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POSSUM versus ACS NSQIP for Morbidity and Mortality Prediction in Indian Surgical Patients

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ABSTRACT: Non-cardiac surgery carries substantial and variable perioperative risk, and accurate preoperative risk stratification remains central to informed consent, resource planning, and quality benchmarking; however, the performance of widely used risk models such as POSSUM and the ACS NSQIP Surgical Risk Calculator in Indian surgical populations remains insufficiently characterized, given differences in comorbidity burden, nutritional status, and disease presentation compared with the Western cohorts in which these tools were developed. This prospective observational study included 163 adults undergoing elective or emergency non-cardiac surgery at a South Indian tertiary care centre; physiological, operative, and preoperative variables were recorded, and predicted morbidity and mortality risks from POSSUM and ACS NSQIP were compared against observed 30-day outcomes using AUROC with DeLong testing, Hosmer–Lemeshow calibration, and Youden-index-derived sensitivity, specificity, and predictive values. Morbidity occurred in 47 patients (28.8%) and mortality in 9 (5.5%). POSSUM showed numerically higher discrimination for morbidity (AUROC 0.708 vs. 0.638), whereas ACS NSQIP discriminated mortality better (AUROC 0.882 vs. 0.839), though neither difference reached statistical significance (p=0.279 and p=0.365, respectively); both models showed acceptable calibration on Hosmer–Lemeshow testing, with under-prediction of risk in higher-risk strata for morbidity. These findings indicate that POSSUM and ACS NSQIP perform comparably overall, without demonstrable superiority of either model, but may serve complementary clinical roles, with ACS NSQIP being useful for preoperative risk communication and POSSUM for postoperative audit.

1. INTRODUCTION

Non-cardiac surgery encompasses a broad spectrum of operative procedures spanning general surgery, urology, orthopaedics, gynaecology, and vascular surgery and collectively represents one of the largest contributors to global surgical volume (Moonesinghe et al., 2013). The associated perioperative risk is considerable and highly variable, as outcomes depend on the interaction between patient physiology, operative complexity, and the quality of institutional care delivery (Scott et al., 2014). Postoperative complications including pneumonia, sepsis, surgical site infection, acute kidney injury, thromboembolic events, and cardiac morbidity contribute substantially to prolonged hospitalisation, intensive care utilisation, and preventable mortality, particularly among elderly, anaemic, or nutritionally compromised patients undergoing emergency procedures (Karabulut et al., 2024).

Accurate preoperative risk quantification is a cornerstone of contemporary perioperative medicine. Structured risk scoring allows clinicians to move beyond subjective clinical judgement toward evidence-based stratification, facilitating informed consent, targeted preoperative optimization, appropriate utilization of ICU resources, and meaningful institutional audits (Spota et al., 2025). Two widely used instruments for this purpose are the Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM) and ACS NSQIP Surgical Risk Calculator. POSSUM integrates 12 physiological and six intraoperative variables into logistic regression equations to estimate morbidity and mortality risks, making it well suited for perioperative audits (Tekkis et al., 2003).

The ACS NSQIP calculator, by contrast, relies entirely on preoperative patient-level data to generate individualised 30-day risk estimates across multiple complication domains, rendering it directly applicable at the point of preoperative assessment (Bilimoria et al., 2013). POSSUM and American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) were chosen as they are widely validated, clinically relevant risk prediction models representing operative severity–based and preoperative risk–based approaches, enabling comprehensive comparative evaluation.

Both tools were derived and validated predominantly in Western surgical populations, and their performance in Indian patients remains insufficiently characterised. The Indian surgical demographic is distinct; a higher prevalence of malnutrition, anaemia, delayed disease presentation, socioeconomic barriers to preoperative optimisation, and a different comorbidity spectrum introduce systematic differences that may compromise the accuracy of imported prediction models. The present study aimed to assess and compare the predictive performance of the POSSUM and ACS NSQIP scoring systems for postoperative morbidity and mortality following non-cardiac surgery in the Indian population, with particular emphasis on their ability to estimate observed postoperative complications and 30-day mortality.

