regions per patient; percentages are not mutually exclusive). The most frequently involved regions were the head and neck (35%), torso back (32.8%), and right upper extremity (28.3%). By comparison, torso front involvement was reported in 10.9% of cases. Extremity involvement included the right lower extremity (25.2%) and left upper extremity (24.9%), whereas the left lower extremity was involved in 12.5%. Inhalation injury was recorded in 0.3% of patients.

SHAP-based variable ranking identified second-degree burns as the highest-importance feature for hospitalization prediction

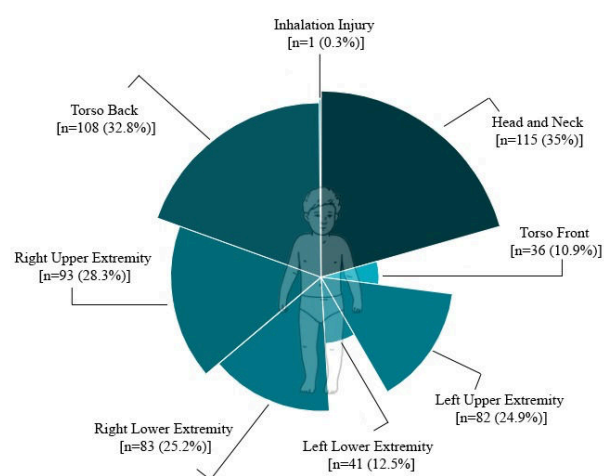


Figure 1. Distribution of Burn Injuries by Body Region (multiple regions per patient; percentages not mutually exclusive)

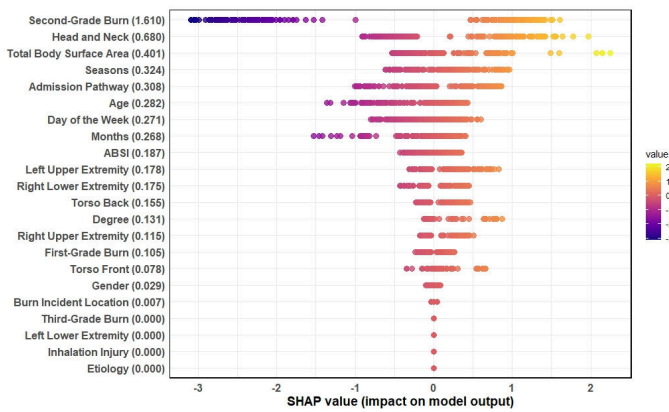


Figure 2. SHAP Summary Plot Depicting Variable Importance in Predicting Hospitalization of Pediatric Burn Patients

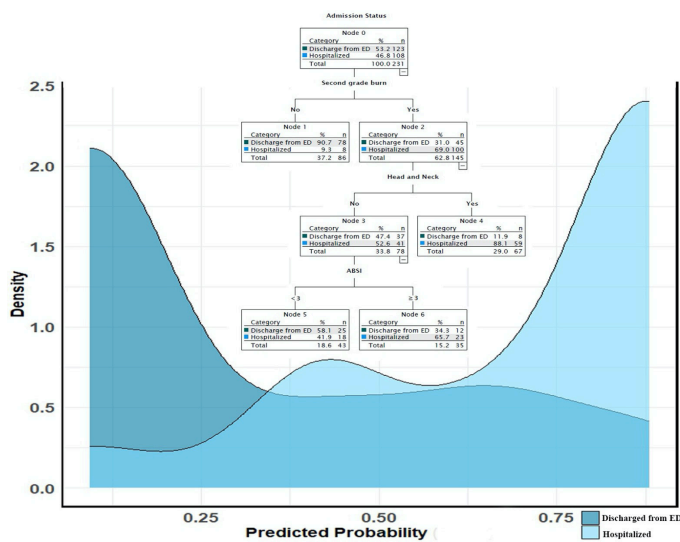


Figure 3. Decision Tree-Based Predictive Model and Probability Density Plot for Hospitalization and Discharge in Pediatric Burn Patients

(mean absolute SHAP value 1.611). Other ranked features included head and neck involvement (0.680), TBSA (0.400), season (0.324), and admission pathway (0.308). Together with age (0.282), day of week (0.271), month (0.268), and ABSI score (0.187), these variables accounted for 95% of cumulative mean absolute SHAP importance (Fig. 2).

A decision tree model was developed using the training set ($n = 231$), and its structure is shown in Fig. 3. Model performance on the held-out test set was as follows: sensitivity 93.5%, specificity 61.5%, and AUC 0.841 (bootstrap-derived 95% CI: 0.153–0.907; $p < 0.001$). Furthermore, overall accuracy was 76.5% (95% CI: 0.669–0.845), with a negative predictive value of 91.4%, positive predictive value of 68.3%, and F1 score of 78.9%.

Discussion

This study characterizes burn-related ED presentations among children aged 0–5 years and examines the practical disposition decision of inpatient management versus safe discharge. Here, “hospitalization” denotes either direct inpatient admission at our center or transfer to an advanced care facility for inpatient management when local capacity or logistical constraints precluded on-site admission. Using a CART-based decision-tree approach, second-degree burns, head and neck involvement, and ABSI >3 emerged as the principal factors associated with admission decisions in this cohort. These findings may inform triage standardization and resource planning by formalizing admission-associated patterns; however, given that the approach is a classical CART decision tree, it is presented as an interpretable baseline rather than a methodologically novel AI system.

