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Effects of Stroke Awareness on Onset-to-Hospital Time and Healthcare Costs in Acute Ischemic Stroke: A Cross-Sectional Study

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ABSTRACT

Introduction: Early diagnosis and treatment are essential for the effective treatment of ischemic stroke. The objective of this study was to assess the effect of stroke knowledge among patients and caregivers on hospital arrival, clinical outcomes, and healthcare costs.

Methods: This is a cross-sectional study of 219 patients with ischemic stroke and their family members. Awareness of stroke was measured using a structured questionnaire, and the participants were divided into two groups: those with a high level of awareness of stroke and those with a low level of awareness of stroke. The primary outcome measures were time to hospital arrival, modified Rankin Scale (mRS) scores at 1 and 3 months, and the total treatment cost within 3 months.

Results: Patients in the high-awareness group presented to the hospital much earlier (58±21.8 min vs. 185±40.3 min, p=0.001), displayed better functional outcome at 1 month (mRS: 1.64 vs. 2.19, p=0.01) and at 3 months (mRS: 1.52 vs. 1.95, p=0.01) and lower treatment costs ($998 vs. $1679, p=0.001). Interestingly, calling the emergency service as a first response was associated with significantly lower costs. On the other hand, low awareness was associated with delayed intervention, worse clinical outcomes, and greater economic strain.

Conclusion: A better understanding of the signs of a stroke by patients and their caregivers leads to faster treatment, improved recovery, and lower costs. Stroke awareness can be enhanced through public health efforts, potentially leading to a significant reduction in the clinical and economic burden of stroke.

Keywords: Awareness, economic burden, hospital arrival time, ischemic stroke, modified Rankin Scale

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INTRODUCTION

Ischemic stroke is still responsible for a high rate of mortality and disability. It poses a significant economic and social burden on patients, their families, and healthcare systems worldwide (1). Early diagnosis of stroke symptoms and prompt medical attention are important factors influencing the clinical course, especially in view of the time-dependency of treatments such as intravenous thrombolysis (IVT) and mechanical thrombectomy (MT). Although most clinical studies have focused primarily on treatment paradigms, delayed arrival at hospital remains a significant barrier in stroke management, leading to less-than-ideal outcomes and an additional burden on healthcare systems (2). Awareness of symptoms is crucial for decreasing prehospital delay of stroke (3). Conversely, higher levels of stroke awareness are linked to shorter onset-to-activation times, such as time to contact emergency services, and accuracy of symptom recognition (3,4). In this study, we examine how stroke knowledge among ischemic stroke patients and their caregivers is associated with the timing of hospital arrival and attributable hospitalization costs. We speculate that this heightened awareness may facilitate earlier symptom recognition, timelier responses, and prompt hospital arrival, ultimately leading to lower medical costs.

Highlights

- **High stroke awareness significantly shortens hospital arrival time.**
- **Early admission is associated with better 1- and 3-month functional outcomes.**
- **Patients with high awareness have markedly lower treatment costs.**
- **Use of emergency call services reduces both time to treatment and expenses.**
- **Increasing public stroke awareness provides clinical and economic benefits.**

METHODS

Study Design and Participants

The study included 219 patients with clinical suspicion of ischemic stroke and their accompanying relatives. Recruitment took place from March 2020 to July 2024 at a tertiary care center. All participants or their legal guardians provided written informed consent, the ethical guidelines were followed, and the institutional research ethics board approved the study.

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Data Collection

The patients' and relatives' ages, genders, and educational levels were recorded. A medical history was obtained from every patient with an emphasis on common comorbidities like hypertension, diabetes mellitus, and atrial fibrillation, and previous treatments including anticoagulants, as well as antiplatelet drugs. The severity of stroke was defined by radiological findings including early ischemic changes on Computed Tomography (CT) and the degree of vascular stenosis on CT angiography (CTA) for both intracranial and extracranial vessels.

Awareness Assessment

Stroke literacy was assessed using a structured questionnaire which was administered to the relatives accompanying the patients. The "Questionnaire for Stroke Awareness" tool included questions related to knowledge regarding stroke symptoms, the initial response to the symptoms, possible interpretations of the initial symptoms, and sources of previous information about stroke (e.g., healthcare professional, internet, social media). According to the overall score, participants were categorized into two groups: those with high awareness (score ≥10 points) and those with low awareness (score <10 points).

