World Neurosurgery: X 32 (2026) 100639

Contents lists available at ScienceDirect

World Neurosurgery: X

journal homepage: www.journals.elsevier.com/world-neurosurgery-x

Determinants of in-hospital mortality and surgical burden in acute spontaneous intracerebral hemorrhage: A prospective study from Jimma University Medical Center

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ARTICLE INFO

Keywords:
Intracerebral hemorrhage
Hemorrhagic stroke
In-hospital mortality
ICH score
Neurosurgery
Ethiopia

ABSTRACT

Background: Acute spontaneous intracerebral hemorrhage (ICH) carries high early mortality, and neurosurgical assessment is often considered. Evidence from Ethiopia remains limited. We examined in-hospital mortality and the relationship between a protocol trigger for neurosurgical assessment and actual surgery at Jimma University Medical Center.

Methods: Adults with CT-confirmed spontaneous ICH admitted from 1 May 2025 through February 2026 were followed to discharge or death. Admission oxygen saturation and hematoma location were recorded. The primary outcome was in-hospital mortality. A prespecified assessment trigger was not treated as an indication for surgery. Analyses used complete-case denominators and TRIPOD reporting principles.

Results: Of 173 patients, 41 died (23.7%). Admission SpO2 <90% occurred in 10 (5.8%), of whom 9 died. Mortality was 10/81 (12.3%) without intraventricular extension and 27/80 (33.8%) with extension ($p = .002$). Among 160 patients with a complete ICH Score, mortality was 4.1% (2/49) at score 0 and 15.2% (21/138) at score <3, versus 72.7% (16/22) at score ≥3 (odds ratio 14.86; 95% CI 5.21–42.33). Thirty-six patients (20.8%) met the assessment trigger and 4 (2.3%) underwent hematoma evacuation. No external ventricular drain was recorded.

Conclusion: Mortality tracked neurological severity, hemorrhage burden, hypoxemia, and complications. The difference between the assessment trigger and surgery is not evidence of unmet operative indications. The ICH Score discriminated mortality. The exploratory model requires external validation.

1. Introduction

Stroke is a leading cause of death and disability worldwide, and intracerebral hemorrhage (ICH) is its most fatal subtype [1–3]. Although less common than ischemic stroke, ICH contributes disproportionately to early death, particularly in low- and middle-income countries.[4,5] Prognosis depends on the level of consciousness, hematoma volume and location, intraventricular extension, oxygenation, and complications that develop in hospital [6–9].

Guidelines and prognostic scores were developed mainly in high-income settings [8–11]. Ethiopian studies have been largely descriptive.[12,13] Jimma University Medical Center (JUMC) is a tertiary hospital in southwestern Ethiopia that admits a substantial number of adults with spontaneous ICH. What is still uncertain locally is not whether a new prediction tool can be built from this cohort, but how mortality is distributed and how often patients who might need a neurosurgical opinion actually undergo an operation.

This prospective cohort had three aims: to describe in-hospital mortality and its clinical and radiological correlates; to test whether the established ICH Score,[8] reconstructed from its components, discriminates mortality in this cohort; and to describe, without inferring surgical benefit, the difference between a prespecified trigger for neurosurgical assessment and the operations that were performed. The study does not present a new nomogram, a locally validated prediction tool, or evidence that surgery improves survival.

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https://doi.org/10.1016/j.wnsx.2026.100639
Received 30 May 2026;
Available online 23 October 2026
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2. Materials and methods

2.1. Study design and setting

We conducted a prospective hospital-based cohort study of adults with acute spontaneous ICH admitted to JUMC from 1 May 2025 through February 2026. Patients were enrolled at admission and followed until discharge or death. JUMC provides medical and surgical services for Jimma and the surrounding region. The study was designed to estimate associations with in-hospital mortality and to describe neurosurgical assessment triggers and actual operations. It was not designed to develop a clinical prediction model for bedside use.

2.2. Study population and eligibility criteria

The source population comprised adults admitted to JUMC with acute stroke. The study population consisted of consecutive patients aged ≥18 years with spontaneous ICH confirmed by computed tomography (CT) during the study period. Patients were eligible if they had CT-confirmed spontaneous ICH with documented information on hematoma size, location, extension, and mass effect. Patients were excluded if the hemorrhage was secondary to trauma or surgery, associated with subarachnoid hemorrhage, lacked adequate CT documentation, or if the patient or legally authorized representative declined participation. Patients were enrolled consecutively until the predefined study sample was reached.

2.3. Participants

Consecutive adults aged ≥18 years with spontaneous ICH confirmed by computed tomography (CT) were eligible when hematoma size, location, extension, and mass effect were documented. Hemorrhage secondary to trauma or surgery, hemorrhage associated with subarachnoid hemorrhage, missing CT documentation, and declined consent were exclusions. Recruitment continued until the planned sample of 173 participants with an in-hospital outcome was reached.

