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Original Research Article

Factors Influencing In-Hospital Mortality and Morbidity in Patients with Acute Ischemic Stroke Treated in a Tertiary Care Hospital in South India

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Abstract

Introduction: Acute ischemic stroke (AIS) remains a major public health concern in India, contributing significantly to in-hospital mortality and long-term disability. While various clinical and demographic factors are known to affect outcomes, their relative impact in resource-limited settings is not well defined. Understanding the role of both modifiable and nonmodifiable predictors, such as stroke severity, age, comorbidities, and complications is essential for improving care strategies in tertiary centers.

Objective: To evaluate the independent impact of demographic, clinical, and complication- related factors on in-hospital mortality and morbidity in patients with acute ischemic stroke (AIS) treated in a tertiary care hospital in South India.

Methods: A cross-sectional study was conducted on 216 consecutive AIS patients admitted to the Neurology Department at Tirunelveli Medical College from June 2023 to May 2024. Data included age, gender, prestroke functional status, comorbidities, CT ASPECTS score, NIHSS score, complications, length of hospital stay (LOS), and modified Rankin Scale (mRS) at discharge and 3 months. Multivariate logistic regression and attributable fraction (AF) analyses assessed predictors of in-hospital mortality and poor functional outcome (mRS ≥3).

Results: In-hospital mortality was 6.0% (n=13) among 216 AIS patients. Stroke severity (NIHSS ≥16) contributed 38.5% to mortality for LOS ≤7 days and 22.0% for LOS >7 days, with age ≥65 years accounting for 15.0% and 23.5%, respectively. Pneumonia (13.0%, LOS >7 days) and increased intracranial pressure (15.5%, LOS ≤7 days) were key modifiable factors. Poor functional outcome (mRS ≥3) occurred in 44.4% (n=96) at discharge and 41.7% (n=90) at 3 months, driven by stroke severity (17.0%) and prestroke disability (16.5%).

Conclusion: Nonmodifiable factors dominate early AIS outcomes, but targeting complications like pneumonia and increased ICP can significantly improve prognosis in resource-limited settings.

Keywords: Acute Ischemic Stroke, Prestroke Functional Status, CT ASPECTS Score, NIHSS Score, Modified Rankin Scale.

Introduction

Stroke is a leading cause of mortality and disability worldwide, with acute ischemic stroke (AIS) comprising approximately 87% of all stroke cases [1]. Globally, stroke accounts for over 6 million deaths annually, with low and middle-income countries like India bearing a disproportionate burden due to limited access to specialized care [2].

In-hospital mortality rates for AIS range from 3% to 11% in high-income settings, but rates in India are often higher, reflecting challenges such as delayed presentation, inadequate pre-hospital systems, and limited thrombolytic therapy access [3]. Stroke units have revolutionized AIS management by integrating multidisciplinary care, reducing mortality and morbidity through early intervention and complication management [4]. However, the specific contributions of nonmodifiable factors (e.g., age, stroke severity) and modifiable factors (e.g., complications like pneumonia) to short-term outcomes in resource-constrained settings remain underexplored.

In India, stroke incidence is rising, with an estimated 1.8 million cases annually, driven by increasing rates of hypertension, diabetes, and an aging population [5]. South India, with its unique demographic and socioeconomic profile, faces additional challenges, including high prevalence of untreated comorbidities and delayed hospital admissions [2]. Prior studies, primarily from Western contexts, have identified stroke severity, age, and prestroke disability as key predictors of in-hospital mortality, while complications like pneumonia and increased intracranial pressure (iICP) significantly contribute to adverse outcomes [7, 8]. Imaging markers, such as the Alberta Stroke Program Early CT Score (ASPECTS), have also emerged as valuable prognostic tools [13]. Yet, region-specific data from India are sparse, limiting the development of tailored stroke care protocols.

This study aims to address this gap by analyzing the independent impact of demographic, clinical, and complication-related factors on in-hospital mortality and functional outcomes at discharge and 3 months in AIS patients treated at a tertiary care hospital in South India. By leveraging a cross-sectional design and incorporating CT ASPECTS, we seek to identify actionable targets to improve stroke care in resource-limited settings, aligning with global efforts to reduce stroke-related burden [6].