2. MATERIALS AND METHODS

2.1 Study Design and Participants

This prospective observational comparative study included 163 adult patients who underwent non-cardiac surgical interventions at a tertiary teaching institution between January 2025 and April 2026. The required sample size was estimated using an anticipated postoperative morbidity prevalence of 12%, a confidence level of 95%, and an allowable error margin of 5%, resulting in a calculated minimum sample size of 163 subjects.

Ethical approval for the study was obtained from the Institutional Ethics Committee (SRMIEC-ST0925-2874), and all study procedures adhered to the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment in the study.

Patients aged 18 years or older undergoing elective or emergency non-cardiac surgery under either general or regional anaesthesia were considered eligible, provided that complete perioperative clinical records were available. Patients undergoing cardiac or neurosurgical procedures, those scheduled for minor day-care procedures without hospital admission, pregnant patients, individuals requiring repeat surgery during the same admission, and patients with incomplete clinical information were excluded.

2.2 Data Collection

Data were prospectively collected using a structured and predesigned proforma. Demographic characteristics, including age, sex, and body mass index, were recorded. Clinical information included American Society of Anesthesiologists (ASA) physical status classification, functional capacity, and associated comorbid conditions, including diabetes mellitus, hypertension, congestive heart failure, chronic obstructive pulmonary disease, and history of smoking. Preoperative laboratory and physiological variables, including haemoglobin, white blood cell count, blood urea, serum sodium, serum potassium, heart rate, and arterial blood pressure, were documented for calculation of the POSSUM score. Intraoperative variables, including operative severity, estimated blood loss, duration of surgery, number of concurrent procedures, peritoneal contamination, presence of malignancy, and operative urgency, were also recorded.

2.3 Risk Score Calculation

Predicted probabilities of postoperative morbidity and mortality were derived independently using the POSSUM and American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) risk prediction models. For POSSUM, the 12 physiological and six operative variables were scored according to the original POSSUM scoring system. The physiological and operative scores were then entered into the original POSSUM logistic regression equations to calculate the predicted probabilities of postoperative morbidity and mortality. Predicted morbidity was calculated using the equation, $\ln[R/(1-R)] = -5.91 + (0.16 \times \text{physiological score}) + (0.19 \times \text{operative severity score})$, while predicted mortality was calculated using the equation, $\ln[R/(1-R)] = -7.04 + (0.13 \times \text{physiological score}) + (0.16 \times \text{operative severity score})$, where R represents the predicted probability of the respective outcome.

For the ACS NSQIP Surgical Risk Calculator, the relevant preoperative patient and procedural variables, including demographic characteristics, comorbidities, functional status, ASA physical status, and planned surgical procedure, were entered into the web-based ACS NSQIP risk calculator to obtain the corresponding predicted postoperative risk probabilities. All variables required for calculation of the ACS NSQIP predicted risks were available for all included patients. Therefore, no imputation, default-value substitution, or exclusion due to missing ACS NSQIP predictor variables was required.

Postoperative outcomes were assessed through daily clinical review during the hospital stay. Following discharge, outcome status was assessed through outpatient attendance or structured telephone follow-up on postoperative days 15 and 30. Information regarding the occurrence of postoperative complications, readmission where applicable, and survival status was obtained during follow-up and documented in the study proforma. All postoperative outcomes were assessed and documented by a single investigator using the predefined study proforma. Complications were identified based on clinical documentation and follow-up information obtained during the study period.

2.4 Statistical Analysis

The predictive performance of POSSUM and ACS NSQIP for postoperative morbidity and mortality was assessed using measures of discrimination and calibration. Discrimination was evaluated using the area under the receiver operating characteristic curve (AUROC), with corresponding 95% confidence intervals (CIs). The AUROCs of POSSUM and ACS NSQIP were compared using the DeLong test for correlated receiver operating characteristic curves. Calibration of the predicted probabilities with the observed outcomes was assessed using the Hosmer–Lemeshow goodness-of-fit test, and calibration plots were used to provide a graphical assessment of agreement between predicted and observed risks.

For evaluation of discriminatory performance at an optimal threshold, Youden's index was used to identify the optimal cutoff value. At the identified cutoff, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for the prediction of postoperative morbidity and mortality. Statistical analyses were performed using IBM SPSS Statistics, version 29.0. The calibration plots and diagnostic performance measures were generated using the statistical procedures available in the statistical analysis software.