2.4. Sample size and sampling

The original sample-size calculation used a single-population proportion formula (expected proportion 50%, 95% confidence level, 5% margin of error) with a finite-population correction and an allowance for non-response, giving a target of 173. That calculation was not an events-per-variable calculation for prediction-model development. With 41 deaths, a four-predictor exploratory model has about 10 events per variable, which is only marginally adequate under TRIPOD guidance.[14]

2.5. Data collection and variables

Data were collected prospectively with a structured instrument at admission and were updated until discharge or death. Sources were interview, examination, the medical record, laboratory and CT reports, treatment charts, and the hospital register. The primary outcome was in-hospital death during the index admission. Patients discharged alive, discharged against medical advice, or referred were classified as survivors for this endpoint ($n = 132$). Secondary descriptions were the neurosurgical assessment trigger, the operation performed, procedure type, and in-hospital complications.

2.6. Clinical and radiological assessment

Glasgow Coma Scale (GCS) score and peripheral oxygen saturation (SpO2) were recorded once, at admission, with the other vital signs. SpO2 <90% was defined from that single admission measurement. For description, GCS was categorized as 13–15, 9–12, and 3–8, so that a score of 8 is inside the lowest category rather than left unassigned. The subgroup with GCS <8 is also reported, because earlier text used that cut-point, but it is not used as a category that excludes GCS 8.

Hematoma volume was estimated with the ABC/2 method and categorized as <10 mL, 10 to <30 mL, and ≥30 mL. The high-level site recorded on CT (supratentorial, infratentorial, intraventricular, or other) was retained. In addition, the free-text CT location was classified, mutually exclusively and in this order, as cerebellar; brainstem (pontine or midbrain); primary intraventricular; both basal ganglia and thalamus; basal ganglia (including caudate, lentiform nucleus, and external capsule); thalamus; lobar (frontal, parietal, temporal, occipital, or insular); or unspecified. Cerebellar and brainstem hemorrhages were not combined in the location table.

2.7. ICH score

The ICH Score (GCS, age, hematoma volume, infratentorial origin, and intraventricular hemorrhage) was reconstructed from those components because the originally entered score did not match them. The score could be completed for 160 of 173 patients. The 13 patients without a score were excluded from every analysis that used the score (complete-case analysis). No imputation was used. The score was examined as an ordinal variable and as ≥3 versus <3.

2.8. Surgical eligibility and surgical intervention

A patient was classified as meeting a prespecified trigger for neurosurgical assessment, not as having an indication for surgery, if any of the following were recorded: (1) supratentorial hemorrhage with volume >20 mL and admission GCS 5–12; (2) infratentorial hemorrhage with hydrocephalus; (3) infratentorial hemorrhage with volume >15 mL; or (4) intraventricular hemorrhage with admission GCS <13. These rules estimate how often a neurosurgical opinion might be sought. They are not AHA/ASA or ESO indications, and they are not the inclusion criteria of recent surgical trials.

The four rules are also not clinically equivalent. Rules 1 and 3 concern possible hematoma evacuation, and even then location matters: selected cerebellar hemorrhages may warrant evacuation, whereas primary brainstem hemorrhage is not routinely evacuated. Rule 2 mixes cerebellar hydrocephalus, which may prompt evacuation or cerebrospinal-fluid diversion, with brainstem hemorrhage, which should not be treated as an indication for clot removal. Rule 4, intraventricular hemorrhage with impaired consciousness, is a reason to consider external ventricular drainage (EVD), not hematoma evacuation. The data did not allow a reliable split of all 36 patients into "evacuation" versus "CSF diversion," because hydrocephalus and the decision for EVD were not recorded as separate operative indications. The 36 patients are therefore reported only as a broad assessment-trigger group.

An operation was defined as craniotomy or minimally invasive hematoma evacuation documented on the treatment form. EVD, decompressive craniectomy, and the reason an operation was not offered were not separate fields. With four operations, no treatment effect was estimated.

2.9. Missing data

Missing values were handled by complete-case analysis for the variable in question. Denominators are stated wherever they are not 173. Intraventricular extension was available for 161 patients, volume category for 167, medical-treatment checklists for 160, and the ICH Score for 160. Admission SpO2 and GCS were available for all 173 patients. Percentages are exact counts divided by the stated denominator. The word "approximately" is not used for these proportions.

2.10. Data quality assurance

The data-collection instrument was developed from the study objectives and relevant literature and was pretested before the main study. Data collectors received training regarding participant recruitment, clinical assessment, completion of the data-collection instrument, and confidentiality. Completed forms were reviewed for completeness and consistency. Data were entered into a computerized database and checked for missing, inconsistent, or implausible values.

2.11. Statistical analysis

Data were entered using EpiData version 4.7 and analyzed using IBM SPSS Statistics version 25. Continuous variables were assessed for distribution and summarized using mean and standard deviation or median and interquartile range, as appropriate. Categorical variables were summarized using frequencies and percentages. Patients were classified according to their in-hospital outcome as survivors or non-survivors. Differences between groups were assessed using the χ^2 test or Fisher's exact test for categorical variables. For continuous variables, the independent-samples *t* test or Mann–Whitney *U* test was used according to the distribution of the data.