A large meta-analysis of pediatric burns reported scald injuries as the predominant etiology and highlighted a disproportionate burden among children under five years of age [12]. Consistent with this literature, scalds accounted for the majority of presentations in our cohort, and the youngest age stratum constituted the largest share of cases; a modest male predominance was also observed, in line with prior pediatric series [13–16]. In our setting, scalds—most commonly involving hot beverages, cooking liquids, and bath water—reflected household exposures typical of early childhood [2], and even apparently limited injuries may still entail clinically meaningful depth and pain burden that can influence the need for inpatient monitoring and structured wound care [17].

Admission was most strongly associated with second-degree burns, a pattern consistent with the heterogeneous depth and variable healing trajectory of partial-thickness injuries and their attendant analgesic and follow-up requirements. Evidence syntheses similarly indicate that partial-thickness burns—particularly when coupled with greater TBSA or high-consequence anatomical sites—are linked to higher hospitalization likelihood [18]. Contemporary consensus guidance on second-degree burn wound care provides additional context for disposition considerations in the ED [19]. Head and neck involvement showed a strong association with admission, plausibly reflecting higher clinical stakes related to airway risk, feeding difficulties, and functional/cosmetic sequelae; craniofacial pediatric series likewise report greater morbidity and longer inpatient courses for burns affecting these regions [5,20]. Season also appeared among influential predictors in our analyses and may reflect shifting exposure and supervision patterns across the year; prior reports similarly describe temporal clustering, often with increases during warmer months, while winter mechanisms may follow distinct pathways [2,16].

ABSI contributed as a pragmatic severity summary in our cohort, particularly when combined with depth and anatomical involvement. Notably, ABSI was originally developed for broader burn prognostication—especially mortality—rather than to guide ED admission decisions in very young children [10]. Nevertheless, pediatric and contemporary evaluations suggest ABSI can function as a standardized severity anchor, and in our dataset an ABSI threshold above 3 aligned with a higher likelihood of inpatient management [21,22]. Accordingly, ABSI should be interpreted as an adjunctive severity indicator rather than a stand-alone admission criterion.

Severe full-thickness injuries were uncommon, which may reflect the predominance of domestic scald mechanisms and evolving household safety and care-seeking patterns. Longitudinal observations in pediatric burns have described reductions in severe domestic injuries over time, albeit with context-dependent variability [23]. Despite the relative rarity of high-grade burns, the concentration of admissions among the youngest children underscores the persistent vulnerability of this developmental stage and supports targeted prevention and caregiver-focused risk mitigation [24].

From a health-system perspective, pediatric burns impose substantial resource and family burden, and more consistent disposition decisions may support efficient allocation without compromising safety [6,7]. This is particularly relevant where access to specialized burn care and reliable outpatient follow-up is heterogeneous, amplifying the consequences of uncertainty in ED triage [1]. Within these constraints, an explicit rule-based model may provide a structured summary of routinely available variables, while responsible implementation of data-driven tools requires careful attention to transparency, calibration, and clinical oversight [11,25].

This study has several important limitations. Its single-center, retrospective design constrains generalizability and may reflect local referral patterns, admission thresholds, and documentation practices; moreover, several disposition-relevant determinants could not be consistently captured (e.g., prehospital first aid, socioeconomic context, caregiver reliability, outpatient care feasibility). The analysis focused on ED disposition rather than longitudinal endpoints; thus, functional, cosmetic, psychosocial, and rehabilitation-related outcomes—particularly salient for burns involving joints—were not assessed. Although length of stay was reported descriptively, it was not analyzed as a study endpoint, and mortality-related outcomes were not examined. We did not perform multivariable logistic regression benchmarking; therefore, these findings should not be interpreted as demonstrating

superiority over classical statistical models. Because transfer decisions may be influenced by institutional capacity and organizational factors, combining transfers with inpatient admissions may have introduced outcome heterogeneity, and temporal drift in admission practices across 2019–2024 (including potential COVID-era effects) was not formally evaluated. In addition, the bootstrap-derived AUC confidence interval was relatively wide, indicating limited precision of the discrimination estimate and warranting cautious interpretation of model stability. Finally, clinical utility was not evaluated using decision curve analysis or net benefit metrics, nor were model-assisted decisions compared against clinician judgment; accordingly, the potential to reduce unnecessary admissions cannot be quantified from this retrospective dataset. Prospective multicenter validation is required to assess transportability, calibration, and clinical impact.

Conclusion

This study provides a comprehensive epidemiological assessment of pediatric burn injuries in children aged 0–5 years and proposes a decision tree–based framework for hospitalization risk stratification in the ED. Scald injuries predominated, underscoring the need for prevention strategies that target domestic hazards in early childhood. The model highlighted second-degree burns, head and neck involvement, and an elevated ABSI score as the most influential factors associated with hospitalization. Pending external validation and prospective impact evaluation, this CART-based model provides explicit decision rules derived from routinely available variables; however, its clinical utility requires external validation and prospective impact assessment.

Ethics

Ethics Committee Approval: This study was approved by the Muğla Sıtkı Koçman University (Date: 05.11.2024, Decision no: 141).

Informed Consent: Written informed consent was obtained.

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