3. RESULTS AND DISCUSSION

During the study period, 163 patients who were scheduled for non-cardiac surgeries were included. Table 1 provides a summary of the baseline characteristics of these participants. The largest proportion of participants fell within the 45–59 year age group (n = 56; 34.4%), followed by those aged 30–44 years (n = 45; 27.6%), 60 years and above (n = 35; 21.5%), and 18–29 years (n = 27; 16.6%). Among the 163 patients included in the study, 105 (64.4%) were males, while 58 (35.6%) were females. Body mass index distribution revealed that 103 patients (63.2%) had a normal BMI, 35 (21.5%) were overweight, 19 (11.7%) were obese, and 6 (3.7%) were underweight. With respect to ASA physical status classification, the majority were ASA Class II (n = 89; 54.6%), followed by ASA Class I (n = 37; 22.7%), ASA Class III (n = 36; 22.1%), and ASA Class IV (n = 1; 0.6%). The distribution of comorbidities is presented in Table 1. Diabetes mellitus was present in 32 patients (19.6%) and hypertension in 25 patients (15.3%). Chronic obstructive pulmonary disease was identified in 2 patients (1.2%) and congestive heart failure in 1 patient (0.6%). No patient had disseminated malignancy, a pre-existing wound infection, or a documented bleeding disorder. The majority of participants were non-smokers (n = 144; 88.3%), with active smokers accounting for 11.7% of the cohort.

Postoperative outcomes were also recorded for all 163 patients. A morbidity endpoint occurred in 47 patients (28.8%), and 9 patients (5.5%) died within 30 days of surgery. These observed event rates form the reference standard against which the POSSUM and ACS NSQIP predicted risks were subsequently compared.

Table 1. Baseline Demographic, Clinical Characteristics, and Comorbidities of the Study Population (n = 163)

Variable	**Category**	**Frequency (n)**	**Percentage (%)**
Age (years)	18–29	27	16.6
	30–44	45	27.6
	45–59	56	34.4
	≥60	35	21.5
Gender	Male	105	64.4
	Female	58	35.6
BMI	Underweight	6	3.7
	Normal	103	63.2
	Overweight	35	21.5
	Obese	19	11.7
ASA Class	I	37	22.7
	II	89	54.6
	III	36	22.1
	IV	1	0.6
Diabetes	No	131	80.4
	Yes	32	19.6
Hypertension	No	138	84.7
	Yes	25	15.3
Congestive Heart Failure (CHF)	No	162	99.4
	Yes	1	0.6
Chronic Obstructive Pulmonary Disease (COPD)	No	161	98.8
	Yes	2	1.2
Disseminated Cancer	No	163	100
Wound Infection	No	163	100

Bleeding Disorder	No	163	100
Smoking	No	144	88.3
	Yes	19	11.7

The discriminative performance of both models for postoperative morbidity and mortality is presented in Table 2.

Table 2. Discriminative Performance of ACS NSQIP and POSSUM Models for Postoperative Mortality and Morbidity

Outcome	Model	AUC (95% CI)	DeLong Z	p-value
Mortality	ACS NSQIP	0.882 (0.788–0.976)	0.905	0.365
	POSSUM	0.839 (0.715–0.963)		
Morbidity	ACS NSQIP	0.638 (0.545–0.732)	−1.082	0.279
	POSSUM	0.708 (0.606–0.810)		

DeLong Z and p-value apply to inter-model comparison.

For morbidity prediction, POSSUM achieved an AUROC of 0.708, while ACS NSQIP yielded an AUROC of 0.638; although POSSUM showed numerically superior discrimination, the inter-model difference was not statistically significant (p = 0.279) (see Figure 1). For postoperative mortality prediction, ACS NSQIP demonstrated higher discrimination (AUROC = 0.882) compared with POSSUM (AUROC = 0.839); however, this difference was not statistically significant (p = 0.365) (see Figure 2).

Calibration assessment using the Hosmer–Lemeshow goodness-of-fit test is presented in Table 3 for morbidity and mortality.