Binary logistic regression was used to examine factors associated with in-hospital mortality. Univariable associations were initially assessed, followed by multivariable logistic regression incorporating clinically relevant variables and variables meeting the prespecified criteria for multivariable analysis. Associations were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). Because the study included 41 deaths, the multivariable analysis was restricted to a parsimonious set of predictors to reduce the risk of model overfitting. A two-sided P value < 0.05 was considered statistically significant.

2.12. Assessment of prognostic performance and TRIPOD reporting

Data were entered in EpiData 4.7 and analyzed in IBM SPSS Statistics 25. Continuous variables are median (IQR). Groups were compared with the $\chi 2$ or Fisher exact test, or the Mann–Whitney *U* test. Binary logistic regression estimated odds ratios (ORs) and 95% confidence intervals (CIs). The exploratory multivariable model included GCS <8, ICH Score ≥3, SpO2 <90%, and any in-hospital complication. Because ICH Score ≥3 exists only for 160 patients, models that contain the score are restricted to those 160 patients. Univariable ORs for GCS <8, SpO2 <90%, and any complication use all 173 patients. The crude OR for ICH Score ≥3 is the exact cross-product ratio from Table 3, not a rounded or imputed figure.

Discrimination of the reconstructed ICH Score was summarized with the area under the receiver-operating-characteristic curve (AUC). The exploratory model was assessed in the same cohort, so apparent performance is optimistic. Internal validation used 2000 bootstrap resamples. There was no external validation. Reporting follows the TRIPOD statement[14]: design, eligibility, outcome, predictors, sample size, missing data, model building, discrimination, internal validation, and the absence of external validation are stated. The model is not offered for clinical use.

2.13. Ethical considerations

The Jimma University Institute of Health institutional review board approved the study (JUIH/IRB/402/2026). Written informed consent was obtained from participants or legal representatives. The study followed the Declaration of Helsinki.

3. Results

3.1. Cohorts and mortality

The analytic cohort was 173 patients with a documented in-hospital outcome. Forty-one patients died (23.7%) and 132 did not. Median age was 50 years (IQR 45–60). Men were 112/173 (64.7%). Vital signs and comorbidities are in Table 1.

GCS was recorded for all 173 patients: 96 (55.5%) scored 13–15, 53 (30.6%) scored 9–12, and 24 (13.9%) scored 3–8. Mortality in these categories was 6/96 (6.3%), 15/53 (28.3%), and 20/24 (83.3%). The lowest category includes 9 patients with GCS 8, of whom 7 died (7/9, 77.8%), and 15 patients with GCS <8, of whom 13 died (13/15, 86.7%). The earlier statement that compared GCS <8 with GCS ≥8 (mortality 28/158, 17.7%) remains arithmetically correct but hides the nine patients with GCS 8 inside the higher group. That comparison is not used as the descriptive categorization.

3.2. Radiological characteristics

On the high-level site variable, 153/173 hemorrhages (88.4%) were supratentorial, 11 (6.4%) infratentorial, 8 (4.6%) intraventricular, and 1 (0.6%) recorded only as right basal ganglia (Table 2). Intraventricular extension was known for 161 patients. Mortality was 27/80 (33.8%)

Table 1
Baseline sociodemographic and clinical characteristics according to in-hospital mortality.

Characteristic	Overall ($n = 173$)	Survivors ($n = 132$)	Non-survivors ($n = 41$)	*P* value
Age, median (IQR), years	50 (45–60)	50 (45–60)	55 (47–60)	.154
Sex, n (%)				1.000
Male	112 (64.7)	85 (64.4)	27 (65.9)	
Female	61 (35.3)	47 (35.6)	14 (34.1)	
Marital status, n (%)				.751
Married	129 (74.6)	99 (75.0)	30 (73.2)	
Widowed	24 (13.9)	18 (13.6)	6 (14.6)	
Divorced	12 (6.9)	8 (6.1)	4 (9.8)	
Single	8 (4.6)	7 (5.3)	1 (2.4)	
Educational status, n (%)				.786
No formal education	80 (46.2)	63 (47.7)	17 (41.5)	
Primary education	78 (45.1)	57 (43.2)	21 (51.2)	
Secondary education	14 (8.1)	11 (8.3)	3 (7.3)	
Higher education	1 (0.6)	1 (0.8)	0	
Any comorbidity, n (%)				.741
Yes	147 (85.0)	111 (84.1)	36 (87.8)	
No	26 (15.0)	21 (15.9)	5 (12.2)	
Systolic BP, median (IQR), mm Hg	171 (160–190)	171 (159–190)	180 (160–190)	.326
Diastolic BP, median (IQR), mm Hg	105 (90–120)	104 (90–120)	108 (95–115)	.512
Pulse rate, median (IQR), beats/min	87 (75–97)	85 (74–96)	94 (80–100)	.020
Respiratory rate, median (IQR), breaths/min	22 (22–25)	22 (22–24)	24 (22–28)	.002
Temperature, median (IQR), °C	36.6 (36.3–36.9)	36.5 (36.2–36.8)	36.9 (36.5–37.6)	<.001
SpO_2, median (IQR), %	95 (93–96)	95 (94–96)	92 (90–95)	<.001

