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STROKE AND THROMBOLYTIC THERAPY AWARENESS AMONG MEDICAL STUDENTS: A CROSS-SECTIONAL STUDY AT DAI NAM UNIVERSITY, VIETNAM

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ABSTRACT

Background: Stroke is a critical global health issue, consistently ranking as a leading cause of mortality and long-term disability. In Vietnam, while stroke units have expanded, public awareness and the timely use of advanced therapies remain significant challenges. This study aims to assess the awareness regarding stroke and thrombolytic therapy among medical students at Dai Nam University in 2024.

Methods: A cross-sectional descriptive study was conducted from November 2024 to March 2025 at Dai Nam University, Hanoi. Data were collected through a self-administered structured questionnaire. Descriptive statistics and SPSS version 25.0 were used for data analysis, with the Chi-square test employed to compare between pre-clinical and clinical groups.

Results: Among 228 medical students in the study, a vast majority of participants (97.4%) had previously heard of stroke, but only 46.1% were aware of thrombolytic therapy. Clinical students demonstrated significantly higher proficiency in identifying risk factors and warning signs, such as limb weakness (93.9%) and facial deviation (93.1%), compared to pre-clinical students ($p < 0.05$). Notably, only 19.7% of the total sample correctly identified the 4.5-hour "golden hour" window for thrombolysis. While 72.8% of students chose immediate emergency transport as the primary action, a small proportion (6.1%) still favored unscientific traditional practices.

Conclusion: The study highlights a substantial gap between general stroke awareness and specific knowledge of emergency interventions among medical students. While clinical training significantly improves symptom recognition, there is a need to enhance education regarding the time-sensitive nature of thrombolytic therapy. These results emphasize the necessity of updating medical curricula to include more focused training on acute stroke protocols and the 4.5-hour treatment window to improve future stroke care in Vietnam.

Keywords: Stroke, Thrombolysis, Awareness, Medical Students, Dai Nam University.

1. INTRODUCTION

Stroke remains a critical global health challenge, consistently ranking as the second leading cause of mortality and the third leading contributor to disability-adjusted life years (DALYs) worldwide [1]. The epidemiological landscape of stroke is shifting significantly, with low- and middle-income countries (LMICs) experiencing a sharp rise in incidence compared to high-income nations [2,3]. In these regions, stroke often occurs at a younger age and is associated with higher case fatality rates, creating a substantial socioeconomic burden [3,4].

Vietnam, as a rapidly developing country in Southeast Asia, reflects this growing crisis. Recent data from the Global Burden of Disease (GBD) indicates that stroke is the primary cause of death among cardiovascular diseases in the country, accounting for over 135,000 fatalities annually [5]. The incidence and prevalence of stroke in major Vietnamese metropolitan areas, such as Hanoi and Ho Chi Minh City, are among the highest in the region, driven by prevalent risk factors including hypertension, unhealthy diets, and increasing fasting plasma glucose levels [6]. Despite these alarming figures, the healthcare infrastructure and public awareness required for effective stroke management remain inconsistent, particularly in rural areas.

The prognosis of acute ischemic stroke has been revolutionized by reperfusion therapies, specifically intravenous thrombolysis using alteplase [7,8]. However, the efficacy of this treatment is strictly time-dependent, requiring administration within a narrow "golden hour" window—typically 4.5 hours from symptom onset [9,10]. In Vietnam, while specialized stroke units have expanded in urban centers, the utilization of thrombolysis remains low due to significant pre-hospital delays and a lack of public knowledge regarding stroke recognition.

Medical students represent a pivotal group in bridging this gap in awareness. As future healthcare professionals, their proficiency in identifying stroke warning signs and understanding the urgency of thrombolytic therapy is essential for improving clinical outcomes. Furthermore, they serve as vital health educators within their families and communities, potentially reducing the time between symptom onset and hospital arrival.

While studies have assessed the awareness regarding stroke in various populations, there is limited research focusing specifically on medical students within the

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Vietnamese private university context. Therefore, this study aims to evaluate the awareness regarding stroke and thrombolysis among medical students at Dai Nam University. By identifying specific deficiencies in their understanding, this research seeks to provide evidence-based recommendations for enhancing medical curricula and strengthening the future workforce's capacity to manage the stroke epidemic in Vietnam.

2. MATERIALS AND METHODS

2.1. Study design

A cross-sectional descriptive study was conducted from November 2024 to March 2025 at Dai Nam University, Hanoi, Vietnam.

