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Factors Contributing to Prolonged Length of Stay in Patients with Acute Stroke

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ABSTRACT

Background & Objective: Extended hospital stays are associated with increased morbidity and substantial healthcare expenses. This study investigates factors contributing to prolonged hospitalization in patients with cerebrovascular accidents (CVAs).

Materials & Methods: This retrospective cross-sectional study analyzed the medical records of CVA patients hospitalized over a two-year period (2014-2015). A total of 190 patients were included using systematic random sampling, and their demographic, clinical, and paraclinical data were recorded. A prolonged length of stay (LOS) was defined as an in-hospital stay of 12 days or longer.

Results: Among 190 included patients with acute stroke, 146 (76.8%) were male, the median age was 72.56 ± 9.55 years, and 80 (42.1%) had a prolonged LOS. Univariate Poisson regression analysis showed a significant association between infection and prolonged LOS with a p-value of 0.010. Meanwhile, the use of ventilators demonstrated borderline significance with a p-value of 0.065. In the multiple Poisson regression analysis, only infection was significantly associated with prolonged LOS (p-value = 0.014).

Conclusion: The results indicated that infection was associated with prolonged LOS. This factor should be considered an independent predictor of hospital stay duration in patients with stroke.

Keywords: Stroke, Cerebrovascular Accident, Length of Stay, Hospitalization, Hospital Stay

1. Introduction

Cerebrovascular accident (CVA) ranks as the second most prevalent cause of death and the third leading cause of disability worldwide (1). According to the World Health Organization, there are an estimated 15 million stroke patients worldwide each year. Of these, 5 million dies, while an additional 5 million are permanently disabled (2). In 2020, cerebrovascular diseases claimed 7.08 million lives globally, with 3.48 million deaths from ischemic stroke, 3.25 million from intracerebral hemorrhage (ICH), and 0.35 million from subarachnoid hemorrhage (3). Asia, which is home to more than 60% of the world's population, has the highest stroke incidence rate (4). CVA imposes significant health and economic burdens on patients, their families, and the healthcare system (1, 5), contributing to approximately 34% of global healthcare expenditures (4).

Length of stay (LOS) refers to the period during which patients spend in the hospital, from admission to discharge. LOS plays a pivotal role in determining hospitalization costs in stroke patients (5, 6). The overall cost of stroke-related hospitalization is significantly influenced by the stroke type, diagnosis, and comorbidities (7). Considering the substantial costs and waste of resources associated with prolonged hospital stays, healthcare policies have recently focused on trends in extended hospitalization (8, 9) and in a study by Pellico-López et al (10), prolonged hospital stays accounted for 15.8% of total hospitalization costs. Similarly, a study in Taiwan found that although only 10.4% of stroke patients had an LOS exceeding 23 days, they were responsible for 38.9% of total hospitalization days and 48.7% of inpatient healthcare expenditures (11). Identifying the determinants of LOS can provide valuable insights into cost containment without compromising the quality of care. Prolonged LOS increases hospitalization costs, reduces hospital capacity, limits medical staff availability, and restricts access to inpatient care for other patients (12, 13). Moreover, prolonged hospital stays are associated with complications such as nosocomial infections and gastrointestinal bleeding (14, 15).

Various factors influence LOS, and stroke type and severity are among the well-documented and strong predictors of LOS (16). Comorbidities (17), malnutrition (18), and infections (19) are also associated with prolonged LOS. In a study conducted in Taiwan involving 2,358 patients with acute cerebrovascular disease, prolonged LOS was defined as hospital stays of 23 days or longer. The study found that surgical procedures, infections or aspiration pneumonia, speech or swallowing disorders, female sex, stroke type, a higher number of comorbidities, and advanced age were all statistically associated with prolonged LOS (11).