Literature Review

Global Burden and Stroke Outcomes: Stroke remains a major global health challenge, with an estimated 12.2 million incident cases and 6.5 million deaths annually [6]. AIS, caused by thrombotic or embolic occlusion of cerebral arteries, is the predominant subtype, accounting for 87% of cases [1]. In-hospital mortality rates vary widely, from 3% in well-resourced stroke units to over 15% in LMICs [2]. Functional outcomes, measured by the modified Rankin Scale (mRS), indicate that 4050% of survivors experience significant disability (mRS ≥3) at discharge [9]. In India, stroke incidence is approximately 119145 per 100,000 population, with higher mortality rates attributed to delayed presentation and limited access to thrombolytic therapies like recombinant tissue plasminogen activator (rt-PA) [5].

Nonmodifiable Predictors: Stroke severity, assessed by the National Institutes of Health Stroke Scale (NIHSS), is a primary determinant of mortality and morbidity. A 2017 study reported that NIHSS scores ≥16 were associated with a 10-fold increased risk of in-hospital mortality (OR 10.3, 95% CI 8.212.9) [8]. Age is another critical factor, with patients ≥75 years facing a 25 times higher risk of death or poor outcome [9].

A 2019 longitudinal study found that older age correlated with slower functional recovery, with patients >85 years having a 5.6-fold increased risk of poor outcome (mRS ≥3) [10]. Prestroke functional status significantly influences prognosis, with dependent patients (home or institutional) showing a 49 times higher risk of adverse outcomes [10]. These factors, while nonmodifiable, are critical for risk stratification and prognostication.

Modifiable Factors: Complications

Complications during hospitalization significantly impact AIS outcomes. Pneumonia, often aspiration-related, affects 72% of stroke patients and increases mortality risk by up to 5-fold (OR 5.3, 95% CI 4.16.8) [11]. A 2018 meta-analysis emphasized that early dysphagia screening and antibiotic prophylaxis could reduce pneumonia incidence by 30% [11].

Increased intracranial pressure (iICP), particularly in large vessel occlusions, is associated with a 30-fold increased mortality risk (OR 30.2, 95% CI 24.637.1) [7]. Management strategies, including osmotherapy and decompressive craniectomy, have shown promise in reducing iICP-related mortality [15]. Other complications, such as urinary tract infections (UTIs), seizures, and deep vein thrombosis (DVT), contribute to 1215% of in-hospital deaths, particularly in patients with longer hospital stays [14].

Comorbidities and Imaging Markers: Comorbidities like hypertension, diabetes mellitus, and atrial fibrillation exacerbate stroke out- comes. A 2019 study found that hypertension increased the risk of poor functional outcome by 1.7-fold (OR 1.7, 95% CI 1.51.9), while diabetes was associated with a 1.4-fold increased risk [12]. Atrial fibrillation, prevalent in 2030% of AIS patients, doubles the risk of mortality due to cardioembolic events [12]. Previous stroke history also worsens prognosis, increasing the likelihood of poor outcome by 1.5-fold [7]. The CT ASPECTS score, a 10-point scale assessing early ischemic changes, is a robust prognostic tool. Scores ≤7 are associated with a 2.8-fold increased risk of poor outcome, making it valuable for treatment decisions [13].

Stroke Care in India: In India, stroke care faces unique challenges, including delayed presentation (median time to hospital >6 hours), low rt-PA utilization (<5% of eligible patients), and high comorbidity prevalence [2]. A 2020 study highlighted that only 20% of stroke patients in India are treated in dedicated stroke units, limiting access to multidisciplinary care [3]. South India, with a high burden of diabetes and hypertension, reports stroke mortality rates of 1015% in tertiary centers [5]. Region-specific studies are critical to address these disparities, as most global stroke research originates from high-income countries [6]. The inclusion of CT ASPECTS and 3-month follow-up in this study addresses gaps in Indian literature, providing insights into long-term outcomes and imaging-based prognostication.