Table 3. Calibration of ACS NSQIP and POSSUM Models for Predicting Postoperative Morbidity and Mortality Using the Hosmer–Lemeshow Goodness-of-Fit Test

Outcome	Model	χ^2 (df)	p-value
Morbidity	ACS NSQIP	7.304 (8)	0.504
	POSSUM	6.271 (8)	0.617
Mortality	ACS NSQIP	5.48 (2)	0.065
	POSSUM	13.01 (8)	0.112

For morbidity, POSSUM returned a chi-square value of 6.271 (p = 0.617) and ACS NSQIP 7.304 (p = 0.504), indicating satisfactory agreement between predicted and observed outcomes. For mortality, ACS NSQIP returned a chi-square value of 5.48 (p = 0.065) and POSSUM 13.01 (p = 0.112), with both models demonstrating adequate calibration across the study cohort.

Optimal Cutoffs and Diagnostic Accuracy

Youden index–derived optimal cutoffs, together with the corresponding sensitivity, specificity, PPV, and NPV for each model–outcome pairing, are presented in Table 4. Both mortality models achieved high sensitivity and NPV, but PPV remained low for ACS NSQIP (17.5%) and POSSUM (20.5%), a consequence of the low mortality event rate in this cohort (9/163 events) rather than a deficiency in model performance. For morbidity, POSSUM showed better overall discrimination than either ACS NSQIP formulation ("any complication" or "serious complication"), although the any-complication formulation of ACS NSQIP achieved the highest sensitivity (74.5%) among the morbidity models.

Table 4. Discrimination and Performance of POSSUM and ACS NSQIP at the Youden-Optimal Cutoff for Each Outcome

Model / Outcome	AUROC	Optimal cutoff	Sensitivity	Specificity	PPV	NPV
POSSUM – Morbidity	0.708	≥19.5%	55.3%	87.9%	65.0%	82.9%
POSSUM – Mortality	0.839	≥3.6%	88.9%	79.9%	20.5%	99.2%
ACS NSQIP (Any Complication) – Morbidity	0.662	≥3.0%	74.5%	56.9%	41.2%	84.6%
ACS NSQIP (Serious Complication) – Morbidity	0.638	≥4.6%	57.4%	66.4%	40.9%	79.4%
ACS NSQIP – Mortality	0.882	≥0.2%	77.8%	78.6%	17.5%	98.4%

Calibration Beyond the Hosmer–Lemeshow Statistic

Predicted and observed event rates were compared across risk deciles for morbidity and risk quartiles for mortality (Figures 3a,3b & 4a,4b). For morbidity, both models under-predicted risk with increasing severity: observed rates exceeded predicted rates from roughly the 6th–7th decile onward, most markedly in the highest decile (POSSUM: 52.4% predicted vs. 82.4% observed; ACS NSQIP: 12.0% predicted vs. 52.9% observed). This pattern reflects a calibration-in-the-large and calibration-slope issue rather than a simple goodness-of-fit failure, and should be reported alongside the Hosmer–Lemeshow results rather than in place of them.

For mortality, both models separated the lowest- and highest-risk groups reasonably well observed mortality rose from 0% in the lowest risk stratum to 19.5% (POSSUM, Quartile 4) and 17.5% (ACS NSQIP, higher-risk group) in the highest. However, with only 9 deaths in the cohort, these estimates carry wide uncertainty and should be interpreted cautiously; this reflects the small absolute number of mortality events (9 of 163 patients) rather than a general limitation of the analysis.

This prospective observational study compared the discriminatory and calibration performance of POSSUM and ACS NSQIP in predicting 30-day postoperative morbidity and mortality among 163 adult patients undergoing non-cardiac surgery at a South Indian tertiary care centre. POSSUM demonstrated numerically higher discrimination for morbidity (AUROC 0.708 vs. 0.638), whereas ACS NSQIP demonstrated numerically higher discrimination for mortality (AUROC 0.882 vs. 0.839). However, neither inter-model difference was statistically significant on DeLong testing. Both instruments demonstrated no statistically significant lack of fit according to the Hosmer–Lemeshow goodness-of-fit test, and calibration should be interpreted in conjunction with the corresponding calibration plots.

The numerically higher discrimination observed with POSSUM for morbidity may be related to its structural integration of operative severity variables alongside physiological parameters. POSSUM incorporates physiological and operative variables, including operative complexity, estimated blood loss, peritoneal contamination, and urgency of surgery. These variables may capture aspects of surgical risk that are not fully represented in a predominantly preoperative risk assessment model. However, because the difference in morbidity discrimination between POSSUM and ACS NSQIP was not statistically significant, the present findings do not establish the superiority of POSSUM for morbidity prediction. Rather, they suggest that the two instruments may capture different domains of perioperative risk. This observation is broadly consistent with findings reported by Madhavan et al. (2016).