Predicting LOS enables hospitals to identify patients at high risk of prolonged hospitalization, facilitating the provision of optimized treatment plans and early interventions to prevent additional complications (20). Predicting LOS can also facilitate earlier discharge and lead to more cost-effective care involving community nurses and physicians affiliated with the local healthcare system (20). Ultimately, estimating LOS can help healthcare institutions to secure patient satisfaction, optimize resource utilization, and reduce costs (20). The present study was designed with the primary objective of identifying the determinants of LOS in stroke patients.

2. Materials and Methods

2.1 Study setting and participants

In this retrospective cross-sectional study, the medical records of patients with CVA who were hospitalized over a two-year period (2014-2015) were analyzed. A total of 190 patients were selected through a systematic random sampling method. Patients were categorized into four groups based on the season of hospitalization, and samples were selected proportionally to the number of admissions in each season. Patient data were obtained from Vali-e-Asr Hospital, affiliated with Zanjan University of Medical Science (ZUMS), in Zanjan, Iran. Hospital neurologists identified eligible cases after applying the inclusion and exclusion criteria. It is worth noting that the hospital did not have a dedicated stroke care unit during the study period.

2.2 Eligibility criteria

Inclusion criteria included CVA cases confirmed by the National Institutes of Health Stroke Scale (NIHSS), physical examination, and imaging studies.

Exclusion criteria included cerebral venous sinus thrombosis, cerebral venous thrombosis, subdural and epidural hematomas, post-traumatic cases, and death during the study period.

2.3 Variables and data collection

The data collection tool was a researcher-developed questionnaire, designed based on a review of the scientific literature and the perspectives of neurologists. It was intended solely as a repository for collecting information on the study variables. This questionnaire collected various data, including demographic characteristics and paraclinical records (such as imaging procedures to evaluate cerebral blood flow involvement), as well as the type of CVA, which was classified as either ischemic or hemorrhagic. CVA territory was categorized as anterior or posterior, and stroke size was classified as large, affecting major arteries such as the middle cerebral artery, posterior cerebral artery, anterior cerebral artery, or internal carotid artery, or small, involving penetrating or terminal branches, including lacunar infarcts. Additional information was collected on the length of hospital stay (≥12 days or <12 days), and complications (excluding infections), such as urinary incontinence, acute renal failure, hypertension, dysglycemia, deep vein thrombosis, dysphagia, aphasia and other speech disorders, constipation, fecal incontinence, cerebral edema, and seizures. Information was also recorded on ventilator use, cardiopulmonary resuscitation (CPR), and interventional procedures including central venous line placement, gastrojejunostomy, tracheostomy, and total parenteral nutrition, as well as on risk factors for atherosclerosis, including hypertension, diabetes mellitus, and dyslipidemia. Data on hospital-acquired infections, CVA history, and relevant past medical history were also recorded. Malnutrition was assessed based on factors such as involuntary weight loss during hospitalization, reduced food intake or nutrient absorption, physical signs including muscle wasting and loss of subcutaneous fat, and biochemical markers including low serum albumin levels.

2.4 Statistical analysis

Data were analyzed using Stata (Version 16; Stata Corp, College Station, Texas, USA), and figures were created using R software (version 4.4.1). The Shapiro–Wilk test and diagnostic plots (Q–Q plot) were used to assess the normality of data distribution. Quantitative variables were presented as mean ± standard deviation (SD), while qualitative variables were presented as frequency (%). In univariate analysis, simple Poisson regression was used to examine the association between demographic and clinical factors and the length of hospitalization. Model building was performed using a backward selection approach based on the Akaike Information Criterion (AIC) with a significance threshold of 0.2. Multiple Poisson regression was then applied to assess factors associated with the discharge rate; however, results were reported in terms of hospitalization length rather than discharge rate. Only variables with a p-value less than 0.2 in the univariate model were included in the multivariate model. A p-value less than 0.05 was considered statistically significant. The classification of the length of stay was based on a cutoff point of 12 days.