2.2. Study subjects

The study subjects were medical students in the Faculty of Medicine of Dai Nam University. The study participants were selected based on the following criteria:

- ***Inclusion Criteria:*** Full-time undergraduate medical students currently enrolled at Dai Nam University during the study period. Students from all academic years (from first to fith year) and all genders were eligible for participation.

- ***Exclusion Criteria:*** Students not enrolled in the Faculty of Medicine (e.g., students from other departments such as Pharmacy or Nursing). Individuals who declined to provide informed consent or refused to participate in the survey.

2.3. Data collection

A convenience sampling method with a total population approach was employed. All medical students currently enrolled at Dai Nam University who met the inclusion criteria and were available during the study period were invited to participate.

The survey was initially designed using Google Forms and pre-tested on 10 students to standardize the instrument and ensure the clarity of the questions. Following the pilot test, the finalized questionnaire was distributed via a web link and QR code through official student groups and social media platforms. Additionally, invitations were extended during class breaks to encourage participation. Collected data were reviewed, cleaned, and verified daily. The final dataset was exported from Google Forms into an Excel file for further processing. After data cleaning and verification, 228 responses were deemed eligible for study inclusion.

2.4. Study tool

The research utilized a self-administered, structured questionnaire adapted from the validated instrument by [11]. The tool was designed to evaluate the primary components of knowledge regarding stroke and consisted of the following sections:

Part 1: Current year of study.

Part 2: Knowledge of stroke: Covered general information, risk factors (e.g., hypertension, smoking, oily food), and warning signs (e.g., limb weakness, facial deviation, speech difficulties).

Part 3: Knowledge of thrombolysis: Assessed awareness of thrombolytic therapy, the "golden hour" window period, and specialized centers providing this treatment.

Part 4: Attitudes and Practices: Evaluated the students' perspectives on stroke preventability and their intended actions when witnessing a suspected stroke case.

2.5. Variables and Indicators

Independent Variables: Academic level (Pre-clinical: Years 1–2; Clinical: Years 3–6).

Dependent Variables:

Knowledge: Proportion of students correctly identifying risk factors, symptoms, and the 4.5-hour thrombolysis window.

Attitude: Percentage of students believing stroke is treatable/preventable.

Practice: Percentage of students choosing to take a patient to the emergency department immediately.

2.6. Data Analysis

Quantitative data were cleaned and entered into a computer using Excel software and analyzed with SPSS version 25.0. Descriptive statistics, such as percentages and frequencies, were used for categorical variables. Mean, standard deviation (SD), maximum, and minimum values were calculated for continuous variables. The Chi-square test was applied to analyze the associations between academic year and the awareness's levels, with a P-value < 0.05 considered statistically significant.

2.7. Ethical Considerations

The research protocol was reviewed and approved by the Scientific Council of Dai Nam University. All participants were thoroughly informed about the study's objectives and procedures. Participation was entirely voluntary, and interviews were conducted only after obtaining informed consent. All personal information was kept strictly confidential, anonymized during analysis, and used solely for research purposes.

3. RESULTS

Of the 228 students participating in the study, first-year students had the highest participation rate (35.1%), followed by fifth-year students (28.5%) and fourth-year students (25.0%), while third-year students had the lowest participation rate at only 3.9%.

While nearly all participants (97.4%) had previously heard of stroke, there was a significant difference in clinical exposure; clinical students were twice as likely to have seen a stroke patient compared to their pre-clinical counterparts (69.5% vs 34.0%, p < 0.001). Regarding anatomical knowledge, the clinical group demonstrated a significantly higher accuracy in identifying the brain as the affected organ (96.9%) compared to the pre-clinical group (76.3%, p < 0.001).

Table 1. General information about stroke (n=228)

General information about stroke	n (%)	Academic level		p-value
		Pre-clinical	Clinical	
Heard about stroke				
Yes	222 (97.4)	93 (95.9)	129 (98.5)	0.226
No	6 (2.6)	4 (4.1)	2 (1.5)	
Seen someone with stroke				
Yes	124 (54.4)	33 (34.0)	91 (69.5)	< 0.001
No	104 (45.6)	64 (66.0)	40 (30.5)	