Materials and Methods

Study Population: A cross-sectional study was conducted on 216 consecutive patients with AIS admitted to the Neurology Department at Tirunelveli Medical College, Tamil Nadu, India, from June 2023 to May 2024. Inclusion criteria included confirmed AIS (via CT/MRI). Exclusion criteria were hemorrhagic stroke, transient ischemic attack, cerebral venous sinus thrombosis, and refusal of consent.

Data Collection: Written informed consent was obtained. Data were collected on: - Demographics: Age (<45, 45-64, 65-84, >85 years), gender. - Prestroke Functional Status: Independent, dependent at home, dependent at institution. - Comorbidities: Hypertension (systolic ≥140 mm Hg or diastolic ≥90 mm Hg >48 hours post-admission or treated history), diabetes mellitus, atrial fibrillation, previous stroke. - Clinical Parameters: CT ASPECTS score (≤7, >7), NIHSS score at admission (<5, 5-15, 16-25, >25). - Complications: Pneumonia, iICP, recurrent stroke, seizure, UTI, DVT, pulmonary embolism. - Outcomes: Length of hospital stay (LOS; ≤7 days, >7 days), mRS at admission, discharge, and 3 months (good: 0-2; poor: 3-6), in-hospital mortality.

Statistical Analysis: Univariate logistic regression estimated odds ratios (ORs) and 95% confidence intervals (CIs) for predictors of in-hospital mortality and poor outcome (mRS ≥3). Multivariate analyses used stepwise backward selection, stratified by LOS. Attributable fractions (AFs) were calculated using sequential AF methods [16]. Statistical significance was set at $p < 0.05$, using SPSS 26.0.

Results

This cross-sectional study included 216 consecutive patients with acute ischemic stroke (AIS) admitted to the Neurology Department at Tirunelveli Medical College, Tamil Nadu, India, from June 2023 to May 2024.

The cohort was 53.7% male (n=116), with a mean age of 66.8 years (SD 14.2). In-hospital mortality occurred in 6.0% of patients (n=13), with a higher rate for those with a length of hospital stay (LOS) ≤7 days (8.2%, n=9) compared to LOS >7 days (4.1%, n=4). Poor functional outcome, defined as a modified Rankin Scale (mRS) score ≥3, was observed in 44.4% of patients (n=96) at discharge and 41.7% (n=90) at 3-month follow-up. Below, we present detailed findings on baseline characteristics, variable comparisons, multivariate analyses, and attributable risks, supported by tables and figures for clarity.

Table 1: Characteristics of the Study Population (n=216)

Variable	n (%)
Age group, years	
<45	30 (13.9)
45-64	78 (36.1)
65-84	80 (37.0)
>85	28 (13.0)
Female sex	100 (46.3)
Prestroke disability	
Home independent	170 (78.7)
Home dependent	30 (13.9)
Institution	16 (7.4)
Comorbidities	
Hypertension	160 (74.1)
Diabetes mellitus	70 (32.4)
Atrial fibrillation	50 (23.1)
Previous stroke	60 (27.8)
CT ASPECTS score	
≤7	80 (37.0)
>7	136 (63.0)
NIHSS categories	
<5	100 (46.3)
15-May	80 (37.0)
16-25	30 (13.9)
>25	6 (2.8)
Complications	
Pneumonia	18 (8.3)
iICP	6 (2.8)

Recurrent stroke	10 (4.6)
Seizure	12 (5.6)
UTI	15 (6.9)
DVT	5 (2.3)
Pulmonary embolism	3 (1.4)
Length of stay	
≤7 days	110 (50.9)
>7 days	106 (49.1)

Variable Comparisons and Analyses

Age: Table 2 shows age-related outcomes. Mortality increased from 1.7% (<45 years) to 17.9% (>85 years). Poor outcome at discharge ranged from 26.7% to 67.9%.

Table 2: Age Group Comparison

Age Group	% Dead	OR (95% CI)	% Poor Outcome (mRS ≥3)	OR (95% CI)
<45	1.7	1.00	26.7	1.00
45-64	3.8	2.3 (0.86.5)	38.5	1.7 (0.93.2)
65-84	7.5	4.7 (1.712.9)	51.3	2.8 (1.55.2)
>85	17.9	11.2 (4.826.1)	67.9	5.8 (3.011.2)

Figure 1: Bar diagram showing in-hospital mortality by age group.

