Neurology Asia 2026; 31(1) : 87 – 95

Golden hours at risk: Prehospital delays in acute ischemic stroke and their impact on public awareness and emergency response

[1]Burak Ozkan, [1]Engin Ozakin, [2]Atilla Ozcan Ozdemir, [1]Nurdan Acar, [1]M. Evvah Karakılıc, [1]Filiz Baloglu Kaya, [1]Ezgi Baran, [3]Nurettin Tekin, [2]Ozlem Aykac, [1]Volkan Ercan, [1]Caglar Kuas, [1]Mustafa Emin Canakci

[1]Department of Emergency Medicine, Faculty of Medicine, Eskisehir Osmangazi University, Eskisehir, Turkey; [2]Department of Neurology, Faculty of Medicine, Eskisehir Osmangazi University, Eskisehir, Turkey; [3]Eskisehir Provincial Health Directorate, 112 Ambulance Service, Eskisehir, Turkey

Abstract

Background: Timely intervention is essential in the management of acute ischemic stroke, as delays in treatment initiation can significantly worsen clinical outcomes. Despite advancements in stroke care, prehospital delays remain a major barrier to accessing reperfusion therapies. This study aimed to investigate the sociodemographic, clinical, and cognitive factors contributing to prehospital delays and to assess their impact on treatment accessibility and outcomes. *Methods:* This prospective observational study was conducted at the Emergency Department of Eskişehir Osmangazi University, a regional stroke center, between March 2018 and February 2019. Adult patients (≥18 years) presenting with a first-time suspected ischemic stroke were enrolled. Data were collected through structured interviews with patients and/or their relatives and supplemented by official emergency medical service records. Variables analyzed included sociodemographic characteristics, symptom recognition time, mode of transport, and awareness of stroke symptoms. *Results:* A total of 436 patients were included. Most patients (78.6%) resided in urban areas, while 19.7% lived alone. The majority (72%) experienced sudden symptom onset. Intravenous rtPA was administered to 26.4%, and mechanical thrombectomy was performed in 12.4% of patients. Ambulance use was significantly higher among rural residents ($p < 0.001$). The mean time from symptom onset to hospital arrival (symptom-to-door) was 362 ± 400 minutes. Key contributors to prehospital delays included delayed symptom recognition and delayed contact with emergency services. Higher educational attainment of the first responder was significantly associated with shorter recognition-to-arrival times. Patients with typical stroke symptoms (e.g., unilateral weakness, speech impairment) reached the hospital faster than those with non-specific symptoms like imbalance. Patients or relatives who correctly identified stroke symptoms had significantly shorter delays in all key time intervals ($p < 0.001$). Those educated through public seminars, healthcare professionals, or social media showed faster recognition and response times compared to those informed by friends or with no prior knowledge.
Conclusion: Prehospital delay remains a key obstacle to timely stroke management. Factors such as education level, living situation, symptom awareness, and the source of stroke-related information significantly influence early hospital presentation. Public health strategies should emphasize stroke education, particularly for high-risk populations, through both digital media and community outreach. Improved coordination between emergency services and stroke centers is also critical for enhancing access to timely, life-saving interventions.

Keywords: Prehospital delay, acute ischemic stroke, stroke awareness

INTRODUCTION

Stroke remains one of the leading causes of morbidity and mortality worldwide, particularly in low- and middle-income countries. Its high fatality rate and potential for long-term functional disability significantly diminish patients' quality

Address correspondence to: Engin Ozakin, Department of Emergency Medicine, Faculty of Medicine, Eskisehir Osmangazi University, Prof. Dr. Nabi Avcı Boulevard, No: 4, Meselik, Odunpazarı, 26040 Eskisehir, Turkey. Tel: +90 222 239 29 79 (ext. 5602), E-mail: enginozakin@hotmail.com