General information about stroke	n (%)	Academic level		p-value
		Pre-clinical	Clinical	
Stroke can be prevented				
Yes	219 (96.1)	92 (94.8)	127 (96.9)	0.420
No	9 (3.9)	5 (5.2)	4 (3.1)	
Stroke is a communicable disease				
Yes	5 (2.2)	1 (1.0)	4 (3.1)	0.303
No	223 (97.8)	96 (99.0)	127 (96.9)	
Stroke is a hereditary disease				
Yes	72 (31.6)	20 (20.6)	52 (39.7)	0.002
No	156 (68.4)	77 (79.4)	79 (60.3)	
The organ is affected by stroke				
Brain	201 (88.2)	74 (76.3)	127 (96.9)	< 0.001
Others	27 (11.8)	23 (23.7)	4 (3.1)	
Risk factor of stroke*				
Smoking	164 (71.9)	59 (60.8)	105 (80.2)	0.001
Alcohol	179 (78.5)	68 (70.1)	111 (84.7)	0.008
Heredity	73 (32.0)	19 (19.6)	54 (41.2)	0.001
Oily food	161 (70.6)	60 (61.9)	101 (77.1)	0.012
Hypertension	217 (95.2)	89 (91.8)	128 (97.7)	0.038
Diabetes mellitus	147 (64.5)	44 (45.4)	103 (78.6)	< 0.001
Signs and symptoms with positive response*				
Double vision	84 (36.8)	21 (21.6)	63 (48.1)	< 0.001
Blindness	32 (14.0)	11 (11.3)	21 (16.0)	0.313
Slurring of speech	150 (65.8)	52 (53.6)	98 (74.8)	0.001
Facial weakness	201 (88.2)	79 (81.4)	122 (93.1)	0.007
Loss of consiousness	172 (75.4)	64 (66.0)	108 (82.4)	0.004
Abnormal body movements	176 (77.2)	81 (83.5)	95 (72.5)	0.051
Weakness of limbs	199 (87.3)	76 (78.4)	123 (93.9)	< 0.001
Headache	151 (66.2)	53 (54.6)	98 (74.8)	0.001

**: Can choose more than one answer*

Knowledge of risk factors also varied significantly; clinical students identified hypertension (97.7%), diabetes mellitus (78.6%), and smoking (80.2%) as major risk factors more frequently than pre-clinical students. Similarly, the recognition of warning signs was notably higher among clinical students, particularly for weakness of limbs (93.9%) and facial weakness (93.1%). Although double vision was the least recognized symptom overall, awareness was substantially better in the clinical cohort (48.1% vs 21.6%, p < 0.001) (Table 1).

Table 2. Information about the treatment and prognosis of stroke (n=228)

Information about the treatment and prognosis of stroke	n(%)	Academic level		p-value
		Pre-clinical	Clinical	
Actions after recognizing a stroke				
Take patient to emergency immediately	166 (72,8)	65 (67.0)	101 (77.1)	0.096
Cardiopulmonary resuscitation (CPR)	36 (15.8)	15 (15.5)	21 (16.0)	
Finger-prick bloodletting	14 (6.1)	9 (9.3)	5 (3.8)	
Unknown	12 (5.3)	8 (8.2)	4 (3.1)	
Stroke can be treated				
Yes	164 (71.9)	63 (64.9)	101 (77.1)	0.044
No	64 (28.1)	34 (35.1)	30 (22.9)	
Prognosis/Needs of stroke patients*				
Needs lifelong medications	132 (57.9)	53 (54.6)	79 (60.3)	NA
Requires family assistance throughout their life	130 (57.0)	68 (70.1)	62 (47.3)	
Improves with appropriate physiotherapy	217 (95.2)	89 (91.8)	128 (97.7)	
Bed-ridden for life	34 (14.9)	22 (22.7)	12 (9.2)	

Best means for public awareness*				
Newspapers	169 (74.1)	73 (75.3)	96 (73.3)	NA
Radio/ television	173 (75.9)	73 (75.3)	100 (76.3)	
Doctors/ medical personal	179 (78.5)	72 (74.2)	107 (81.7)	
Posters and pamphlets	141 (61.8)	60 (61.9)	81 (61.8)	
Community and school based programs	202 (88.6)	88 (90.7)	114 (87.0)	

**: Can choose more than one answer*

When asked about the immediate action for a suspected stroke case, 72.8% of all students correctly chose to transport the patient to the emergency department immediately. Although clinical students showed a higher compliance rate with this practice compared to pre-clinical students (77.1% vs 67.0%), the difference did not reach statistical significance (p = 0.096). Notably, a small proportion of students still favored incorrect traditional methods, such as finger-prick bloodletting (6.1%). Regarding treatment perspectives, a significantly higher percentage of clinical students (77.1%) believed that stroke is a treatable condition compared to those in the pre-clinical phase (64.9%, p = 0.044). In terms of prognosis, the vast majority (95.2%) recognized the importance of physiotherapy in recovery. However, pre-clinical students were more likely to perceive stroke patients as being permanently bedridden (22.7%) or requiring lifelong family assistance (70.1%) compared to clinical students. For public education, community and school-based programs were identified as the most ef fective means of raising awareness (88.6%), followed by guidance from medical personnel (78.5%) (Table 2).