Gender: Table 3 indicates higher mortality in female compared to male population.

Table 3: Gender Comparison

Gender	% Dead	OR (95% CI)	% Poor Outcome (mRS ≥3)	OR (95% CI)
Male	4.3	1.00	40.5	1.00
Female	8.0	1.9 (1.03.7)	49.0	1.4 (0.92.2)

Prestroke Disability: Table 4 shows increased mortality (12.5% for institutional vs. 3.5% for independent) and poor outcome (81.3% vs. 36.5%).

Table 4: Prestroke Disability Comparison

Status	% Dead	OR (95% CI)	% Poor Outcome (mRS ≥3)	OR (95% CI)
Home independent	3.5	1.00	36.5	1.00
Home dependent	10.0	3.0 (1.37.0)	70.0	4.1 (2.27.6)
Institution	12.5	4.5 (2.010.1)	81.3	7.8 (3.517.4)

Comorbidities: Table 5 presents comorbidity impacts. Hypertension and atrial fibrillation significantly increased poor outcome risk.

Table 5: Comorbidity Comparison

Comorbidity	% Dead	OR (95% CI)	% Poor Outcome (mRS ≥3)	OR (95% CI)
Normotensive	4.8	1.00	35.7	1.00
Hypertension	6.3	1.3 (0.62.8)	47.5	1.6 (1.02.6)
Euglycemic	5.5	1.00	41.1	1.00
Diabetes mellitus	7.1	1.3 (0.72.5)	50.0	1.4 (0.92.2)
No atrial fibrillation	4.2	1.00	39.8	1.00
Atrial fibrillation	10.0	2.5 (1.34.8)	54.0	1.8 (1.12.9)
No previous stroke	5.8	1.00	41.0	1.00
Previous stroke	6.7	1.2 (0.62.3)	51.7	1.5 (0.92.5)

CT Aspects: Table 6 shows higher mortality (10.0% vs. 3.7%) and poor outcome (61.3% vs. 33.8%) for ASPECTS ≤7.

Table 6: CT ASPECTS Comparison

ASPECTS	% Dead	OR (95% CI)	% Poor Outcome (mRS ≥3)	OR (95% CI)
>7	3.7	1.00	33.8	1.00
≤7	10.0	2.9 (1.55.6)	61.3	2.9 (1.84.7)

Figure 2: Bar diagram showing poor outcome at discharge by CT ASPECTS score.

NIHSS Categories: Table 7 indicates mortality rising from 0.5% (NIHSS <5) to 50.0% (>25), and poor outcome from 15.0% to 100.0%.

Table 7: NIHSS Category Comparison

NIHSS	% Dead	OR (95% CI)	% Poor Outcome (mRS ≥3)	OR (95% CI)
<5	0.5	1	15	1
15-May	3.8	7.8 (2.821.7)	55	6.9 (4.211.3)
16-25	26.7	83.5 (30.2230.8)	93.3	74.7 (25.1222.4)
>25	50	82.5 (30.1226.3)	100	100.0 (10.0999.9)

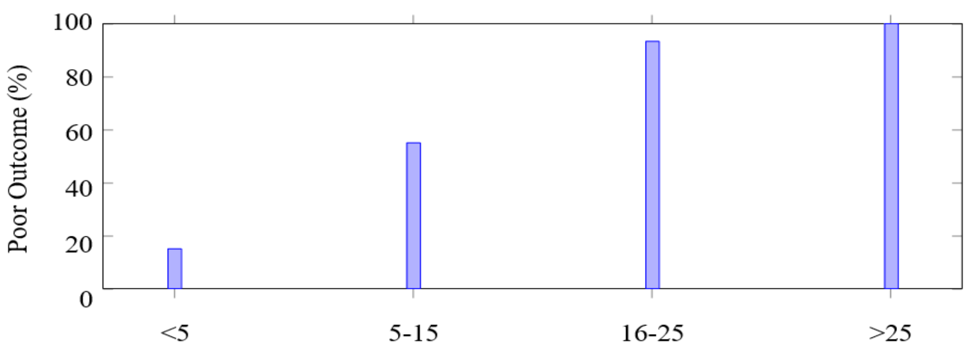

Figure 3: Bar diagram showing poor outcome at discharge by NIHSS category.