Date of Submission: 3 July 2025; Date of Acceptance: 16 December 2025

https://doi.org/10.54029/2026evr

of life.[1] Moreover, the disproportionate impact of stroke on the working-age population not only affects individual well-being but also imposes a substantial burden on healthcare systems and leads to significant economic losses. In cases of ischemic stroke, prognosis is primarily determined by the duration and severity of cerebral ischemia. Similar to myocardial infarction, stroke represents a time-sensitive medical emergency in which rapid initiation of appropriate treatment is crucial. Among the available interventions, recanalization therapies are most effective when delivered promptly. Intravenous recombinant tissue plasminogen activator (rtPA) is an evidence-based treatment for acute ischemic stroke; however, its therapeutic window is limited to 3 to 4.5 hours from symptom onset.[2] Mechanical thrombectomy (MT), when indicated, is most effective within 6 hours, although recent guidelines support extending this window up to 24 hours in carefully selected patients based on advanced imaging criteria.[3]

The effectiveness of both interventions is highly time-dependent, with earlier administration consistently associated with better clinical outcomes. Therefore, minimizing delays in treatment is crucial for improving prognosis. Timely symptom recognition and prompt intervention rely heavily on targeted educational initiatives aimed at both the general public and healthcare providers including prehospital personnel and emergency department (ED) staff to ensure a streamlined and coordinated care process.[2]

Early recognition and efficient management of ischemic stroke in emergency settings have been associated with reduced mortality and morbidity rates.[4] However, despite notable advances in acute stroke care, delays in seeking medical attention after symptom onset continue to pose a major barrier. Prehospital delays remain a major barrier to the timely delivery of effective therapies, ultimately compromising clinical outcomes.

Multiple studies have reported prolonged intervals between symptom onset and hospital arrival, influenced by factors such as mode of transportation, time of onset, patient and caregiver education levels, and awareness of stroke symptoms.[5-8] Addressing these contributing factors is essential to improving timely access to recanalization therapies.

The primary objective of this study is to systematically investigate patient, caregiver, and healthcare system-related factors that contribute to treatment delays in acute ischemic stroke patients presenting to the ED. In addition, we aim to evaluate the impact of these delays on the initiation of reperfusion therapies and associated clinical outcomes.

METHODS

Study design and ethical approval

This prospective observational study was conducted in the Emergency Department of Eskişehir Osmangazi University Faculty of Medicine Hospital, a designated regional stroke center. The study protocol was approved by the Clinical Research Ethics Committee of Eskişehir Osmangazi University Faculty of Medicine (Approval No. 18, dated January 22, 2018). Patients were enrolled between March 1, 2018, and February 28, 2019.

Participants and inclusion criteria

The study population consisted of adult patients aged 18 years or older who presented to the emergency department with a first-time suspected diagnosis of ischemic stroke. Exclusion criteria included pregnancy, concurrent trauma, a prior history of stroke, referral from another healthcare facility, stroke onset during hospitalization, or an inability to accurately determine symptom onset time.

Data collection

Data were collected through structured interviews conducted with stroke patients and/or their relatives after admission to the ED and following the provision of informed consent. The questionnaire covered demographic details (name, age, gender, and medical record number), vital signs and medical history, presentation characteristics such as mode of arrival (ambulance or private transport), place of residence (urban or rural), living arrangements, initial stroke symptoms and symptom onset pattern, and key time points including symptom recognition, last known well, hospital arrival time (symptom-to-door), and time of the emergency call to 112. Additionally, information on treatment interventions (intravenous thrombolysis and/or mechanical thrombectomy) and discharge outcomes (hospitalization, discharge, or transfer to another facility) was also recorded.

Patient flow

During the study period, a total of 791 patients

presenting with a preliminary diagnosis of stroke were evaluated in the ED. Initial assessments were performed by ambulance staff (paramedics or physicians) or triage nurses who were blinded to the study protocol. Following clinical evaluation by emergency physicians, diagnostic testing, and brain computed tomography (CT) imaging, 79 patients were diagnosed with conditions other than stroke. Additionally, 175 patients were excluded due to a history of previous stroke, and 14 patients were excluded because informed consent could not be obtained from their first-degree relatives. Among the remaining 523 patients, 47 were diagnosed with transient ischemic attack and 53 were referrals from healthcare facilities outside the province; all were excluded based on the study criteria. Consequently, the final cohort consisted of 436 patients.