Comparison with existing literature should be interpreted cautiously because several previous studies evaluated P-POSSUM rather than the original POSSUM model used in the present study. Although POSSUM and its derivatives are related instruments, they use different equations and may demonstrate different predictive performance, particularly for mortality. Therefore, findings from studies evaluating P-POSSUM should not be considered directly equivalent to the performance of the original POSSUM model observed in the present cohort.

Vather and Bissett (2006), evaluating POSSUM and its derivatives in 308 patients undergoing major colorectal surgery, reported satisfactory discriminative ability for postoperative mortality across the POSSUM variants, with POSSUM and P-POSSUM demonstrating better performance than Cr-POSSUM. Bahl et al. (2026), studying POSSUM and P-POSSUM in an Indian emergency gastrointestinal surgical cohort, reported high AUROC values for morbidity and mortality. Sevinyan et al. (2024), in a head-to-head comparison of P-POSSUM and ACS NSQIP in gynaecological oncology robotic surgery, reported superior morbidity discrimination with ACS NSQIP and found that P-POSSUM overestimated morbidity and mortality. Fernandes et al. (2020), analysing gastrointestinal cancer patients in a surgical intermediate care unit, reported limited individual predictive accuracy for both P-POSSUM and ACS NSQIP and found that a composite model incorporating variables from both instruments achieved higher discrimination.

The numerically higher mortality discrimination observed with ACS NSQIP in the present study is clinically plausible. Postoperative mortality is influenced by preoperative physiological reserve, comorbid disease burden, and functional status, which are incorporated into the ACS NSQIP Surgical Risk Calculator. The calculator was developed using a large multicentre surgical dataset and has demonstrated strong discriminatory performance for mortality across surgical populations.

Karabulut et al. (2024), comparing ACS NSQIP and P-POSSUM in patients undergoing major hepatobiliary surgery, reported higher mortality discrimination for ACS NSQIP than for P-POSSUM. Although the present findings showed a similar numerical pattern, direct comparison should be interpreted cautiously because Karabulut et al. evaluated P-POSSUM rather than the original POSSUM model. Furthermore, the difference in mortality discrimination between ACS NSQIP and POSSUM in the present study was not statistically significant. Blair et al. (2018) further reported the predictive validity of ACS NSQIP across surgical populations, whereas Scott et al. (2014), evaluating POSSUM and P-POSSUM in a level 1 critical care setting, found that although both models demonstrated satisfactory discrimination, calibration performance was less consistent.

The interpretation of the mortality findings should also consider the small number of observed mortality events in the present cohort (n = 9; 5.5%). A limited number of outcome events may reduce the precision and stability of estimates of discriminatory and calibration performance and may contribute to wider confidence intervals. Therefore, although ACS NSQIP demonstrated numerically higher mortality discrimination than POSSUM, this difference was not statistically significant and should be interpreted cautiously. Confirmation of these findings in larger cohorts with a greater number of mortality events is warranted.

Calibration is an important component of prediction-model performance. In the present study, neither instrument demonstrated statistically significant lack of fit according to the Hosmer–Lemeshow goodness-of-fit test. However, Hosmer–Lemeshow results alone should not be considered definitive evidence of calibration, particularly in relatively small samples, and should be interpreted together with the calibration plots. Previous studies, including Bhalerao et al. (2025), have also reported acceptable calibration for POSSUM-derived models across different surgical risk groups. The calibration findings of the present study should nevertheless be interpreted cautiously because of the sample size and the limited number of mortality events.

From a clinical perspective, the findings suggest that both instruments may have complementary roles rather than indicating the clear superiority of one model over the other. ACS NSQIP, which is based primarily on preoperative patient and procedural characteristics, may be useful for preoperative risk communication and shared decision-making. POSSUM incorporates operative variables and may therefore be particularly useful for postoperative audit and institutional quality assessment. However, this proposed complementary use should be interpreted as a practical application based on the characteristics of the two instruments and existing literature rather than as evidence of superiority demonstrated by the present study. Further multicentre validation in larger Indian surgical populations is required before definitive recommendations regarding the preferential use of either model can be made.