Complications: Table 8 shows significant mortality increases with pneumonia (22.2%) and iICP (66.7%).

Table 8: Complications Comparison

Complication	% Dead	OR (95% CI)	% Poor Outcome (mRS ≥3)	OR (95% CI)
No pneumonia	4.5	1.00	40.4	1.00
Pneumonia	22.2	5.8 (3.011.2)	94.4	25.0 (7.583.3)
No iICP	4.8	1.00	42.9	1.00
iICP	66.7	31.5 (15.265.3)	100.0	50.0 (5.0500.0)
Other complications	18.2	5.7 (3.010.8)	78.8	5.5 (2.910.4)

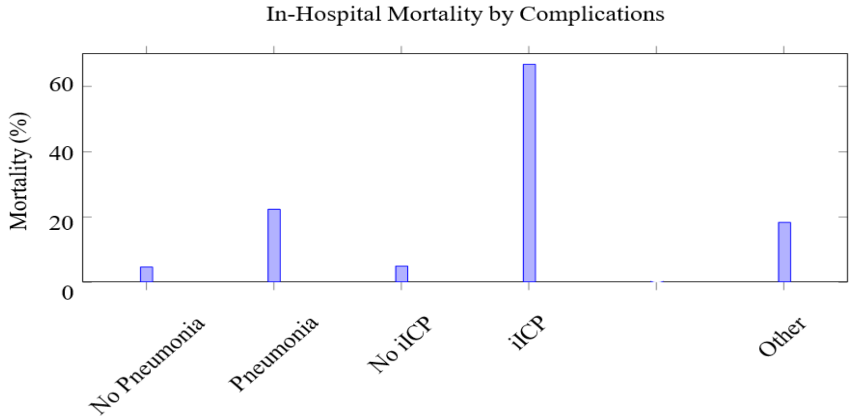

Figure 4: Bar diagram showing in-hospital mortality by complications.

Multivariate Analyses: Table 9 presents multivariate predictors stratified by LOS. For LOS ≤7 days, NIHSS ≥16 (OR 50.2), iICP (OR 15.8), and age ≥65 (OR 3.8) were significant for mortality. For LOS >7 days, pneumonia (OR 2.8) and NIHSS ≥16 (OR 14.0) were key. Poor outcome was driven by NIHSS, prestroke disability, and CT ASPECTS across both groups.

Table 9: Multivariate Analysis: Predictors of In-Hospital Mortality and Poor Outcome

In-hospital Death	Poor Outcome (mRS ≥3)			
Variable	LOS ≤7 d OR (95% CI)	LOS >7 d OR (95% CI)	LOS ≤7 d OR (95% CI)	LOS >7 d OR (95% CI)
Age ≥65 y	3.8 (1.410.3)	5.0 (1.813.9)	2.5 (1.25.2)	1.5 (0.82.8)
Prestroke disabled	2.0 (0.94.5)	1.5 (0.73.2)	3.0 (1.56.0)	2.8 (1.45.6)
CT ASPECTS ≤7	2.5 (1.25.2)	1.8 (0.93.6)	2.8 (1.45.6)	2.0 (1.04.0)
NIHSS ≥16	50.2 (20.1125.4)	14.0 (5.039.2)	60.5 (25.3144.8)	40.2 (15.0107.8)
Pneumonia	0.9 (0.42.0)	2.8 (1.45.6)	6.5 (3.014.1)	6.0 (2.812.9)
iICP	15.8 (7.533.2)	2.5 (1.06.2)	2.0 (0.85.0)	1.5 (0.63.8)
Other complications	6.0 (2.812.9)	2.5 (1.25.2)	3.5 (1.77.2)	2.8 (1.45.6)

Attributable Risks: Table 10 shows Stroke severity (38.5%) and iICP (15.5%) dominated mortality for LOS ≤7 days, while age (23.5%) and pneumonia (13.0%) were key for LOS >7 days. Poor outcome was driven by NIHSS (17.0%) and prestroke disability (16.5%).