Abbreviations: IQR, interquartile range; SpO_2, peripheral oxygen saturation.
Note: Continuous variables are presented as median (IQR) and categorical variables as number (percentage). *P* values for continuous variables were calculated using the Mann–Whitney *U* test; categorical variables were compared using the χ^2 test. The mortality groups comprise 132 survivors and 41 non-survivors.

Table 2a
Radiological characteristics of patients with spontaneous intracerebral hemorrhage according to in-hospital mortality.

Radiological characteristic	Overall, n (%)	Survivors, n (%)	Non-survivors, n (%)	*P* value
Site of hemorrhage	*n* = 173	*n* = 132	*n* = 41	.306
Supratentorial	153 (88.4)	118 (89.4)	35 (85.4)	
Infratentorial	11 (6.4)	9 (6.8)	2 (4.9)	
Intraventricular	8 (4.6)	4 (3.0)	4 (9.8)	
Other/recorded as right basal ganglia	1 (0.6)	1 (0.8)	0	
Intraventricular extension	*n* = 161	*n* = 124	*n* = 37	.002
Yes	80 (49.7)	53 (42.7)	27 (73.0)	
No	81 (50.3)	71 (57.3)	10 (27.0)	
Midline shift	*n* = 173	*n* = 132	*n* = 41	.005
Yes	63 (36.4)	40 (30.3)	23 (56.1)	
No	110 (63.6)	92 (69.7)	18 (43.9)	
Hematoma volume, median (IQR), mL	14 (5–25)	12 (5–20)	25.5 (8.5–42.75)	<.001
Hematoma volume category	*n* = 167	*n* = 129	*n* = 38	<.001
<10 mL	63 (37.7)	53 (41.1)	10 (26.3)	
10–<30 mL	70 (41.9)	60 (46.5)	10 (26.3)	
≥30 mL	34 (20.4)	16 (12.4)	18 (47.4)	

Abbreviations: IQR, interquartile range. **Note:** Data are presented as number (percentage) unless otherwise indicated. Percentages for each radiological variable are calculated using the number of patients with available data for that variable (denominators shown in the header of each section). Continuous variables are presented as median (IQR). *P* values were calculated using the χ^2 test (or Fisher's exact test where appropriate) for categorical variables and the Mann–Whitney *U* test for hematoma volume. The mortality groups comprise 132 survivors and 41 non-survivors.

when extension was present and 10/81 (12.3%) when it was absent ($p = .002$). The previous text reported 17.3% and $p = .007$ for the group without extension; those figures do not match Table 2 and have been removed. Midline shift was associated with death: 23/63 (36.5%) versus 18/110 (16.4%) ($p = .005$). Median volume was 25.5 mL (IQR 8.5–42.75) in patients who died and 12 mL (IQR 5–20) in survivors ($p < .001$).

Specific location, classified from the CT report as defined in the Methods, is shown in Table 2b and Fig. 1. Deep supratentorial hemorrhage (basal ganglia, thalamus, or both) accounted for 129/173 patients (74.6%). Lobar hemorrhage accounted for 22/173 (12.7%), of whom 4 had a volume of 30–80 mL. Cerebellar hemorrhage was present in 5/173 (2.9%) and brainstem hemorrhage in 11/173 (6.4%).

Table 2b
Mutually exclusive CT location and in-hospital mortality ($n = 173$).

Location	n (%)	Deaths, n/N (%)
Basal ganglia	79 (45.7)	14/79 (17.7)
Thalamus	34 (19.7)	9/34 (26.5)
Basal ganglia and thalamus	16 (9.2)	9/16 (56.3)
Lobar	22 (12.7)	2/22 (9.1)
Brainstem (pontine or midbrain)	11 (6.4)	3/11 (27.3)
Cerebellar	5 (2.9)	1/5 (20.0)
Primary intraventricular	5 (2.9)	3/5 (60.0)
Unspecified	1 (0.6)	0/1 (0)
Total	173 (100)	41/173 (23.7)

Note: Categories are mutually exclusive. A hemorrhage involving both the basal ganglia and the thalamus is listed once, in that row, and is not also counted as basal ganglia or thalamus. Primary intraventricular hemorrhage is not the same variable as intraventricular extension of a parenchymal hematoma (Table 2).