Limitations

Several limitations of this study warrant consideration. First, the sample size (n = 163) was modest, which likely constrained the statistical power available to detect meaningful differences between the two prediction models' discriminative performance. This limitation was particularly evident for mortality, where the small number of observed events yielded less stable estimates and correspondingly wide confidence intervals around model performance metrics. Second, because the study was conducted at a single tertiary-care institution in South India, the results may not extend readily to other clinical settings, given potential differences in patient case mix, surgical volume, and perioperative management protocols elsewhere. Third, the cohort encompassed a diverse array of non-cardiac surgical procedures, and this procedural heterogeneity may have introduced variation in baseline risk profiles that could have affected how well each model discriminated and calibrated across different patient subgroups. Taken together, these factors underscore the need for validation of these findings in larger, multicentre cohorts before the comparative performance of these models can be considered generalizable.

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4. CONCLUSION

Both POSSUM and ACS NSQIP showed useful discriminatory performance for predicting 30-day postoperative morbidity and mortality in adults undergoing non-cardiac surgery at this South Indian tertiary care centre, with no statistically significant difference between the two models overall. POSSUM discriminated morbidity somewhat better, while ACS NSQIP performed somewhat better for mortality, though neither difference reached statistical significance.

These findings point to potentially complementary roles for the two models in perioperative practice: ACS NSQIP for preoperative risk assessment and patient counselling, and POSSUM for postoperative audit and quality benchmarking. Given the lack of statistically significant superiority for either model, however, this complementary framing should be viewed as a plausible practice consideration rather than a firm conclusion. Larger, multicentre studies across diverse Indian surgical populations, with more outcome events, are needed to confirm the generalizability of these models and to inform the development of population-appropriate risk-prediction tools.

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CONFLICT OF INTEREST STATEMENT

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ETHICS STATEMENTS

Ethical Consideration

This study was approved by the Institutional Ethics Committee of SRM Medical College Hospital and Research Institute (Approval No. SRMIEC-ST0925-2874). The study was conducted in accordance with the ethical principles applicable to research involving human participants, including the Declaration of Helsinki.

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FIGURE LEGENDS

Figure 1. ROC Curve for Morbidity Prediction Using ACS NSQIP and POSSUM Models.

Figure 2. ROC Curve for Mortality Prediction Using ACS NSQIP and POSSUM Models.

Figure 3a. Calibration Plot — POSSUM Model, Postoperative Morbidity (Risk Deciles).

Figure 3b. Calibration Plot — ACS NSQIP Model, Postoperative Morbidity (Risk Deciles).

Figure 4a. Calibration Plot — POSSUM Model, Postoperative Mortality (Risk Quartiles).

Figure 4b. Calibration Plot — ACS NSQIP Model, Postoperative Mortality (Risk Groups).