3. Result

During the study period, 1,800 patients were admitted with CVA, and out of these, 190 (10.5%) met the eligibility criteria for inclusion in the study. Most patients were male (76.8%) and aged 65 years or older (81.1%). The mean LOS was 11.00 ± 4.83 days, and 80 patients (42.1%) experienced a prolonged LOS (≥12 days). During the hospitalization, 41 patients (21.57%) developed pneumonia, and 2 (1.05%) contracted urinary tract infection. Table 1 displays the demographic and clinical characteristics of patients according to hospitalization duration.

As Figure 1 demonstrates, a positive association was observed between infection rates and prolonged hospital stays. The overall infection rate was 22.6%. Among patients with a LOS of fewer than 12 days, 11 (10.0%) developed an infection, compared to 32 (40.0%) of those with a prolonged LOS (≥12 days).

As can be seen in Figure 2, ischemic stroke was the predominant stroke type among all patients. However, hemorrhagic stroke was more frequent in patients with a prolonged LOS (≥12 days).

Table 2 displays the results of the univariate Poisson regression analysis concerning factors associated with the discharge rate. A statistically significant association was observed between infection and discharge rate (p-value = 0.01, RR = 0.64, 95% CI = 0.45-0.89). Ventilator use and comorbidities demonstrated borderline associations with discharge rate (p-value = 0.065, RR = 0.59, 95% CI = 0.34-1.03, and p-value = 0.074, RR = 0.75, 95% CI = 0.54-1.02, respectively). In contrast, demographic variables such as age and gender, as well as other clinical characteristics, were not significantly associated with the discharge rate (p-value > 0.05).

Table 3 demonstrates the results of multiple Poisson regression analyses examining the relationship between discharge rate and selected clinical factors. As tabulated, a statistically significant negative association was found between infection and discharge rate (p-value = 0.014, RR = 0.65, 95% CI = 0.46-0.91), indicating that patients with infections had a 35% lower discharge rate compared to those without infections. In contrast, no statistically significant association was detected between discharge rate and complications. Although the rate ratio for complications was 0.55, indicating a potential reduction in the discharge rate, the wide confidence interval (CI = 0.24-1.25) suggests considerable uncertainty.

Table 1. Demographic data and clinical characteristics by length of hospitalization.

Variables		Length of hospitalization		
		<12 days, n (%)	12≤ days, n (%)	Total n (%)
Number of patients		110 (57.9)	80 (42.1)	190 (100)
Gender	Female	26 (23.6)	18 (22.5)	44 (23.2)
	Male	84 (76.4)	62 (77.5)	146 (76.8)
Age ± mean		72.5 ± 9.9	72.6 ± 9.1	72.56 ± 9.55
Age	65≤	94 (85.5)	60 (75)	154 (81.1)
	<65	16 (14.5)	20 (25)	36 (18.9)
Stroke type	Ischemic	103 (93.6)	70 (87.5)	173 (91.1)
	Hemorrhagic	7 (6.4)	10 (12.5)	17 (8.9)
	Infection (yes)	11 (10.0)	32 (40.0)	43 (22.6)
	Complication (yes)	0 (0.0)	6 (7.5)	6 (3.2)
	Risk factor (yes)	9 (8.2)	0 (0.0)	9 (4.7)
	Comorbidity (yes)	21 (19.1)	34 (42.5)	55 (28.9)
	CPR (performed)	2 (1.8)	11 (13.8)	13 (6.8)
	Ventilator (yes)	2 (1.8)	12 (15.0)	14 (7.4)
	Procedure (yes)	2 (1.8)	12 (15.0)	14 (7.4)
	stroke history (yes)	46 (41.8)	39 (48.8)	85 (44.7)
	Malnutrition (yes)	1 (0.9)	4 (5.0)	5 (2.6)
Treatment delay(hours)	< 6	29 (26.4)	21 (26.2)	50 (26.3)
	6-24	77 (70.0)	48 (60.0)	125 (65.8)

	> 24	4 (3.6)	11 (13.8)	15 (7.9)
Stroke territory	Posterior	66 (60.0)	39 (48.8)	105 (55.3)
	Anterior	44 (40.0)	41 (51.2)	85 (44.7)
Stroke size	Small	107 (97.3)	67 (83.8)	174 (9.1)
	Large	3 (2.7)	13 (16.2)	16 (8.4)

(CPR: Cardiopulmonary Resuscitation)

Table 2. Association between the rate of discharge and related factors (Univariate Poisson regression).