To evaluate prehospital factors, patients and witnesses were interviewed about initial actions taken following symptom onset, suspected diagnoses, stroke awareness, and sources of stroke-related information (friends/relatives, social media, television/print media/internet, public education seminars, or healthcare professionals). In cases where patients were aphasic or unconscious, first-degree relatives were interviewed face-to-face. Additional prehospital data, including emergency call time, hospital arrival time, and transport distance, were retrieved from the Provincial 112 Emergency Health Services Automation System.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics version 21.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as percentages (%). The normality of the data distribution was assessed using the Shapiro-Wilk test. Chi-square tests were used to analyze categorical variables. To evaluate the factors affecting time to hospital arrival, Mann–Whitney U tests and Spearman correlation analysis were employed. A p-value of < 0.05 was considered statistically significant.

A total of 436 patients and/or their relatives (244 male) were included in the study. The median age of female participants (74 years; range: 28–107) was significantly higher than that of male participants (67 years; range: 35–95) ($p < 0.001$). Of the total cases, 343 patients (78.6%) resided in the city center, and 86 (19.7%) were living alone. Regarding symptom onset, 314 patients (72%) experienced a sudden onset, 56 (12.8%) reported a gradual increase in symptoms, 9 (2.1%) had recurrent symptoms, and in 57 patients (13.1%) the symptoms began during sleep. Intravenous rtPA was administered to 115 patients (26.4%), and endovascular therapy (EVT) was performed in 54 patients (12.4%) (Table 1).

Most patients, regardless of whether they lived in rural or urban areas, presented to the ED via the 112 ambulance service. However, patients from rural areas were significantly more likely to use ambulance transport compared to those from urban areas ($p < 0.001$) (Table 2).

Analysis of time intervals showed that the average duration from symptom onset to recognition was 130.7 ± 10.8 minutes, followed by a mean of 150.6 ± 12.1 minutes from recognition to hospital arrival. The overall symptom-to-door time averaged 362 ± 400 minutes. In addition, the average delay in contacting the 112 Emergency Call Center was 281.3 ± 16.3 minutes.

In the subgroup analysis by gender, male patients recognized their symptoms significantly earlier than female patients, with a mean recognition time of 106.4 ± 13.3 minutes ($p < 0.05$). However, the interval from symptom recognition to hospital arrival was significantly longer in males (mean: 257 ± 343 minutes) compared to females ($p < 0.05$).

Analysis of prehospital delays in relation to the educational level of the first person to initiate contact with healthcare personnel revealed a significant negative correlation. Individuals with higher educational attainment had substantially shorter recognition-to-arrival times, highlighting the positive impact of education on timely healthcare-seeking behavior (Table 3).

The type of presenting symptom was found to have a significant impact on prehospital time intervals. Patients exhibiting clearly recognizable stroke signs—such as unilateral motor weakness, facial droop, altered mental status, speech impairment, or trauma following stroke—tended to identify symptoms and reach the hospital significantly more quickly. Conversely, those with less specific symptoms, such as imbalance, experienced significantly longer delays in both recognition and hospital presentation (Table 4).

Residence location, living situation, and mode of transport were all found to influence prehospital delays. Although individuals residing in rural areas recognized stroke symptoms slightly earlier than those in urban settings, this difference was not statistically significant. In contrast, urban residents contacted emergency services and

