

## Burn Classification, Total Body Surface Area Assessment, And Epidemiology: Foundations For Modern Burn Care

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### INTRODUCTION

Burn injuries represent a complex form of trauma characterized by tissue destruction, systemic inflammatory response, metabolic derangements, and potential multiorgan dysfunction. Despite advances in prevention and treatment, burns continue to pose a significant global health burden. Early and accurate assessment of burn depth and extent remains the cornerstone of effective management, directly influencing triage decisions, fluid resuscitation strategies, need for surgical intervention, and referral to specialized burn centers. This article reviews burn classification by depth, methodologies for estimating total body surface area (TBSA), global epidemiological patterns, and the clinical relevance of accurate initial burn evaluation in contemporary practice.

#### Classification of Burns by Depth

Burn depth reflects the degree of tissue destruction and the regenerative capacity of the skin, making it one of the strongest predictors of healing time, infection risk, scarring, and functional outcome.

Superficial (First-Degree) Burns are limited to the epidermis. Clinically, they present with erythema, tenderness, and dry skin without blistering. Capillary refill is preserved, and pain is prominent due to intact nerve endings. These burns heal within days through epidermal regeneration and do not result in scarring.

Superficial Partial-Thickness (Second-Degree) Burns involve the epidermis and superficial dermis. They are characterized

by blister formation, moist appearance, severe pain, and brisk capillary refill. Because epithelial appendages such as hair follicles and sweat glands remain intact, spontaneous re-epithelialization occurs rapidly, usually within two to three weeks, with minimal scarring.

Deep Partial-Thickness (Second-Degree) Burns extend deeper into the dermis, damaging a greater proportion of dermal structures. These burns often appear mottled, pale, or erythematous, with diminished sensation and sluggish capillary refill. Healing is prolonged and unpredictable, frequently exceeding three weeks, which increases the risk of hypertrophic scarring and contractures. Surgical excision and grafting are commonly required.

Full-Thickness (Third-Degree) Burns involve complete destruction of the epidermis and dermis. The affected tissue appears dry, leathery, and insensate due to nerve destruction. Because no epithelial elements remain, spontaneous healing is not possible, and definitive management requires early excision and skin grafting to reduce infection risk and improve outcomes.

Fourth-Degree Burns extend beyond the skin into underlying fascia, muscle, tendon, or bone. These devastating injuries are often associated with high-energy mechanisms and severe systemic insult. Management is complex and may necessitate limb amputation, staged reconstruction, or palliative approaches depending on patient condition and associated injuries.<sup>1</sup>



**Figure 1. Superficial and deep second-degree burn.**



**Figure 2. Deep compartmental second-degree burn**



**Figure 3. Third burn degree**



**Figure 4. Third degree burn, with abdominal compartment syndrome**

#### Estimation of Total Body Surface Area Burned

TBSA estimation is critical for determining burn severity, guiding initial fluid resuscitation, predicting morbidity and mortality, and establishing criteria for transfer to specialized burn centers.

The Rule of Nines is a rapid bedside method that divides the adult body into anatomical regions representing multiples of 9% of TBSA. Each upper extremity accounts for 9%, each lower extremity 18%, the anterior trunk 18%, posterior trunk 18%, and the head and neck 9%. Although practical for emergency settings, this method lacks precision in pediatric patients and individuals with atypical body proportions.<sup>1-3</sup>

The Lund-Browder chart provides age-adjusted TBSA percentages for each body region and is considered the most accurate method, particularly in children. By accounting for developmental changes in body surface distribution, it

reduces systematic over- or underestimation inherent in simpler models.<sup>1-3</sup>

The Palmar Method estimates burn size using the patient's palm (including fingers) as approximately 1% of TBSA. This technique is especially useful for small, scattered, or irregular burns, although it may overestimate surface area in adults if the palm alone is incorrectly equated to 1%.<sup>1,3</sup>