Clinical Outcomes and Cost Analysis

The primary clinical endpoint was the time (in minutes) from symptom onset to hospital presentation. Functional status was evaluated with the modified Rankin Scale (mRS) before treatment and at 1 month and 3 months of follow-up. The economic endpoint was the overall cost of treatment through 3 months in US dollars. Costs were compared in relation to stroke awareness and the initial response of initial response (receiving care at home vs. being transported to the hospital by relatives).

To improve transparency and reproducibility of the economic evaluation, we further detailed the cost calculation process. Only direct medical costs incurred within the first three months after stroke were included. These consisted of emergency department assessment, laboratory studies, neuroimaging (CT, CTA, and when performed, MRI), hospitalization in ward or intensive care unit, medications, intravenous thrombolysis, mechanical thrombectomy, and other supportive in-hospital medical treatments. Rehabilitation services, outpatient follow-up visits, and long-term disability-related expenditures were not included.

All cost data were retrieved retrospectively from the hospital's official billing system (Medula/Social Security Institution reimbursement database). Since all patients were treated under the national public insurance coverage, the costs reflect SGK reimbursement tariffs only. No private insurance payments or out-of-pocket expenses were incorporated. Costs originally recorded in Turkish Lira were converted to US dollars using the mean monthly exchange rate corresponding to the treatment date.

Statistical Analysis

Quantitative data were described using means ± SD, and qualitative data were presented as frequencies and percentages. Group comparisons for continuous variables were performed using the Student's t-test or the Mann-Whitney U test, as appropriate. The chi-square test was used for comparing categorical variables. P <0.05 was deemed to be statistically significant. All analyses were conducted using IBM Statistical Package for Social Sciences (SPSS) program version 30.0.

This study was approved by the Non-Interventional Research Ethics Committee of İzmir Katip Çelebi University (Approval No: 0511, Date: 22.09.2022)

RESULTS

Participant Characteristics

There were 219 ischemic stroke patients and their family members who participated in the study. Fifty-eight percent of the patients were male, with a mean age of 68.42±12.53 years. The average time of formal education was 7.76±4.4 years for patients and 12.07±3.81 years for their relatives. Hypertension (67.1%), diabetes mellitus (46.6%), were the most frequent comorbidities (Table 1).

Radiological Findings

All patients had brain CT scanning, and 192 (87.67%) of them had carotid and cerebral CTA. Early ischaemic changes were present in 12 cases within a middle cerebral artery territory of <30%. Other radiological findings are summarised in Table 2.

Awareness and Initial Response to Stroke

The most prevalent initial manifestation was weakness in an extremity (32.6%) followed by speech difficulty (25.4%) and balance impairment (19.5%). Stroke was suspected at symptom onset in only 38.9% of respondents, and 29.1% first contacted emergency services. The sources

Table 1. Demographic characteristics of the patients

	Female	Male	
Number of patients	92 (42%)	127 (58%)	219 (100%)
Number of patient relatives	144 (65.75%)	75 (34.25%)	219 (100%)
Age of patients (mean ± SD)	70.06±11.33	65.67±13.12	68.42±12.53
Age of patient relatives (mean ± SD)	46.38±13.76	49±15.21	48.36±14.01
Education years of patients	6.42±4.1	8.43±4.5	7.76±4.4
Education years of patient relatives	11.87±3.56	12.54±4.01	12.07±3.81
Comorbidity	Present	Not present	
History of ischemic stroke	55 (25.11%)	164 (74.89%)	
Hypertension	147 (67.12%)	72 (32.88%)	
Coronary Artery Disease	70 (31.96%)	149 (68.04%)	
Diabetes Mellitus	102 (46.58%)	117 (53.42%)	
Hyperlipidemia	187 (85.39%)	32 (14.61%)	
Antiaggregant use prior to stroke	89 (40.64%)	130 (59.36%)	
Anticoagulant use prior to stroke	19 (8.68%)	200 (91.32%)	