3.3. ICH score and mortality

Among the 160 patients with a complete reconstructed ICH Score, mortality was 2/49 (4.1%) at score 0, 8/53 (15.1%) at score 1, 11/36 (30.6%) at score 2, 12/18 (66.7%) at score 3, and 4/4 (100%) at score 4 ($p < .001$; Table 3). Mortality was 16/22 (72.7%) for a score ≥3 and 21/138 (15.2%) for a score <3. Thirteen patients could not be scored and are excluded here, not from the cohort.

3.4. Surgical burden and management

A medical-treatment checklist was completed for 160/173 patients. Among those 160, antihypertensive treatment was recorded in 151 (94.4%), mannitol in 58 (36.3%), and antibiotics in 45 (28.1%). The 13 patients without a checklist are not in the treatment percentages.

Thirty-six of 173 patients (20.8%) met at least one assessment trigger, and 137 (79.2%) did not. Four of 173 (2.3%) underwent hematoma evacuation: minimally invasive evacuation in 2 and craniotomy in 2. No EVD and no decompressive craniectomy were recorded. The reason an operation was not performed was not recorded for any patient, so non-operation cannot be classified as a contraindication, a delay, a lack of consent, or a lack of surgical capacity.

The four operations were not a random sample of the 36. Three were cerebellar evacuations and one was a midbrain hemorrhage treated by minimally invasive evacuation. None was a lobar evacuation and none was an isolated basal-ganglia evacuation. One cerebellar patient (volume 5 mL, GCS 9) did not meet the volume or hydrocephalus trigger but still underwent craniotomy. The other cerebellar operations (volumes 30 mL and 20 mL) met an infratentorial volume trigger. The midbrain case was coded "supratentorial" on the high-level site field and had a volume of 15 mL, so it did not meet the written supratentorial or infratentorial volume rules. We therefore cannot say that all four operated patients were inside the group of 36. We also cannot report a trustworthy mortality contrast of "trigger met and operated" versus "trigger met and not operated," because the patient-level flag for the 36 was not stored separately from the summary counts and the operative decisions were not recorded. Two of the four operated patients died. That 2/4 contrast is descriptive only and is confounded by indication (Table 4).

Fig. 2 demonstrates a substantial gap between potential surgical eligibility and actual surgical intervention. Of the 173 patients, 36 (20.8%) were classified as potentially eligible for surgical consideration according to the explicit a priori criteria, whereas only 4 (2.3%) actually underwent surgery.

3.5. In-hospital complications and associated factors

At least one in-hospital complication was recorded in 90/173 patients (52.0%). Mortality was 39/90 (43.3%) when a complication was recorded and 2/83 (2.4%) when it was not ($p < .001$). Complications included raised intracranial pressure or hydrocephalus, aspiration pneumonia, electrolyte disturbance, herniation, and brainstem compression. These events occur after admission. They are markers of deterioration, not baseline predictors.

On univariable analysis, GCS <8, ICH Score ≥3, admission SpO2 <90%, and any complication were associated with death (Table 5). The crude OR for ICH Score ≥3, calculated from Table 3 as (16/6)/(21/117) = 14.86 (95% CI 5.21–42.33), replaces the previously reported OR of 11.43. That earlier OR did not match Table 3 and used an implied denominator of 173. The score is available for 160 patients. In the exploratory multivariable model, GCS <8 (AOR 6.23; 95% CI 1.16–33.48; $p = .033$), SpO2 <90% (AOR 23.76; 95% CI 1.45–390.08; $p = .027$), and any complication (AOR 18.59; 95% CI 3.90–88.71; $p < .001$) remained associated with death. ICH Score ≥3 did not (AOR 2.94; 95% CI 0.89–9.64; $p = .076$). Because GCS is a component of the score, the adjusted ICH Score coefficient is not an independent effect