Variables*	Rate Ratio	P-Value	Lower CI 95%	Upper CI 95%
Gender (Male vs Female)	1.03	0.835	0.74	1.45
Age (≥65 vs <65)	0.99	0.882	0.98	1.01
Stroke Type (Hemorrhagic vs Ischemic)	0.80	0.399	0.49	1.32
Infection (yes)	0.64	0.010	0.45	0.89
Complication (yes)	0.51	0.112	0.22	1.16
Risk Factor (yes)	1.71	0.115	0.87	3.34
Comorbidity (yes)	0.75	0.074	0.54	1.02
CPR (Performed vs not performed)	0.66	0.156	0.37	1.16
Ventilator use (yes)	0.59	0.065	0.34	1.03
Procedure (yes)	0.65	0.125	0.37	1.12
stroke history (yes)	0.93	0.667	0.70	1.25
Malnutrition (yes)	0.71	0.462	0.29	1.74
Treatment delay (hours)	0.91	0.464	0.71	1.16
Stroke Territory (Posterior vs Anterior)	0.95	0.765	0.71	1.27
Stroke Size (large vs Small)	0.66	0.114	0.39	1.10

* In the binary variables that include a No/Yes categorization, the "No" category is treated as the reference group. (CI: Confidence Interval; vs.: versus; CPR: Cardiopulmonary Resuscitation)

Table 3. The associations between the characteristics of patients and the features of tumors (r: the correlation coefficient; the significant associations were bolded).

Variables*	Rate Ratio**	P Value	Lower CI 95%	Upper CI 95%
Infection (yes)	0.65	0.014	0.46	0.91
Complication (yes)	0.55	0.158	0.24	1.25

** The "No" category is treated as the reference group.

* We used a multiple Poisson regression using backward selection estimation based on the AIC criterion and a 0.2 cutoff

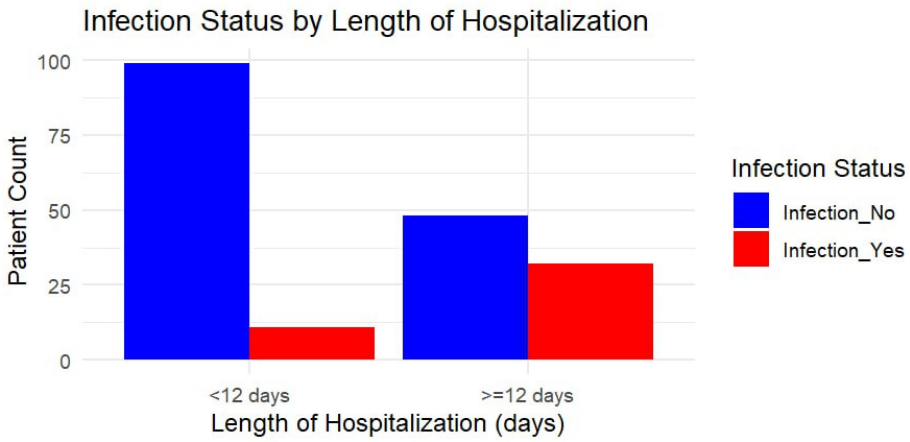

Figure 1. Infection Rates by Length of Hospital Stay (**Prepared by Authors, 2025**).