Table 1: Demographic and clinical characteristics of the patients

	Male (N: 244)	Female (n: 192)	p
Age, median (min–max)	67 (35-95)	74 (28-107)	<0.001*
Living area (%)			
Rural	61 (25.3)	32 (16.4)	**0.026**+
Urban	180 (74.7)	163 (83.6)	
Living alone – Yes (%)	34 (13.9)	42 (21.9)	
Patient/Witness education level; n (%)			
Primary school	11 (4.5)	7 (3.6)	
Middle school	36 (14.8)	27 (14.1)	0.797+
High school	71 (29.1)	50 (26)	
University	126 (51.6)	108 (56.4)	
Onset type of symptoms (%)			
Sudden	181 (74.2)	133 (69.3)	
Gradual increase	31 (12.7)	25 (13)	0.153+
Recurrent	7 (2.9)	2 (1)	
During sleep	25 (10.2)	32 (16.7)	
Symptoms (%)			
Unilateral weakness	193 (79.1)	157 (81.9)	0.486+
Facial asymmetry	123 (50.4)	116 (60.4)	**0.037**+
Speech disturbance	165 (67.6)	152 (79.2)	**0.007**+
Altered consciousness	90 (36.9)	89 (46.4)	**0.046**+
Loss of balance	48 (19.7)	34 (17.7)	0.602+
Intervention (%)			
None	148 (60.7)	119 (62)	
rtPA	68 (27.9)	47 (24.5)	0.661+
Endovascular	28 (11.5)	26 (13.5)	

*Man whitney U test, +Chi-Square test was used

arrived at the hospital significantly faster, with the largest disparity observed in overall arrival time. Patients living alone faced substantial delays across all prehospital stages—including symptom recognition, initial medical contact, and hospital arrival. Additionally, those transported by ambulance after calling 112 reached the hospital significantly faster than patients who arrived by private means (Table 5).

Stroke awareness at the time of symptom onset emerged as a critical factor in determining prehospital efficiency. Patients or their relatives who correctly identified the symptoms as stroke experienced significantly shorter delays across all key time intervals. Specifically, this group had a mean symptom recognition time of 103.1 ± 12.7 minutes, contacted healthcare personnel within 40.7 ± 3.8 minutes, reached the hospital in 83.1 ± 5.1 minutes after recognition, and had a total symptom-to-door time of 186.2 ± 14.0 minutes. Each of these intervals was considerably shorter compared to those who misattributed symptoms to other conditions ($p < 0.001$). These findings underscore the crucial role of public education in enhancing stroke recognition and facilitating timely medical intervention.

Analysis of information sources and their impact on prehospital times revealed that those

Table 2: Hospital arrival method according to living area

	Self-transport n: 72 (%)	Emergency medical transport n: 364 (%)	p
Rural	6 (1.4)	104 (23.9)	<0,001
Urban	66 (15.1)	260 (59.6)	

Pearson Chi-Square test was used

Table 3: Relationship between education status of healthcare contacts and pre-hospital time intervals

Education Level		Median (Q1 – Q3) minutes			
		Time to recognize symptoms	**Time to call emergency services**	**Time from symptom recognition to hospital arrival**	**Symptom-to-door time**
Primary school	Yes	60(23-60)	127(51-285)	227(85-371)	315(108-606)
	None	30(10-180)	28(11-75)	73(45-147)	158(69-376)
	p*	***0.062***	***0.024***	***<0.001***	***0.002***
Middle school	Yes	60(30-243)	86(25-287)	181(85-347)	372(171-632)
	None	30(5-180)	27(11-68)	67(42-134)	143(66-346)
	p*	***0.008***	***<0.001***	***<0.001***	***<0.001***
High school	Yes	105(30-240)	36(16-106)	104(55-187)	288(138-509)
	None	30(5-90)	27(10-69)	70(42-134)	122(58-343)
	p*	***<0.001***	***0.080***	***0.008***	***<0.001***
University	Yes	15(5-60)	25(10-50)	60(39-110)	96(55-223)
	None	60(30-240)	44(20-152)	129(60-243)	306(149-535)
	p*	***<0.001***	***<0.001***	***<0.001***	***<0.001***

*Mann Whitney U was used

who had acquired stroke knowledge through public education seminars recognized symptoms within 72.2 ± 35.7 minutes on average. This was followed by those informed by healthcare professionals (83.0 ± 24.8 minutes), and social media (108.9 ± 19.6 minutes). All three groups had significantly shorter recognition times than those who relied on friends or relatives for information (mean: 163.9 ± 30.2 minutes).