Emerging technologies, including computer vision systems and mobile applications, allow three-dimensional body mapping and habitus-specific TBSA calculation. These tools address inaccuracies seen in traditional methods, particularly in obese patients, and show promising interobserver reliability. Their integration into clinical practice may further standardize burn assessment and improve early decision-making.<sup>4</sup>

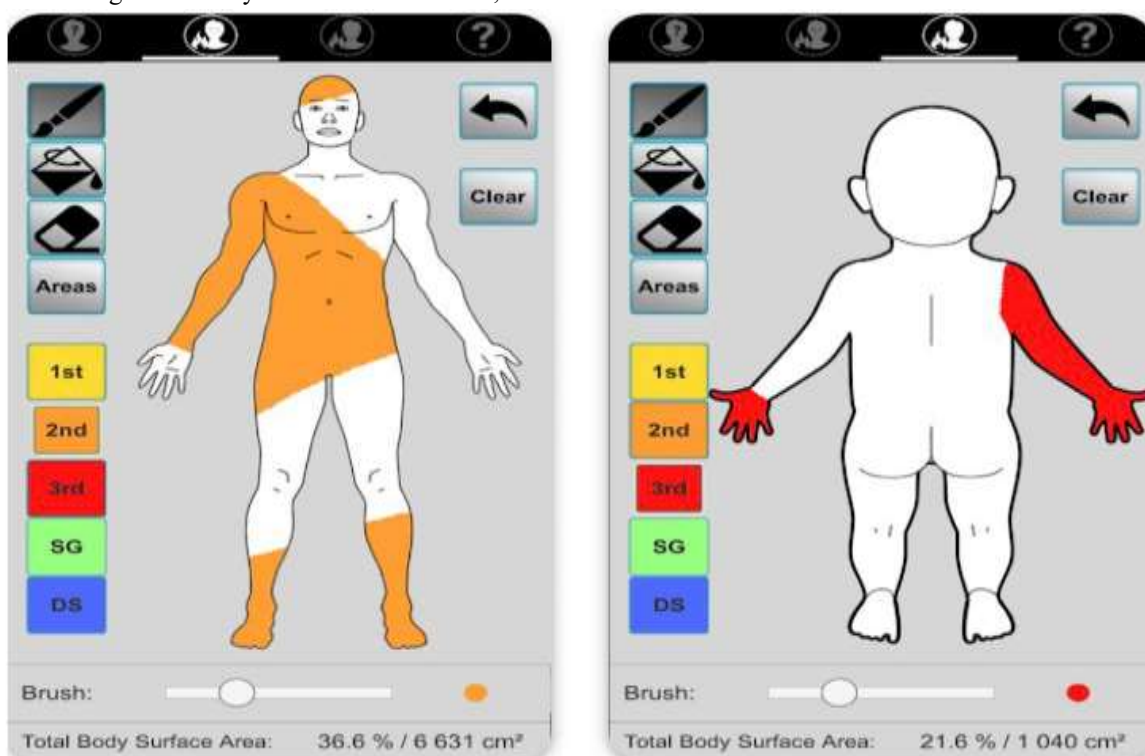


**Figure 5. E-Burn application for quick percentage calculation and handling algorithm**

Table 1. Classification of Burns by Depth, Clinical Features, and Management Implications