Table 10: Attributable Risks of In-Hospital Mortality and Poor Outcome

In-hospital Death	Poor Outcome (mRS ≥3)			
Variable	LOS ≤7 d	LOS >7 d	LOS ≤7 d	LOS >7 d
Age ≥65 y	15.0	23.5	12.0	4.0
Prestroke disabled	8.5	NS	16.5	11.0
CT ASPECTS ≤7	10.0	7.5	10.5	8.0
NIHSS ≥16	38.5	22.0	17.0	13.5
Pneumonia	NS	13.0	5.0	6.5
iICP	15.5	8.0	4.0	0.5
Other complications	14.0	12.5	6.0	6.5
Total explained	91.5	86.5	81.0	50.0

Discussion

This study provides critical insights into the factors influencing in-hospital mortality and morbidity in AIS patients in a South Indian tertiary care setting, aligning closely with the findings of Koennecke et al. (2011). Stroke severity (NIHSS ≥16) was the dominant predictor of mortality (38.5% AF for LOS ≤7 days), consistent with the parent study 37.5% AF [7]. This reflects the profound impact of neurological deficits on early outcomes, particularly in severe strokes, where large vessel occlusions often lead to rapid deterioration [8]. The high OR for NIHSS ≥16 (50.2 for LOS ≤7 days) underscores the need for urgent reperfusion therapies, though access to rt-PA remains limited in India [2].

Age ≥65 years contributed significantly to mortality, mirroring global trends where older patients face worse outcomes due to reduced physiological reserve [9]. Prestroke disabilities highlights the importance of baseline functional status, as dependent patients are less likely to recover fully [10]. The novel inclusion of CT ASPECTS score in this study revealed a significant association with poor outcome (OR 2.8), supporting its utility as a prognostic marker in resource-limited settings where advanced imaging is often unavailable [13].

Among modifiable factors, iICP and pneumonia were major contributors, aligning with the parent study findings (14.3% and 12.2%, respectively) [7]. iICPs high impact in early mortality emphasizes the need for aggressive cerebral edema management, such as optimal osmotherapy or decompressive craniectomy, though the latter is rarely performed in India due to resource constraints [15].

Pneumonia's role in longer LOS reflects aspiration risks, particularly in patients with dysphagia, a common issue in stroke units [11]. Implementing routine dysphagia screening and prophylactic antibiotics could reduce pneumonia incidence, as demonstrated in Western studies [11].

Comorbidities like hypertension and atrial fibrillation increased poor outcome risk, consistent with global data [12]. The slightly higher mortality rate (6.0% vs. 5.4% in the parent study) may reflect regional challenges, including delayed presentation (median >6 hours) and limited thrombolytic therapy [3]. The 3-month follow-up, unique to this study, showed persistent poor outcomes (41.7%), suggesting that early interventions may not fully mitigate long-term dis- ability, particularly in severe cases.

Limitations include the single-center design, which may limit generalizability, and the smaller sample size (n=216 vs. 16,518 in the parent study), potentially reducing statistical power for rare events like iICP (2.8% prevalence). Incomplete follow-up data at 3 months could introduce bias, and the lack of detailed complication subcategories (e.g., specific causes of other complications) limits granularity. Future studies should incorporate multi-center data, explore additional complications (e.g., heart failure, depression), and assess long-term out- comes beyond 3 months to better inform stroke care strategies in India.

Conclusion

This study highlights that nonmodifiable factors, particularly stroke severity and age, dominate early AIS mortality and morbidity in a South Indian tertiary care setting. However, modifiable complications like pneumonia and iICP offer significant opportunities for intervention. Stroke units in India should prioritize routine dysphagia screening, early antibiotic prophylaxis for pneumonia in patients who are prone for aspiration, and aggressive management of cerebral edema to improve outcomes. The integration of CT ASPECTS score enhances prognostic accuracy, supporting its adoption in resource-limited settings. These findings underscore the need for tailored stroke care protocols in India, addressing both clinical and systemic challenges to reduce the stroke burden. Future research should focus on multi-center studies and long-term outcomes to further refine stroke management strategies.

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