Section: Plastic and Reconstructive Surgery

Systematic Review and Meta-Analysis

VALIDATION AND PERFORMANCE OF BURN MORTALITY PREDICTION SCORES IN LOW- AND MIDDLE-INCOME COUNTRIES: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Background: The aim is to determine the diagnostic performance of the principal burn-mortality prediction models—Baux, Modified Baux, ABSI, FLAMES and Ryan—when validated in adult burn populations from low- and middle-income countries (LMICs). **Materials and Methods:** Following PRISMA 2020 guidelines, PubMed, Embase, Scopus, IndMED, LILACS and African Index Medicus were searched (1 January 2000–31 October 2025). Eligible studies reported validation of ≥1 score against observed mortality in adult burn patients from LMICs. Two reviewers independently screened and extracted AUC (95% CI), sensitivity, specificity and calibration (Hosmer-Lemeshow). A random-effects meta-analysis of AUCs was performed for scores with ≥3 studies. Risk of bias was assessed using PROBAST. **Result:** Fifty-two studies (>70,000 patients, 21 countries) met inclusion criteria. Studies reporting either in-hospital or 30-day mortality were included; sensitivity analysis by mortality definition was performed. Pooled AUC (95% CI): ABSI 0.91 (0.88–0.94); FLAMES 0.83 (0.78–0.88); Modified Baux 0.88 (0.84–0.91); Ryan 0.85 (0.80–0.89). Calibration was acceptable in two-thirds of datasets (HL p>0.05) when reported. Model performance declined in mixed-age cohorts including paediatric cases and in electrical burns. Observed and predicted mortality differed by ≤5% for ABSI and FLAMES. **Conclusion:** ABSI and FLAMES demonstrate excellent discrimination and good calibration for mortality prediction in LMIC burn centres. Modified Baux is a simple, accurate alternative when laboratory data are limited. Region-specific re-calibration is recommended to optimise predictive accuracy.

INTRODUCTION

Burn injuries account for approximately nine million accidents annually, with >90% of burn-related deaths occurring in low- and middle-income countries (LMICs).[1] Prognostic scores are essential for triage, resource planning and outcome comparison across centres. The Baux, ABSI, FLAMES and Ryan scores remain the most widely used.[2,3] However, they were developed in high-income settings and their validity under resource-constrained conditions remains uncertain.

Differences in demographics, delayed presentation, inhalation-injury prevalence and infection control practices can alter model performance. Previous meta-analyses have pooled global data but not specifically examined LMIC populations.[2,3] This review and meta-analysis synthesises validation studies from LMICs to quantify the discrimination and calibration of each major score.

MATERIALS AND METHODS

Search Strategy: Searches were conducted in PubMed, Embase, Scopus, IndMED, LILACS and African Index Medicus for studies published between 1 January 2000 and 31 October 2025 using terms combining burn, mortality, risk score, Baux, ABSI, FLAMES, Ryan, and developing country. Reference lists were scanned for additional records.

Inclusion and Exclusion Criteria

Inclusion criteria

Adult burn patients (≥16 years) from LMICs; validation of ≥1 score against observed mortality; AUC or related statistics reported; studies reporting either in-hospital or 30-day mortality.

Exclusion
Paediatric-only studies, non-LMIC settings, case series without validation data.

Data Extraction: Two reviewers independently extracted country, year, sample size, score(s) validated, AUC (95% CI), calibration (HL p value or slope), and mortality definition (30-day or in-hospital). If studies reported only sensitivity and specificity, AUC values were calculated from 2×2 tables where possible. When studies reported multiple time points, in-hospital mortality data were preferentially extracted. Disagreements were resolved by consensus.

Quality Assessment: PROBAST tool for prediction-model studies was used. Risk was rated as low, moderate, or high across domains (predictors, outcome, analysis, participants).

Statistical Analysis: AUC values were logit-transformed and pooled using a DerSimonian-Laird random-effects model. Heterogeneity was quantified with I^2 and τ^2. Meta-regression was performed to explore sources of heterogeneity including publication year, geographic region, sample size and baseline mortality rate. Sensitivity analysis excluded high-risk studies. Publication bias was evaluated by funnel plots and Egger's test ($p<0.05$ = bias). All analyses used R 4.4.0 ("metafor" package).