FIGURES

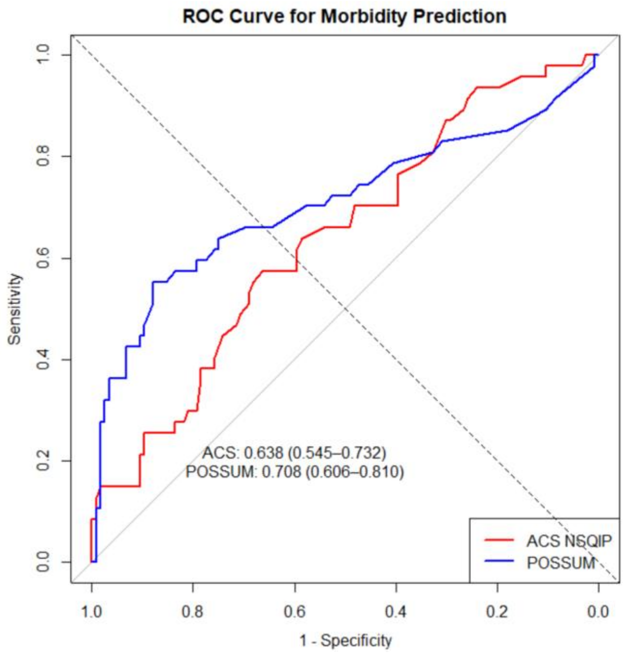

Figure 1. ROC Curve for Morbidity Prediction Using ACS NSQIP and POSSUM Models

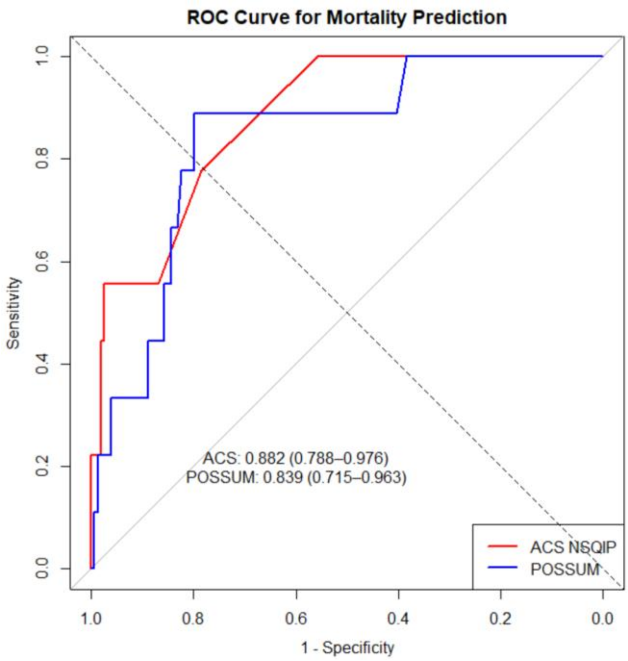

Figure 2. ROC Curve for Mortality Prediction Using ACS NSQIP and POSSUM Models

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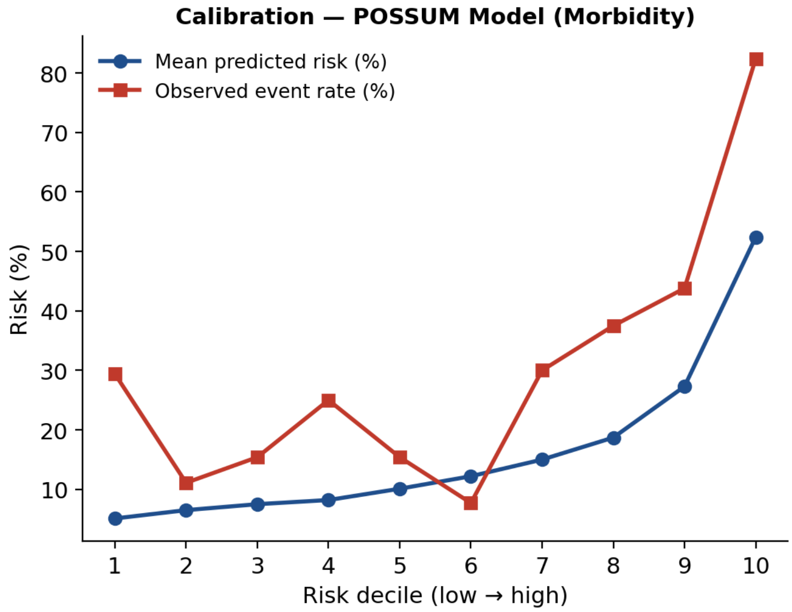

Figure 3a. Calibration Plot — POSSUM Model, Postoperative Morbidity (Risk Deciles)