| Burn Depth                                    | Tissue Involved                | Clinical Characteristics                             | Sensation    | Healing Potential                             | Typical Management                   |
|-----------------------------------------------|--------------------------------|------------------------------------------------------|--------------|-----------------------------------------------|--------------------------------------|
| Superficial (First-Degree)                    | Epidermis only                 | Erythema, dry skin, no blisters                      | Painful      | Heals spontaneously (days)                    | Conservative care, analgesia         |
| Superficial Partial-Thickness (Second-Degree) | Epidermis + superficial dermis | Blisters, moist surface, brisk capillary refill      | Very painful | Rapid spontaneous healing ( $\leq 2-3$ weeks) | Dressings, infection prevention      |
| Deep Partial-Thickness (Second-Degree)        | Epidermis + deep dermis        | Mottled or pale appearance, delayed capillary refill | Decreased    | Delayed, often incomplete                     | Early excision $\pm$ grafting        |
| Full-Thickness (Third-Degree)                 | Entire dermis destroyed        | Dry, leathery eschar, no blanching                   | Insensate    | No spontaneous healing                        | Surgical excision and grafting       |
| Fourth-Degree                                 | Skin + fascia, muscle, or bone | Charred tissue, severe structural damage             | Insensate    | None                                          | Amputation or complex reconstruction |

Epidemiology of Burn Injuries

Burn injuries remain a major contributor to global injury-related morbidity and mortality. Worldwide, burns are the fourth most common type of trauma, with approximately 8.4 million cases annually. While global incidence and mortality have declined over recent decades, largely due to improved prevention and acute care, marked disparities persist between regions. Low- and middle-income countries bear the highest burden, reflecting differences in housing conditions, occupational hazards, access to care, and public safety infrastructure.<sup>2,5,6</sup> In high-income countries, most burns are minor, involving less than 10% TBSA. Over time, the mean burn size and burn-related mortality have decreased, consistent with improved early intervention, standardized resuscitation protocols, and access to specialized burn centers.<sup>2,7,8</sup>

The age distribution of burn injuries is bimodal, predominantly affecting young children—particularly those under five years of age—and adults between 20 and 59 years. Scald injuries are most common in children, often occurring in domestic settings, whereas flame-related burns predominate in adults, frequently associated with occupational or high-risk behaviors. Males consistently demonstrate higher incidence rates across age groups.<sup>2,5-7</sup> Mortality increases with greater TBSA involvement, increased burn depth, advanced age, inhalation injury, and preexisting comorbidities, including cardiovascular disease and obesity. These factors contribute to physiological stress, impaired wound healing, and higher susceptibility to complications such as sepsis and organ failure.<sup>2,7</sup>