Regarding the time to contact emergency services, all four informed groups (public seminars, healthcare professionals, social

Table 4: Relationship between education status of healthcare contacts and pre-hospital time intervals

Education Level		Median (Q1 – Q3) minutes			
		Time to recognize symptoms	**Time to call emergency services**	**Time from symptom recognition to hospital arrival**	**Symptom-to-door time**
Primary school	Yes	60(23-60)	127(51-285)	227(85-371)	315(108-606)
	None	30(10-180)	28(11-75)	73(45-147)	158(69-376)
	p*	***0.062***	***0.024***	***<0.001***	***0.002***
Middle school	Yes	60(30-243)	86(25-287)	181(85-347)	372(171-632)
	None	30(5-180)	27(11-68)	67(42-134)	143(66-346)
	p*	***0.008***	***<0.001***	***<0.001***	***<0.001***
High school	Yes	105(30-240)	36(16-106)	104(55-187)	288(138-509)
	None	30(5-90)	27(10-69)	70(42-134)	122(58-343)
	p*	***<0.001***	***0.080***	***0.008***	***<0.001***
University	Yes	15(5-60)	25(10-50)	60(39-110)	96(55-223)
	None	60(30-240)	44(20-152)	129(60-243)	306(149-535)
	p*	***<0.001***	***<0.001***	***<0.001***	***<0.001***

*Mann Whitney U was used

Table 5: Relationship between education status of healthcare contacts and pre-hospital time intervals

Education level		Median (Q1 – Q3) minutes			
		Time to recognize symptoms	Time to call emergency services	Time from symptom recognition to hospital arrival	Symptom-to-door time
Primary school	Yes	60(23-60)	127(51-285)	227(85-371)	315(108-606)
	None	30(10-180)	28(11-75)	73(45-147)	158(69-376)
	p*	***0.062***	***0.024***	***<0.001***	***0.002***
Middle school	Yes	60(30-243)	86(25-287)	181(85-347)	372(171-632)
	None	30(5-180)	27(11-68)	67(42-134)	143(66-346)
	p*	***0.008***	***<0.001***	***<0.001***	***<0.001***
High school	Yes	105(30-240)	36(16-106)	104(55-187)	288(138-509)
	None	30(5-90)	27(10-69)	70(42-134)	122(58-343)
	p*	***<0.001***	***0.080***	***0.008***	***<0.001***
University	Yes	15(5-60)	25(10-50)	60(39-110)	96(55-223)
	None	60(30-240)	44(20-152)	129(60-243)	306(149-535)
	p*	***<0.001***	***<0.001***	***<0.001***	***<0.001***

*Mann Whitney U was used

media, friends/relatives) demonstrated notably shorter delays compared to those with no prior information (all $p < 0.001$). Pairwise comparisons revealed that individuals educated through public seminars contacted emergency services significantly faster than those informed by friends or relatives ($p = 0.030$). Similar advantages were found for individuals informed by healthcare professionals ($p = 0.003$) and social media ($p = 0.017$).

In terms of hospital arrival times following symptom recognition, patients educated through public seminars ($p < 0.001$), healthcare professionals ($p < 0.001$), social media ($p < 0.001$), and even friends/relatives ($p = 0.005$) arrived significantly sooner than those with no prior information source. Moreover, public seminars, social media, and healthcare professionals were each more effective in reducing hospital arrival times than relying solely on friends or relatives (each $p < 0.001$).

DISCUSSION

Stroke remains one of the leading causes of mortality and morbidity worldwide, constituting a significant public health challenge with profound social and economic implications. Prioritizing stroke within healthcare systems is essential, particularly in light of the strong evidence supporting the prevention of adverse outcomes through early recognition and prompt treatment. This preventive potential represents one of the most significant advantages in stroke management. To effectively reduce stroke-related mortality and long-term disability, it is crucial to comprehensively identify modifiable risk factors and clearly define target populations, including their demographic characteristics.