Table 2. Radiological features of the patients

	Present	Not present	
Signs of early ischemia in CT scan (<1/3 of MCA)	12 (5.5%)	207 (94.5%)	
Brain and carotis CTA	192 (87.67%)	27 (12.33%)	
Stenosis level in right ICA		**Stenosis level in right ICA**	
None	112 (58.33%)	None	106 (55.21%)
<50%	50 (26.04%)	<50%	52 (27.08%)
50–70%	10 (5.21%)	50–70%	14 (7.29%)
71–90%	8 (4.17%)	71–90%	7 (3.65%)
91–99%	2 (1.04%)	91–99%	2 (1.04%)
Complete occlusion	10 (5.21%)	Complete Occlusion	11 (5.73%)
Stenosis level in right MCA		**Stenosis level in left MCA**	
None	172 (89.58%)	None	172 (89.58%)
<50%	6 (3.13%)	<50%	5 (2.6%)
50–70%	1 (0.52%)	50–70%	0 (0%)
71–90%	0 (0%)	71–90%	0 (0%)
91–99%	4 (2.08%)	91–99%	2 (1.04%)
Complete occlusion	9 (4.69%)	Complete occlusion	13 (6.77%)
Stenosis level in BA			
None	179 (93.23%)		
<50%	7 (3.65%)		
50–70%	1 (0.52%)		
71–90%	1 (0.52%)		
91–99%	1 (0.52%)		
Complete occlusion	3 (1.56%)		

CT: computerized tomography; MCA: middle cerebral artery; CTA: computerized tomography angiography; ICA: internal carotid artery; BA: basilar artery.

Table 3. Awareness status of the patient's relatives in terms of stroke

		Responses	
		N	**%**
First recognized symptom	Speech disorder	56	25.4%
	Drooping corner of mouth	40	18.3%
	Weakness in arm and leg	71	32.6%
	Imbalance	42	19.5%
	Vision loss	7	3.1%
	Diplopia	3	1.2%
Total			100.0%
		Responses	
		N	**%**
What was done when the symptom was noticed?	Calling 112 emergency service	64	29.1%
	Applying drug	14	6.5%
	Calling someone for help	40	18.4%
	Cologne sniffing	30	13.6%
	Brought to hospital by a relative	71	32.5%
Total			100.0%
		Responses	
		N	**%**
Which disease did the patient relative think of first?	Metabolic disorder	84	38.5%
	Myocardial infarction	13	6.0%
	Epilepsy	7	3.2%
	Stroke	85	38.9%
	Other	30	13.5%
Total			100.0%
		Responses	
		N	**%**
Acquiring Stroke Knowledge	Healthcare professional	41	18.7%
	Relatives/friends	74	33.8%
	Internet	40	18.1%
	Social media	15	7.0%
	Other	5	2.3%
	No information	44	20.1%
Total		219	100.0%

of information about stroke were diverse. 33.8% of them obtained information from friends or relatives, while the sources that provided information from healthcare professionals were only 18.7%. Interestingly, 20.1% of patients or relatives never heard about stroke at baseline (Table 3).

Clinical Outcomes and Hospital Admission

The duration from symptom onset to hospital arrival was significantly shorter the high-awareness group (58±21.8 min) in contrast to the low-awareness group (185±40.3 min) (p=0.001). A significantly larger percentage of relatives of patients in the high-awareness group thought of stroke as the initial diagnosis than those of patients in the low-awareness group (51.6% vs 18.3%; p=0.001) and were also more likely to call emergency services immediately (47% vs 16%; p=0.001) (Table 4).

Functional Recovery

Functional outcomes, as assessed by the mRS, were significantly different between the high– and low-awareness groups. At 1 month post-stroke,

Table 4. Treatment and disability status of the patients receiving acute treatment

	Received	Not received		
IV thrombolysis	73 (33.3%)	146 (66.7%)		
Mechanical thrombectomy	46 (21%)	203 (79%)		
	All patients (n=73)	**High awareness (n=30)**	**Low awareness (n=43)**	**p**
mRS pre-treatment	2.87±1.71	2.80±1.60	2.97±1.79	0.67
mRS 1. month	1.84±1.81	1.64±1.51	2.19±1.94	**0.01**
mRS 3. Month	1.66±1.87	1.52±1.47	1.95±1.91	**0.01**
	All patients (n=73)	**High awareness (n=30)**	**Low awareness (n=43)**	**p**
Arrival time to hospital (min)	122±32.5	58±21.8	185±40.3	**0.001**
112 emergency call centre as first choice (%)	29.1%	47%	16%	**0.001**
Proportion of relatives considering stroke as the first diagnosis (%)	38.9%	51.6%	18.3%	**0.001**
Cost of treatment at month 3 (US Dollars)	1347.99±1973.51	998±1258.87	1679±2018.44	**0.001**

Table 5. Relationship between patient relative's behaviour and treatment cost

		Cost
Calling 112 emergency service	Yes	437.58±847.85
	No	1522.82±2623.67
Test statistics		**-5.503**
p†		**0.001**
Applying drug	Yes	1023.27±2069.91
	No	306.46±368.85
Test statistics		-1.711
p†		0.087
Calling someone for help	Yes	962.1±1963.39
	No	914.56±2012.27
Test statistics		-1.390
p†		0.165
Cologne sniffing	Yes	1044.91±2184.44
	No	602.7±805.83
Test statistics		-0.165
p†		0.869
Brought to hospital by a relative	Yes	1424.05±2538.68
	No	517.46±1109.55
Test statistics		**-4.900**
p†		**0.001**

mean mRS score was 0.77 (high awareness) vs. 1.24 (low awareness) (p=0.01). Scores at 3 months were 1.52±1.47 and 1.95±1.91 (p=0.01), respectively, demonstrating that the gains persisted in the long term, for patients with more involved caregivers (Table 4).