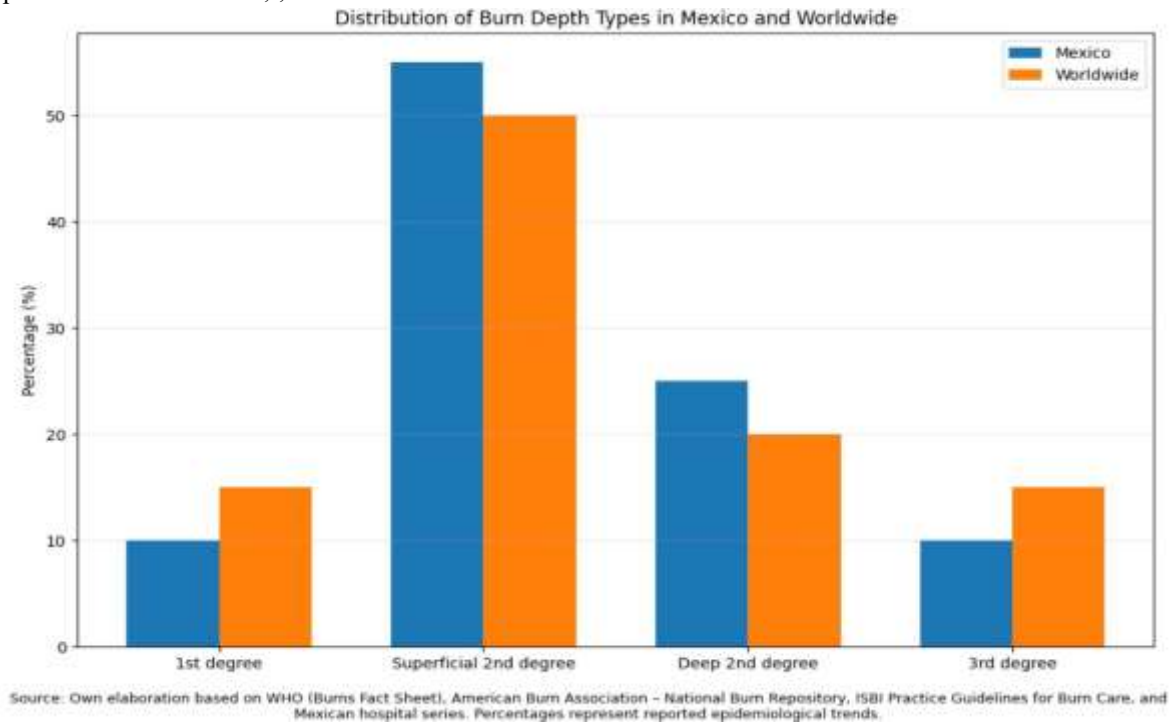


Figure 6

### Clinical Significance of Accurate Burn Assessment

Precise classification of burn depth and TBSA is essential for translating injury assessment into effective clinical action. These parameters guide decisions regarding fluid resuscitation volumes, airway management, nutritional support, surgical timing, and referral to specialized burn centers.

The American Burn Association emphasizes the importance of early and accurate burn assessment for triage and transfer decisions, while the American Heart Association and American Red Cross guidelines underscore the role of standardized burn evaluation in first aid and early hospital care.<sup>2,9</sup> Underestimation may delay definitive treatment and transfer, whereas overestimation can result in unnecessary interventions and resource utilization.

### CONCLUSION

Burn depth classification and TBSA estimation remain fundamental components of burn care. Traditional assessment tools continue to play a critical role in initial evaluation, while emerging digital technologies offer opportunities for improved accuracy and standardization. Coupled with an understanding of global epidemiological trends, precise burn assessment enables timely, evidence-based interventions that improve patient outcomes and optimize healthcare resource allocation.

### REFERENCES

- I. Bitter CC, Storkan M, Overmiller A, et al. Wilderness Medical Society Clinical Practice Guideline on Care of Burns in the Wilderness. *Wilderness Environ Med.* 2025;36(4):549–558. doi:10.1177/10806032251345768.
- II. Greenhalgh DG. Management of Burns. *N Engl J Med.* 2019;380(24):2349–2359. doi:10.1056/NEJMr1807442.
- III. National Library of Medicine. Burn Evaluation. MedlinePlus.
- IV. Choi J, Patil A, Vendrow E, et al. Practical Computer Vision Application to Compute Total Body Surface Area Burn. *JAMA Surg.* 2022;157(2):129–135. doi:10.1001/jamasurg.2021.5848.
- V. Yin X, Huang S, Zhu Z, et al. Global, Regional, and National Burden of Burns. *Injury.* 2025;56(1):111955. doi:10.1016/j.injury.2024.111955.
- VI. Yakupu A, Zhang J, Dong W, et al. Epidemiological Characteristics and Trends of Burns Globally. *BMC Public Health.* 2022;22(1):1596. doi:10.1186/s12889-022-13887-2.
- VII. Abarca L, Guilabert P, Martin N, et al. Epidemiology and Mortality in Hospitalized Burn Patients in Catalonia. *Sci Rep.* 2023;13(1):14364. doi:10.1038/s41598-023-40198-2.
- VIII. Chen L, He X, Xian J, et al. Framework for Managing Severe Burns: 17-Year Retrospective Analysis. *Sci Rep.* 2021;11(1):9374. doi:10.1038/s41598-021-88507-x.
- IX. Hewett Brumberg EK, Douma MJ, Alibertis K, et al. 2024 AHA and American Red Cross Guidelines for First Aid. *Circulation.* 2024;150(24):e519–e579. doi:10.1161/CIR.0000000000001281.