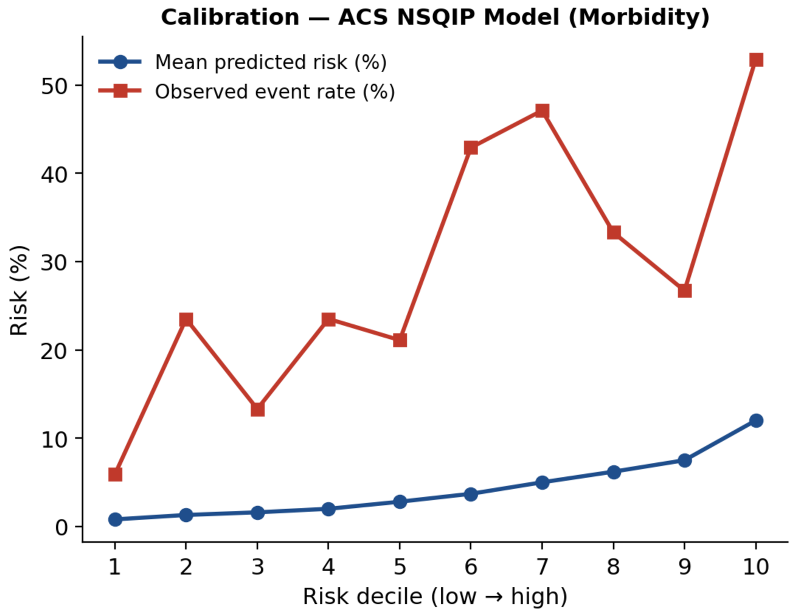

Figure 3b. Calibration Plot — ACS NSQIP Model, Postoperative Morbidity (Risk Deciles)

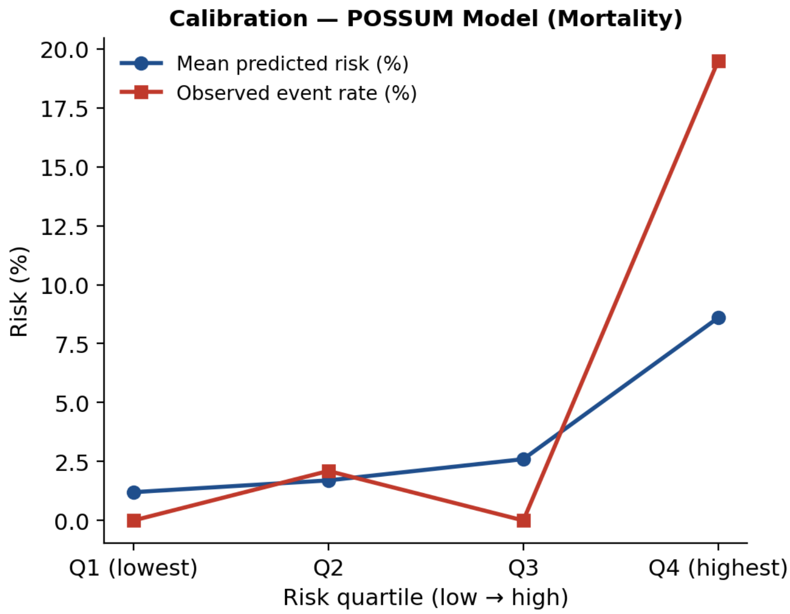

Figure 4a. Calibration Plot — POSSUM Model, Postoperative Mortality (Risk Quartiles)

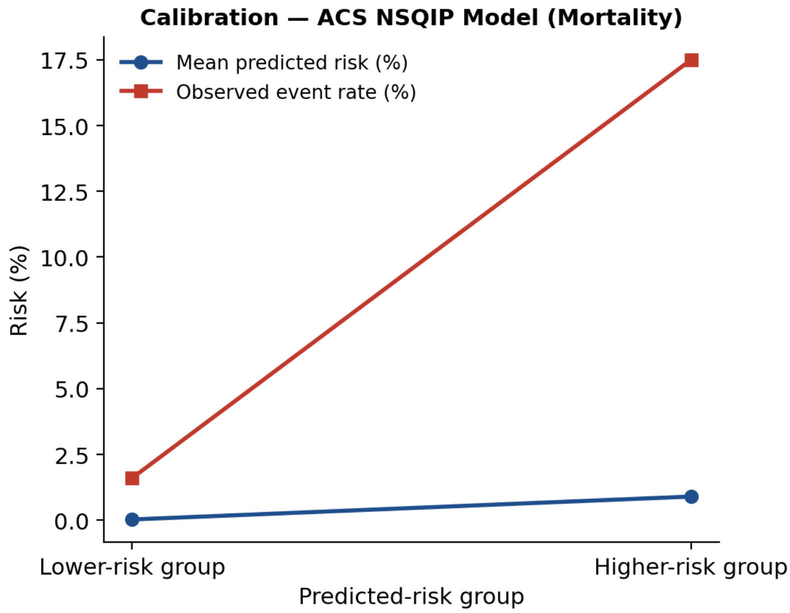

Figure 4b. Calibration Plot — ACS NSQIP Model, Postoperative Mortality (Risk Groups)