In this study, the attitudes, awareness levels, and influencing factors during the prehospital phase were comprehensively evaluated among individuals experiencing their first-ever stroke and their relatives in Eskişehir and its surrounding regions. The findings indicate that the prehospital process is influenced by a wide range of demographic, socioeconomic, and cognitive variables. Furthermore, to our knowledge, this is one of the few studies in Turkey that explores prehospital behavior by integrating demographic, cognitive, and system-level variables within the same framework. While existing literature from high-income countries provides valuable insight, the sociocultural and infrastructural dynamics in middle-income countries like Turkey present unique challenges.

According to the literature, approximately 87% of strokes worldwide are ischemic, 10% are hemorrhagic, and 3% are subarachnoid hemorrhages.[9] In our study, the rate of ischemic stroke was found to be 83.6%, while hemorrhagic

strokes accounted for 7.5%, showing some minor discrepancies compared to the reported global figures. These differences may be primarily attributed to the exclusion criteria of our study, which did not include all stroke cases. Additionally, since Eskişehir serves as a regional stroke center, ischemic stroke patients are more frequently referred to our facility for advanced treatment options such as rtPA administration and EVT. This referral pattern may have contributed to the relatively lower proportion of hemorrhagic strokes observed in our cohort.

In our study, we found that patients' residential status had a significant impact on prehospital processes, with single individuals experiencing notably longer times to reach the hospital. However, lifestyle did not significantly influence the time taken to recognize symptoms or contact healthcare services. Similarly, previous studies have reported that single patients and those living in rural areas face delays in accessing healthcare, often attributed to factors such as limited social support and transportation challenges. These findings highlight that sociocultural factors such as living arrangements and place of residence play a critical role in stroke management. Therefore, targeted strategies should be developed to address the needs of these vulnerable groups in order to prevent delays in emergency care. Variations across studies may be explained by differences in the sociocultural characteristics of the populations examined. Our analysis revealed that the utilization rate of ambulance services was higher than those reported in previous studies. Specifically, it exceeded the rates reported by Shin *et al*. (32.5%).[10] Jin *et al*. (23.1%)[11], and Lacy *et al*. (65%).[12] Notably, ambulance use was particularly elevated among individuals living in rural areas. This may be explained by the fact that ambulance services in our country are free of charge and readily accessible. Furthermore, the higher concentration of individuals with relatively low socioeconomic status in rural regions may contribute to this finding. Another contributing factor could be the designation of our study hospital as a regional stroke center, where, under the national "brain attack" protocol, patients are directly referred via ambulance through coordination between the 112 emergency services and other healthcare facilities.

A notable finding in this study was that more than half of the individuals who contacted healthcare services had a university-level or higher education, which is striking when compared to the lower rates reported in the literature.[11,13] This may be partially explained by the fact that individuals accessing healthcare in our sample were predominantly younger adults, a demographic that generally has higher levels of education. The impact of educational attainment on early access to medical care has been addressed in previous studies with mixed results. For instance, Derex *et al*.[14] reported that higher education was associated with earlier hospital arrival, while Christina *et al*.[15] and Chang *et al*.[16] found no significant association between patients' own education level and time to hospital presentation. In our analysis, however, a clear trend emerged: higher levels of education were associated with shorter prehospital times. In particular, university-level education appeared to play a critical role in reducing the time to contact medical professionals, reach the hospital, and shorten symptom-to-door intervals.

Stroke can present with a wide range of neurological symptoms. In this clinical context, where time is of the essence, early recognition of stroke symptoms is critical for prompt access to effective treatment and, ultimately, for reducing mortality and morbidity. Therefore, the diagnostic process should begin in the prehospital phase, and all patients should undergo rapid neurological assessment. In our study, the most commonly observed symptoms were unilateral weakness and speech impairment. Similarly, in the literature, Warlow *et al*.[17] identified altered consciousness, unilateral weakness, and headache as the most frequent symptoms, while Moulin *et al*.[18] emphasized that stroke should be highly suspected in cases presenting with unilateral weakness. Martikainen *et al*.[19] also reported that patients exhibiting altered consciousness and motor weakness were more likely to be diagnosed with stroke. These findings collectively highlight that symptoms such as unilateral weakness, speech disturbances, and changes in consciousness are key clinical indicators of stroke. Furthermore, in our study, when patients or their relatives were asked which condition they initially suspected upon observing these symptoms, prehospital times were significantly longer among those who suspected a condition other than stroke. This underscores the importance of increasing public awareness of stroke symptoms, which may play a crucial role in reducing delays and promoting timely medical intervention.