Economic Outcomes

The average total treatment cost during the 3-month period were significantly lower in the high-awareness group than in the low-awareness group (US$998±1,258.87 and US$1,679±2,018.44, respectively; p=0.001). Patients in whom family members called an emergency rescue center showed a significant decrease in treatment costs (US$437.58± US$847.85) compared to those who did not (US$1,522.82±US$2,623.67; p=0.001). On the other hand, private transport was significantly associated with the higher treatment costs (1,424.05±2,538.68; p=0.001) (Table 5).

DISCUSSION

The present study shows that higher stroke symptom awareness in patients and their relatives contributes significantly to an earlier hospital arrival, better functional outcome, and reduced treatment cost in ischemic stroke. These observations are in line with an increasing body of literature demonstrating that the health outcomes of protocols for detecting and treating stroke are crucially dependent on expedited treatment, as summarized by the concept "time is brain" (5). The delay in recognizing symptoms of stroke, followed by delayed access to healthcare, is associated with missed opportunities for appropriate interventions, which are time-dependent, including intravenous thrombolysis and mechanical thrombectomy. These various treatments are most beneficial when initiated early, and have been demonstrated to result in dramatic neurological recovery (6).

In our population, family members who had high awareness of stroke tended to identify the symptoms correctly and call the emergency services earlier, leading to significantly shorter onset-to-hospital times. This is particularly critical because the benefit of reperfusion therapy becomes less pronounced over time (7). Our results align with other research, which suggests that public awareness and organized educational interventions are effective in reducing prehospital delay and increasing the likelihood of receiving on-time treatment (8,9). Rate of favorable outcome based on modified Rankin Scale was also significantly higher at 1 and 3 months in the high-awareness group. This is consistent with results from large stroke registries indicating that early thrombolysis and thrombectomy decrease both mortality and long-term disability (10). Given the correlations between awareness and lower mRS scores, timely recognition may be neuroprotective in maintaining neurological function.

At 3 months, patients with high awareness had significantly reduced health expenditure (US$998 vs. US$1,679), which is supported by previous literature demonstrating that delay in treatment results in larger interventions, greater complication rates, more extended hospital stays, and heightened rehabilitation requirements (11,12). Of importance, patients whose relatives called the emergency service had considerably lesser expenditures than those using informal or delayed forms of transportation, highlighting that an efficacious transport service is not only a clinical but also an economic advantage (13).

Although the benefits of stroke treatment are established, our survey data showed a significant void in knowledge: more than 60% of respondents did not know or misperceived stroke symptoms (e.g., not attributing them to stroke but rather metabolic derangements and cardiac events). This lack of awareness is not distinctive to our population and has been reported in various parts of the world, particularly among less educated and older populations (14–16) Few institutions, if any, have implemented similar initiatives so far. However, attempts Future efforts should focus on culturally sensitive educational intervention not only within the clinical context but also involving communities, schools, and workplaces.

It is of interest that a healthcare professional had given information about stroke to only 18.7% of participants. This underscores a missed chance for physician-delivered education, particularly in those with recognized vascular risk factors such as hypertension, diabetes, and atrial fibrillation, which were very common in our population. Targeting such brief educational interventions during outpatient clinic visits or post-discharge follow-up visits could yield substantial improvements in public perceptions and prompt recognition and response to stroke symptoms (17–19).

Limitations

This study has several limitations. Firstly, the study was conducted at a single tertiary care center, which may limit the generalizability of the results to a broader population with more diverse and varied patient demographics. Second, stroke awareness was evaluated through self-reporting, which can be biased by recall bias or participants' failure to provide accurate answers. Third, the cost analysis was limited to direct medical costs, and other indirect costs, such as loss of productivity, long-term disability, or patient burden, were not included in the analysis, which potentially resulted in an underestimation of the total economic burden. Future multicenter, prospective studies using more extensive and societal-level cost models are needed to confirm these findings and build on them.

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