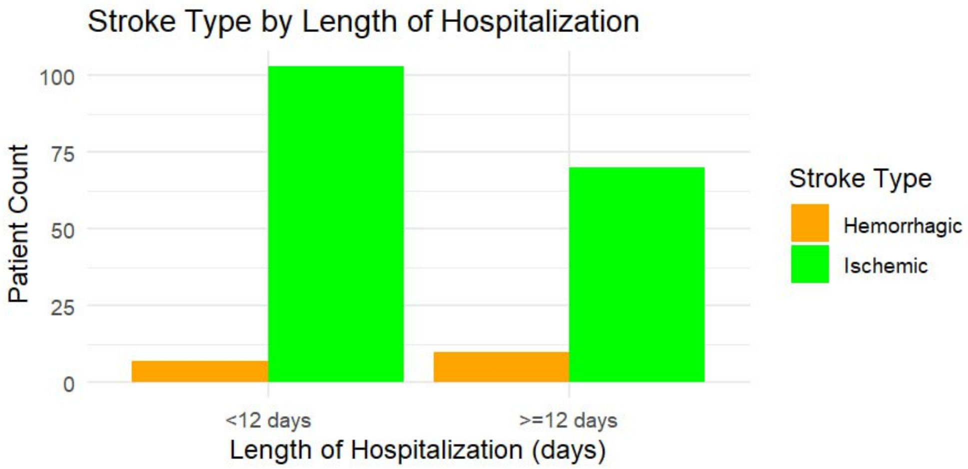

Figure 2. Stroke Types by Length of Hospital Stay (**Prepared by Authors, 2025**).

4. Discussions

Several studies have investigated predictors of prolonged LOS in stroke patients; the present study, however, specifically focused on various factors associated with LOS in individuals with acute stroke. Our findings demonstrated that infection was independently associated with a prolonged hospital stay.

Various studies have employed different thresholds to define prolonged LOS; in the present study, a cutoff point of 12 days was considered. Findings regarding the impact of age on LOS are inconsistent. Although some studies reported no significant association, others reported shorter LOS among younger patients **(21, 22)**. In contrast, two studies reported longer LOS in younger patients **(8, 14)**. Similarly, the impact of gender on LOS has been reported inconsistently. While some studies reported a longer LOS in men **(8, 14, 22, 23)**, others reported that women experienced longer hospitalization **(21, 24)**. In our study, however, neither age nor gender had a significant association with LOS.

Patients with hemorrhagic stroke generally experience a longer LOS compared to those with ischemic stroke **(25)**. Although our study found that patients with hemorrhagic stroke had a longer LOS, this difference was not statistically significant. A retrospective study showed a correlation between larger lesion size and longer length of stay **(26)**; however, our findings did not support this association.

A prospective study of 212 patients with acute ischemic stroke found that those who had a longer LOS were more likely to undergo reperfusion therapy and were less likely to have early do-not-resuscitate (DNR) orders issued **(14)**. Additionally, this study showed that early DNR orders within seven days post-stroke were associated with shorter LOS **(14)**. Similarly, a retrospective analysis of 898 patients with acute ischemic stroke from primary, secondary, and tertiary or university hospitals demonstrated that intravenous thrombolysis independently reduced LOS **(19)**. Our study, however, did not find any significant association between LOS and CPR or other procedures, including reperfusion therapy.

Complications following stroke are major contributors to prolonged LOS **(27-29)**. Stroke-induced immunodepression syndrome impairs cellular immune function, thereby increasing the risk of infection in stroke patients (30). As a result, these patients are particularly vulnerable to hospital-acquired infections, most commonly pulmonary and urinary infections (19, 31-34). Several risk factors have been identified for urinary tract infections and pneumonia in stroke patients, including older age, stroke type, impaired consciousness, dysphagia, diabetes mellitus, hypertension, chronic obstructive pulmonary disease, hyperlipidemia, prolonged hospitalization, bladder dysfunction, and increased use of Foley catheters. Furthermore, higher NIHSS scores and invasive procedures may further increase the risk of infection (35, 36).