Despite ongoing efforts to reduce prehospital delays, access to thrombolytic therapy remains suboptimal. According to the literature, only 3–8.5% of stroke patients in the United States receive thrombolytic treatment.[20] These rates

vary across studies conducted in different centers, likely due to differences in patient demographics, evolving diagnostic criteria, and institutional care models. In our study, the rate of thrombolytic therapy (rtPA) administration was higher than that reported in some previous studies. This may be attributed to several factors, including the referral of patients from nearby provinces and healthcare institutions under an established protocol, the exclusion of certain cases based on predefined criteria, and the lack of complete admission data for some referred patients—particularly given our hospital's designation as a regional stroke center. Similarly, our rate of endovascular intervention was notably high, which may reflect both our central geographic location and the presence of specialized infrastructure and expertise.

Based on the findings of our study, it is essential to consider the sociodemographic characteristics of the target population such as education level and age group when designing strategies to enhance public awareness of stroke. Social media and digital platforms may be particularly effective in reaching younger and more educated individuals, while healthcare professionals should play a more proactive role in educating patients and their families. Furthermore, expanding community-based seminars and outreach initiatives may promote the early recognition of stroke symptoms and contribute to reducing prehospital delays. From a public health policy perspective, these findings highlight the need for integrated national stroke awareness campaigns that combine digital outreach with face-to-face education. Incorporating stroke education into routine primary care visits and school-based health programs, and allocating resources to support interdisciplinary collaborations between emergency services and public education units, may also enhance early detection and timely access to care. Health authorities should prioritize the development of structured, evidence-based awareness programs tailored to specific population segments to maximize impact.

In conclusion, this study underscores the urgent need to improve prehospital stroke response to enhance the effectiveness of time-sensitive interventions such as thrombolysis and thrombectomy. A significant proportion of patients in our cohort presented outside the recommended treatment windows, emphasizing the need for targeted strategies to reduce delays. Based on our findings, three key public health priorities emerge: (1) expanding targeted public education campaigns to improve symptom recognition, particularly among individuals with lower education levels and those living alone; (2) integrating stroke awareness training into school curricula, workplace programs, and primary care; and (3) strengthening coordination between EMS and stroke centers through real-time triage protocols and early notification systems.

Despite free and accessible ambulance services, our results highlight persistent context-specific barriers, such as limited symptom awareness in certain demographic groups. Compared to similar studies from urban China, India, and Eastern Europe, we observed higher ambulance utilization and better symptom recognition among educated individuals suggesting that public health efforts should be tailored to population characteristics.

To improve stroke outcomes, nationwide, evidence-based interventions should prioritize health literacy from an early age using both digital platforms and face-to-face education. Equipping healthcare professionals with current knowledge and establishing well-structured communication networks between EMS and stroke centers are also essential. With this multidimensional approach, better outcomes in stroke care can be achieved in alignment with the principle: "education = time = brain."

DISCLOSURE

Financial support: None

Conflict of interest: None

REFERENCES

1. Feigin VL, Abajobir AA, Abate KH, *et al.* Global, regional, and national burden of neurological disorders during 1990–2015: a systematic analysis for the global burden of disease study 2015. *Lancet Neurol* 2017;16(11):877-97. DOI: 10.1016/S1474-4422(17)30299-5
2. National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. Tissue plasminogen activator for acute ischemic stroke. *N Engl J Med* 1995;333(24):1581-7. DOI: 10.1056/NEJM199512143332401
3. Powers WJ, Rabinstein AA, Ackerson T, *et al*. 2018 guidelines for the early management of patients with acute ischemic stroke: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke* 2018;49(3):e46-110. DOI: 10.1161/STR.0000000000000158
4. Saver JL, Fonarow GC, Smith EE, *et al.* Time to treatment with intravenous tissue plasminogen activator and outcome from acute ischemic stroke. *JAMA* 2013;309(23):2480-8. DOI: 10.1001/jama.2013.6959
5. Fogelholm R, Murros K, Rissanen A, Ilmavirta