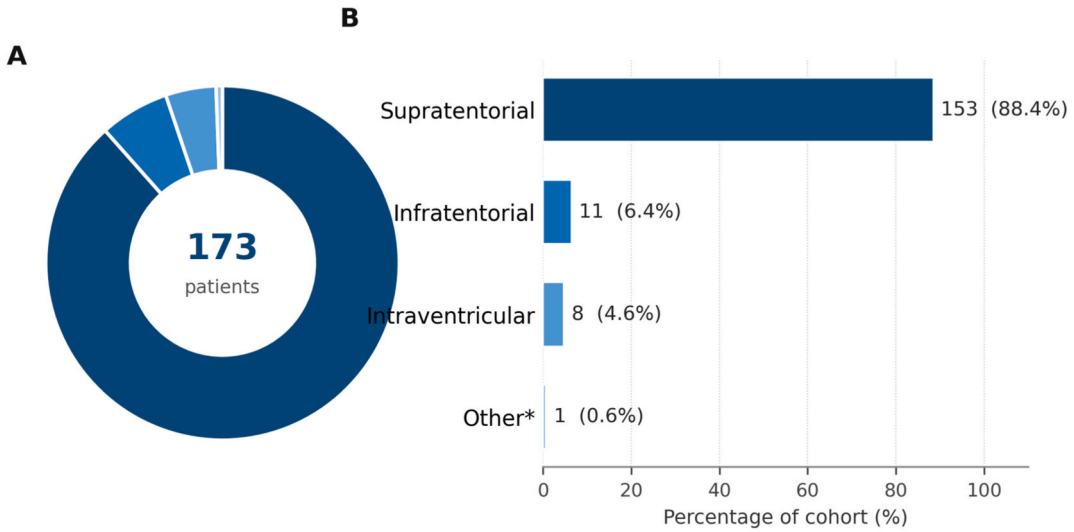


Fig. 1. Distribution of spontaneous intracerebral hemorrhage according to anatomical site ($n = 173$). **Panel A**. Donut chart of hemorrhage site. **Panel B**. Corresponding percentages with absolute counts. **Note**: Site classification is based on the admission computed tomography report. Percentages are calculated using the full analytic cohort ($n = 173$). *Other denotes a single case recorded as right basal ganglia without a higher-level site category in the source record.

Table 3
Reconstructed ICH Score and in-hospital mortality ($n = 160$).

ICH Score	Overall, n (%)	Survivors, n (%)	Deaths, n (%)	Mortality
0	49 (30.6)	47 (38.2)	2 (5.4)	2/49 (4.1%)
1	53 (33.1)	45 (36.6)	8 (21.6)	8/53 (15.1%)
2	36 (22.5)	25 (20.3)	11 (29.7)	11/36 (30.6%)
3	18 (11.3)	6 (4.9)	12 (32.4)	12/18 (66.7%)
4	4 (2.5)	0 (0)	4 (10.8)	4/4 (100%)
Total	160 (100)	123 (100)	37 (100)	37/160 (23.1%)
Score <3	138 (86.3)	117	21	21/138 (15.2%)
Score ≥3	22 (13.8)	6	16	16/22 (72.7%)

Note: $\chi 2$ test across scores 0–4, $p < .001$. Components required: GCS, age, volume, infratentorial location, and intraventricular hemorrhage. Score 0 mortality is 4.1% (2/49) in the abstract, here, and in the results text. The AUC of the score for in-hospital death was 0.80.

Table 4
Assessment trigger, operations, and length of stay.

Item	n/N (%)
Met ≥1 assessment trigger	36/173 (20.8)
Did not meet a trigger	137/173 (79.2)
Supratentorial >20 mL and GCS 5–12	25/173 (14.5)
Infratentorial with hydrocephalus	4/173 (2.3)
Infratentorial volume >15 mL	3/173 (1.7)
Intraventricular hemorrhage and GCS <13	4/173 (2.3)
Any hematoma evacuation	4/173 (2.3)
Minimally invasive evacuation	2/4
Craniotomy	2/4
EVD recorded	0
Decompressive craniectomy recorded	0
Reason for non-operation recorded	0
Hospital stay <7 days	73/173 (42.2)
Hospital stays 7–14 days	78/173 (45.1)
Hospital stay >14 days	22/173 (12.7)

Note: Trigger rows may overlap; the 36 is the union, not the sum of the four rows. The criteria estimate who might need a neurosurgical assessment. They do not identify patients who should have had clot evacuation.

(Table 5). The apparent AUC of the exploratory model was 0.88 and the bootstrap optimism-corrected AUC was 0.87. The calibration slope indicated residual optimism. These AUCs are not a basis for clinical prediction.

4. Discussion

In this prospective cohort of 173 adults with spontaneous ICH at JUMC, 41 patients died in hospital (23.7%). Death was more common with a lower admission GCS, larger hematoma volume, intraventricular extension, midline shift, admission SpO2 <90%, a higher reconstructed ICH Score, and complications recorded during the stay. These are associations. They do not identify a new prognostic tool and they do not show that surgery saves lives.

The numerical corrections in this revision matter because several results sentences did not match the tables. Mortality without intraventricular extension is 10/81 (12.3%), and the *P* value in Table 2 is .002. Mortality with an ICH Score <3 is 21/138 (15.2%), not 16.6%. Antihypertensive therapy, mannitol, and antibiotics were counted among 160 patients with a treatment record, not among all 173. The crude OR for ICH Score ≥3 is 14.86 from those 160 patients. Admission SpO2 was measured with the initial vital signs and was <90% in 10 patients, 9 of whom died.

Most hemorrhages were deep. Basal ganglia and/or thalamic hemorrhage accounted for 129/173 patients (74.6%), lobar hemorrhage for 22 (12.7%), brainstem hemorrhage for 11 (6.4%), and cerebellar hemorrhage for 5 (2.9%). This distribution is the relevant background for any statement about surgery. In ENRICH, early minimally invasive evacuation improved 180-day function when surgery was performed within 24 h, and the benefit was seen in lobar hemorrhage, not in anterior basal ganglia hemorrhage,16. Only 4 of our 22 lobar hemorrhages had a volume of 30–80 mL, the volume range cited for that trial, and none of our four operations was a lobar evacuation. In SWITCH, adding decompressive craniectomy to medical treatment for severe deep (basal ganglia or thalamic) hemorrhage did not significantly reduce death or severe disability at 180 days 17. We recorded no decompressive craniectomy. Applying either trial to the 36 assessment-trigger patients would overstate what this cohort can say: most of the supratentorial triggers were deep hemorrhages, for which those trials do not provide a mandate to operate, and we do not have time-from-onset to surgery.