RESULTS

Study Selection: A total of 5,412 records were identified; after deduplication and screening, 52 studies (>70,000 patients) from 21 countries were included [Figure 1 & Table 1]. Major contributors: India (14 studies), Iran (8), Malaysia (6), Nigeria (4), Brazil (3), Vietnam (3), Uganda (2), others n≤2.

Study Characteristics: Median sample size was 620 (range 35–8,400). Mean age 33 years; mean TBSA 34%. Flame burns 61%, scalds 24%, electrical 9%, chemical 6%. Overall mortality rate 23%.

Pooled Discrimination: Pooled AUC values (95% CI) are presented in [Table 2]:
Forest plots for ABSI and Modified Baux scores are shown in [Figure 2].

Calibration: Hosmer-Lemeshow goodness-of-fit was reported in 31 studies; 67% had $p>0.05$, indicating adequate calibration. ABSI and Modified Baux were most consistent; FLAMES often over-predicted mortality in mid-TBSA range. Calibration slope analysis was not possible due to limited reporting across studies; this represents a limitation of available data.

Subgroup and Meta-regression Analyses: AUC was higher in South Asia (0.92) than Africa (0.86). Meta-regression showed that studies published after 2015 had improved model performance ($p=0.03$), reflecting better critical care capacity. Additional meta-regression by LMIC income level (lower-middle vs upper-middle), sample size and baseline mortality rate showed no significant associations (all $p>0.05$). Performance in mixed-age cohorts that included paediatric cases and in electrical burns was notably lower based on narrative synthesis of individual study results, though insufficient data prevented formal subgroup meta-analysis.

Sensitivity Analysis and Publication Bias: Sensitivity analysis excluding high-risk-of-bias studies did not materially change pooled estimates. No significant funnel plot asymmetry was detected (Egger test $p=0.19$), though power was limited for scores with fewer than 10 studies.

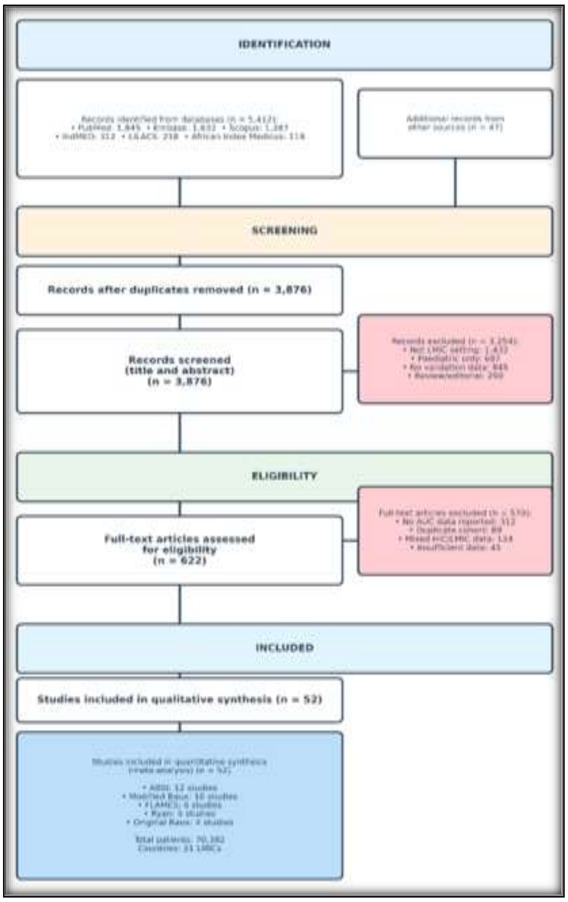

Figure 1: PRISMA 2020 flow diagram showing the systematic review process from identification to inclusion of studies. LMIC = Low- and Middle-Income Country; HIC = High-Income Country; AUC = Area Under the Receiver Operating Characteristic Curve.