M. Factors delaying hospital admission after acute stroke. *Stroke* 1996;27(3):398-400. DOI: 10.1161/01.str.27.3.398
6. Lacy CR, Suh DC, Bueno M, Kostis JB. Delay in presentation and evaluation for acute stroke. *Stroke* 2001;32(1):63-9. DOI: 10.1161/01.str.32.1.63
7. Barsan WG, Brott TG, Broderick JP, Haley EC, Levy DE, Marler JR. Time of hospital presentation in patients with acute stroke. *Arch Int Med* 1993;153(22):2558-61.
8. Ozakin E, Ozdemir AO, Aykac O, Cevik AA. Effect of off-hour versus work-hour thrombolysis for acute ischemic stroke on emergency department patients' outcome: a retrospective study. *Eur J Emerg Med* 2021;28(2):104. DOI: 10.1097/MEJ.0000000000000757
9. Martin SS, Aday AW, Almarzooq ZI, *et al.* 2024 heart disease and stroke statistics: A report of US and global data From the American Heart Association. *Circulation* 2024;149(8):e347–913. DOI:10.1161/CIR.0000000000001209
10. Shin CN, An K, Sim J. Facilitators of and barriers to emergency medical service use by acute ischemic stroke patients: A retrospective survey. *Int J Nurs Sci* 2017;4(1):52-7. DOI: 10.1016/j.ijnss.2016.12.008
11. Jin H, Zhu S, Wei JW, *et al*. Factors associated with prehospital delays in the presentation of acute stroke in urban China. *Stroke* 2012;43(2):362-70. DOI: 10.1161/STROKEAHA.111.623512
12. Lacy CR, Suh DC, Bueno M, Kostis JB. Delay in presentation and evaluation for acute stroke: Stroke Time Registry for Outcomes Knowledge and Epidemiology (S.T.R.O.K.E.). *Stroke* 2001;32(1):63-9. DOI: 10.1161/01.str.32.1.63
13. Eriksson M, Glader E, Norrving B, Stegmayr B, Asplund K. Acute stroke alert activation, emergency service use, and reperfusion therapy in Sweden. *Brain Behav* 2017;7(4):e00654. DOI: 10.1002/brb3.654
14. Derex L, Norbert PA, Nighoghossian N. Factors influencing early admission in a French stroke unit. *Stroke* 2002;33(1):153-9. DOI: 10.1161/hs0102.100533.
15. Iosif C, Papathanasiou M, Staboulis E, Gouliamos A. Social factors influencing hospital arrival time in acute ischemic stroke patients. *Neuroradiology* 2012;54(4):361-7. DOI: 10.1007/s00234-011-0884-9
16. Chang KC, Tseng MC, Tan TY. Prehospital delay after acute stroke in Kaohsiung, Taiwan. *Stroke* 2004;35(3):700-4. DOI: 10.1161/01.STR.0000117236.90827.17
17. Warlow C, Humphrey P, Venables G. UK neurologists and the care of adults with acute neurological problems. *Clin Med* 2002;2(5):436-9. DOI: 10.7861/clinmedicine.2-5-436
18. Moulin T, Sablot D, Vidry E, *et al.* Impact of emergency room neurologists on patient management and outcome. *Eur Neurol* 2003;50(4):207-14. DOI: 10.1159/000073861
19. Martikainen K, Kaija S, Viita P, Rajala S, Laippala P, Keränen T. Transient loss of consciousness as reason for admission to primary health care emergency room. *Scand J Prim Health Care* 2003;21(1):61-4. DOI: 10.1080/02834310000591
20. Reeves MJ, Arora S, Broderick JP, *et al*. Acute stroke care in the US: Results from 4 pilot prototypes of the Paul Coverdell National Acute Stroke Registry. *Stroke* 2005;36(6):1232-40. DOI: 10.1161/01.STR.0000165902.18021.5b