Cerebellar and brainstem hemorrhages should not be pooled. Selected cerebellar hemorrhages with neurological deterioration, brainstem compression, or hydrocephalus may warrant evacuation. Direct evacuation of a primary brainstem hematoma is not routine care. Of the four operations, three were cerebellar and one was midbrain.

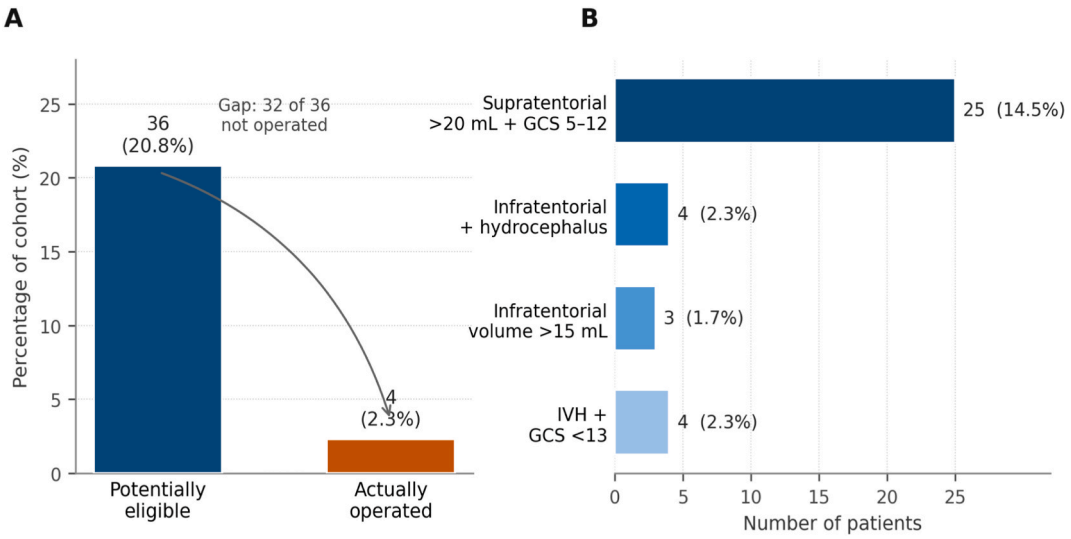


Fig. 2. Patients meeting a neurosurgical assessment trigger versus patients who underwent hematoma evacuation ($n = 173$). **Panel A.** Proportion of the cohort classified as potentially eligible for surgical consideration (36/173, 20.8%) versus the proportion who underwent surgery (4/173, 2.3%). **Panel B.** Distribution of a priori eligibility criteria. Criteria are not mutually exclusive. **Note:** Potential surgical eligibility was defined a priori as any of: (1) supratentorial hemorrhage volume >20 mL with GCS 5–12; (2) infratentorial hemorrhage with hydrocephalus; (3) infratentorial hemorrhage volume >15 mL; or (4) intraventricular hemorrhage with GCS <13. These operational criteria estimate potential surgical burden and are not equivalent to definitive guideline-based indications for surgery. With only 4 operated patients, the figure describes an access/utilization gap and does not estimate a treatment effect.

Table 5
Logistic regression for in-hospital death.

Predictor	Deaths/exposed	Crude OR (95% CI)	P	AOR (95% CI)	P
GCS <8	13/15 vs 28/158	30.18 (6.45–141.29)	<.001	6.23 (1.16–33.48)	.033
ICH Score ≥3	16/22 vs 21/138	14.86 (5.21–42.33)	<.001	2.94 (0.89–9.64)	.076
Admission SpO2 <90%	9/10 vs 32/163	36.84 (4.50–301.43)	<.001	23.76 (1.45–390.08)	.027
Any complication	39/90 vs 2/83	30.97 (7.17–133.84)	<.001	18.59 (3.90–88.71)	<.001

Note: Crude OR for ICH Score ≥3 is the exact odds ratio from the 160. Crude ORs for the other three rows use $n = 173$. The multivariable model that includes the ICH Score is a complete-case model (patients without a score are excluded). Wide intervals reflect few exposed deaths, especially for SpO2 <90% (9 deaths among 10 patients). Complications are in-hospital events, not baseline covariates. OR >1 means higher odds of death.