Dedicated stroke units can reduce LOS in patients with acute stroke (37). In contrast, hospitalization in general neurology or internal medicine wards (38), as well as delays in referral to rehabilitation services (39), have been associated with prolonged LOS. Our hospital did not have a dedicated stroke unit during the study period.

Malnutrition is common among stroke patients and is often attributed to conditions such as dysphagia, reduced consciousness, and cognitive impairment (18). Undernourished patients are generally at a higher risk of prolonged LOS (40). A case-control study involving 791 acute ischemic stroke (AIS) patients and 288 controls reported that a high Controlling Nutritional Status (CONUT) score at admission was a predictor of prolonged LOS in elderly AIS patients (41). However, our study did not find any significant association between malnutrition and LOS.

A retrospective cohort study involving 38,812 patients with middle cerebral artery (MCA) strokes found that individuals with left-sided MCA ischemic strokes had shorter LOS (42). In our study, patients with posterior circulation strokes had a longer LOS compared to those with anterior circulation strokes; however, this difference was not statistically significant.

Several studies have demonstrated that comorbid conditions significantly predict prolonged hospital stays in stroke patients (17, 43). A study conducted in China involving 5,114 patients with ischemic stroke found that a higher Charlson Comorbidity Index (CCI) score was associated with increased LOS (44). Nonetheless, our study did not demonstrate any such association. This inconsistency can be attributed to differences in the prevalence and severity of comorbid conditions, hospital management protocols, or discharge policies across different healthcare settings. Furthermore, the p-value of 0.074 in the univariate Poisson regression analysis suggests that this variable may have reached a statistically significant level with a larger sample size.

A limited number of studies have investigated the relationship between treatment delays and hospital stay duration. In a retrospective cohort study involving 1,435 patients, Chen et al (45) found a positive correlation between delayed transfer to a specialized stroke unit from regional medical centers and prolonged hospitalization (45). However, our study did not find a statistically significant association between treatment delay and LOS. Differences in the definitions and measurements of treatment delay and LOS across studies may account for this inconsistency.

This study had several limitations. First, the NIHSS score was used solely as a diagnostic criterion and not for calculating stroke severity scores. Second, the data utilized in our study were collected several years ago. Nevertheless, these datasets were selected due to their comprehensiveness, reliability, and relevance to the specific objectives of this study.

5. Conclusion

In conclusion, our study found that infection can be an independent predictor of extended length of stay (LOS) in patients admitted with acute stroke. Additional research is needed to confirm these findings and to elucidate more factors that may affect LOS to enhance the overall care and recovery of stroke patients.

6. Declarations

6.1 Acknowledgments

We appreciate our colleagues for their insightful discussions and valuable suggestions, which significantly improved the manuscript.

6.2 Ethical Considerations

This study was conducted following the ethical principles of the Declaration of Helsinki (1964) and its subsequent amendments. The Ethics Committee of Zanjan University of Medical Sciences (ZUMS) approved the study protocol (Ethics code: ZUMS.REC.1394.277).

6.3 Authors' Contributions

Conceptualization of the study: M. Maghbooli and F. Bahrampour. Study design: M. Maghbooli and M. Kakovan. Data collection F. Bahrampour and M. Kakovan. Data analysis and interpretation: F. Bahrampour and M. Kakovan. Manuscript drafting: M. Kakovan. Critical revision and approval of the final manuscript: M. Maghbooli. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

6.4 Conflict of Interest

The authors have stated that they have no conflicts of interest to disclose.

6.5 Fund or Financial Support

This research did not receive funding from any external sources.

6.6 Using Artificial Intelligence Tools (AI Tools)

AI was used only for minor language editing. All text was subsequently reviewed and revised by the authors, and all scientific content was generated entirely by the authors.

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