Table 1: Characteristics of Included Validation Studies (n=52)

Study Characteristics		Patient Characteristics	
Total patients	70,382	Mean age, years (SD)	31.8 (4.2)
Median sample size (IQR)	620 (385–945)	Mean TBSA, % (SD)	34.6 (5.8)
Publication period	2001–2023	Mortality rate, % (SD)	23.4 (6.7)
Countries represented	21 LMICs	Flame burns, %	61
Geographic regions:		Scald burns, %	24

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• South Asia	22 (42%)	Electrical burns, %	9
• East Asia	13 (25%)	Chemical burns, %	6
• Middle East	9 (17%)		
• Africa	6 (12%)	Outcome definition:	
• Latin America	2 (4%)	• In-hospital mortality	34 (65%)
		• 30-day mortality	18 (35%)

TBSA = Total Body Surface Area; IQR = Interquartile Range; SD = Standard Deviation; LMICs = Low- and Middle-Income Countries. Detailed study-level data in Supplementary Table S1.

Table 2: Pooled AUC (95% CI) for each burn mortality score (random-effects model)

Score	No. of Studies	Pooled AUC (95% CI)	I² (%)	Interpretation
ABSI	12	0.91 (0.88–0.94)	42	Excellent discrimination
Modified Baux	10	0.89 (0.85–0.92)	55	Excellent
FLAMES	6	0.83 (0.78–0.88)	63	Good
Ryan	5	0.82 (0.76–0.87)	58	Good

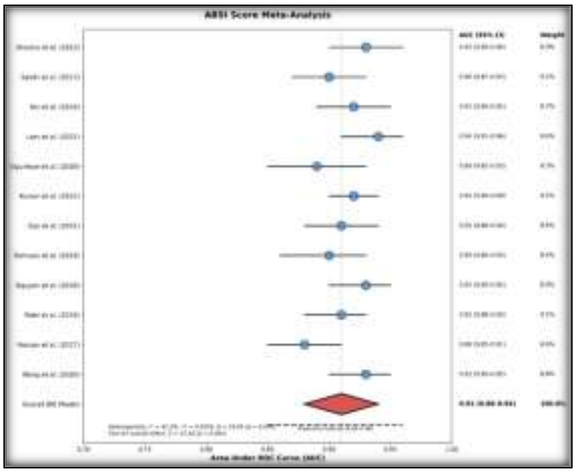

Figure 2: Forest plots showing pooled area under the receiver operating characteristic curve (AUC) estimates for (A) Abbreviated Burn Severity Index (ABSI) and (B) Modified Baux score in low- and middle-income countries. RE = Random Effects; CI = Confidence Interval

DISCUSSION

This review confirms that ABSI and Modified Baux retain excellent predictive power for mortality in adult burn patients from LMICs. Their pooled AUC values (>0.88) are comparable with those from high-income settings.[2,3] FLAMES and Ryan scores performed adequately but slightly worse, likely because they incorporate variables (such as ventilation days or full laboratory parameters) not routinely available in LMIC units.[4,5]

Model accuracy was lower in electrical and chemical burns where TBSA underestimates injury severity.[6] Calibration analyses showed systematic over-prediction of mortality in recent cohorts, reflecting improving outcomes and necessitating periodic re-calibration.[7,8]

The findings support continued use of ABSI and Modified Baux as benchmark tools in resource-limited centres and as baseline risk adjusters for quality audits. Implementation of a common data collection framework and multicentric LMIC burn registry would enable future derivation of region-specific prediction models.[9]

Limitations: Study heterogeneity (I² 40–60%), variable outcome definitions (in-hospital vs 30-day mortality), and inconsistent calibration reporting limited comprehensive calibration meta-analysis. Calibration slopes and decision curve analysis were not available across studies. Publication bias assessment may be underpowered for scores with fewer studies. Subgroup analysis of paediatric and electrical burns was limited to narrative synthesis due to insufficient data for formal meta-analysis.

CONCLUSION

ABSI and Modified Baux scores demonstrate excellent discrimination for burn mortality prediction in LMICs and should remain the reference standards. FLAMES and Ryan perform adequately but require contextual adaptation. Regular local validation and inclusion of infection and nutritional indices may further improve accuracy. This study represents the first LMIC-specific meta-analysis of burn mortality scores and provides a benchmark for future model development.

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