That pattern is consistent with cerebellar evacuation being the operation actually performed, but the numbers are too small for inference. Intraventricular hemorrhage with a reduced conscious level is a reason to consider EVD rather than to remove the parenchymal clot. No EVD was coded. We therefore cannot describe the 36 patients as people who needed an operation they did not receive.

Reviewers asked whether the four operated patients sat inside the 36. The operative notes and the written thresholds do not support a simple "yes." One cerebellar patient who had a craniotomy had a 5 mL hematoma and did not meet the volume or hydrocephalus rule. The midbrain case was not coded as infratentorial on the site field and had a volume of 15 mL. Reasons for operating or not operating were not collected. Without those decisions, the contrast between 36 and 4 is not evidence of unmet indications, of inadequate access, or of a survival benefit. It is evidence only that a broad protocol trigger and a rarely used operation do not count the same patients.

The reconstructed ICH Score still showed a graded rise in mortality, from 4.1% at score 0 to 100% at score 4, with an AUC of 0.80. That is a local description of an existing score, not validation of a new model. Putting GCS and the ICH Score in one regression double-counts the conscious level, which is why the adjusted score coefficient is difficult to interpret and was not significant. Admission hypoxemia was uncommon (10 patients) but closely associated with death; the confidence interval is very wide and should not be used to set an oxygen target. Complications were the strongest adjusted association and, as previously stated, are not baseline risk factors.

Implications for JUMC are limited to what the data support. Admission GCS, a complete CT report that names basal ganglia, thalamus, lobar, cerebellar, and brainstem locations separately, and a single SpO2 identify patients at high risk of dying in hospital. A pathway for neurosurgical consultation is reasonable for cerebellar hemorrhage with mass effect or hydrocephalus and for suspected hydrocephalus that might need an EVD. This study does not show that expanding hematoma evacuation would reduce mortality. The exploratory regression must be tested in another cohort before anyone uses it clinically.

4.1. *Strengths and limitations*

Strengths are the prospective design, CT confirmation, reconstruction of the ICH Score from its components, complete-case denominators, and separation of baseline findings from in-hospital complications. Limitations are the single center, 41 deaths, only four operations, no recorded reason for non-operation, no coded EVD, no functional outcome such as the modified Rankin Scale, and no external validation. The assessment trigger remains a broad screen. Earlier submission files that called a nomogram bedside-ready or locally validated do not represent this revision.

5. Conclusion

In-hospital mortality after spontaneous ICH at JUMC was 23.7% and was associated with a lower admission GCS, greater hemorrhage burden, admission SpO2 <90%, a higher ICH Score, and in-hospital complications. The ICH Score discriminated mortality in the 160 patients who

could be scored. Thirty-six patients met a broad trigger for neurosurgical assessment and four underwent hematoma evacuation, but this difference is not evidence of unmet operative indications or of benefit from surgery. Cerebellar hemorrhage, brainstem hemorrhage, and intraventricular hemorrhage with impaired consciousness do not share one surgical indication. The exploratory model needs external validation and is not for clinical use.

CRediT authorship contribution statement

Elsah Tegene Asefa: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Funding acquisition, Data curation, Conceptualization. **Gidey Berihu Gebru:** Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Alefe Aklewok Tadesse:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Alemayehu Abebe Guji:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Amare Hailu Ashine:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation. **Asaye Wubetu Tsedal:** Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Kedir Negesso Tukeni:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Informed consent

Written informed consent was obtained from all study participants or their legally authorized representatives.

Data availability statement

All data underlying the findings of this study are fully available within the manuscript itself. The tables, figures, and descriptive statistics presented in the article contain the complete dataset used for the analysis.

Consent for publication

Not applicable.

Note

The authors used an AI language tool (Microsoft Copilot) solely to improve clarity and grammar of the text. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Clinical trial registration

Not applicable.

Funding

The author(s) received no specific funding for this work.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript. Organizations that authors work in had no involvement in the design, conduct, analysis, or reporting of this study. The research was conducted independently, with no external funding or institutional influence.

Acknowledgments

The authors gratefully acknowledge the Jimma Institute of Health, Jimma University, for granting permission to conduct this study. The institution had no involvement in the study design, data collection, data analysis, interpretation of findings, or manuscript preparation. The authors also extend their sincere appreciation to all study participants for their valuable cooperation and willingness to participate, and to the data collectors and supervisors for their dedicated efforts and contributions to the successful completion of the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.wnsx.2026.100639.

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List of Abbreviations

AOR –: Adjusted Odds Ratio
CI –: Confidence Interval
CT –: Computed Tomography
GCS –: Glasgow Coma Scale
HR –: Hazard Ratio
ICH –: Intracerebral Hemorrhage
ICP –: Intracranial Pressure

IQR –: Interquartile Range
JUMC –: Jimma University Medical Center
KPI –: Key Performance Indicator
mRS –: Modified Rankin Scale
ROC –: Receiver Operating Characteristic
SD –: Standard Deviation
SPSS –: Statistical Package for the Social Sciences
AUC –: Area Under the Curve