Table 3. General information about thrombolytic therapy (n=228)

General information about thrombolytic therapy	n (%)	Academic level		p-value
		Pre-clinical	Clinical	
Heard about thrombolysis				
Yes	105 (46.1)	21 (21.6)	84 (64.1)	< 0.001
No	123 (53.9)	76 (78.4)	47 (35.9)	
Approriate time to initiate definitive treatment				
Within 4.5 hours	45 (19.7)	8 (8.2)	37 (28.2)	< 0.001
Others	183 (80.3)	89 (91.8)	94 (71.8)	
Indication for thrombolytic therapy				
Ischemic stroke	100 (43.9)	18 (18.6)	82 (62.6)	< 0.001
Others	128 (56.1)	79 (81.4)	49 (37.4)	
Where to apply this therapy				
Provincial and Central Hospitals	38 (16.7)	17 (17.5)	21 (16.0)	NA
Qualified centers	141 (61.8)	48 (49.5)	93 (71.0)	
All hospitals	49 (21.5)	32 (33.0)	17 (13.0)	

Knowledge regarding thrombolytic therapy showed a substantial disparity between the two academic groups (Table 3). Less than half of the total participants (46.1%) had heard of thrombolysis, with clinical students being significantly more aware than their pre-clinical peers (64.1% vs 21.6%, p < 0.001). Regarding the "golden hour" for treatment, only 19.7% of the total sample correctly identified the 4.5-hour window. Although clinical students demonstrated better knowledge, their recognition rate remained low at 28.2%. Furthermore, while 62.6% of clinical students correctly identified ischemic stroke as the primary indication for thrombolysis, only 18.6% of pre-clinical students could do so (p < 0.001). Most clinical students (71.0%) understood that this therapy can only be applied in specialized, qualified medical centers rather than all hospitals.

4. DISCUSSION

This study aimed to assess the current awareness status regarding stroke and thrombolytic therapy among medical students at Dai Nam University. Out of 228 participants, most (97.4%) had previously heard of stroke, 54.4% of the students had witnessed a stroke patient in a clinical setting. The high general awareness and clinical exposure in our sample underscore the impact of specialized medical training as students progress through their academic years.

The distribution of participants across academic years reveals a distinct pattern within the medical program at Dai Nam University. Our study observed the highest participation rates among first-year students (35.1%), followed by those in their fifth (28.5%) and fourth years (25.0%). Conversely, third-year students represented the smallest proportion of the sample at only 3.9%. Several institutional factors contribute to this distribution. First, the Faculty of Medicine at Dai Nam University is a relatively young institution, currently in its fifth year of medical training. Consequently, the fifth-year cohort represents the most senior class at the time of the study. Second, the significantly lower response rate among third-year students can be attributed to the curriculum schedule during the data collection period. During this time, the third-year cohort was predominantly engaged in clinical rotations at off-campus affiliated hospitals. This physical absence from the university campus likely limited their accessibility to the survey, despite the distribution of the questionnaire through digital platforms.

This variation in participation across academic levels provides a comprehensive "snapshot" of knowledge progression—from students just entering the medical

field to those nearing the completion of their clinical training. Similar to findings by Pradhan et al. [11], where students at different stages of preparation showed varying levels of awareness, our study highlights how evolving clinical exposure within a developing medical faculty influences the collective understanding of complex conditions like stroke.

Our study demonstrates a significant progression in stroke-related knowledge as students transition from pre-clinical to clinical years. While general awareness of stroke was high across the entire sample (97.4%), the depth of understanding regarding its pathophysiology and clinical manifestation was markedly superior in the clinical group.

A notable finding was the clinical students' high accuracy in identifying the brain as the affected organ (96.9%). This near-universal recognition in the senior years reflects the impact of specialized modules such as Internal Medicine and Neurology, which are typically introduced in the later stages of the medical curriculum. In contrast, the lower accuracy among pre-clinical students (76.3%) suggests that early-year medical education may still focus more on general biology rather than specific disease pathology. The disparity in risk factor recognition further emphasizes the value of clinical exposure. The significant gap in identifying diabetes mellitus (78.6% in clinical vs. 45.4% in pre-clinical) and hypertension as major precursors to stroke indicates that senior students have a better grasp of the "cardiovascular risk cluster." These results are consistent with a study conducted among medical students in Jordan, which also reported that clinical rotations significantly bolster the ability to link chronic non-communicable diseases with acute vascular events [12]. Moreover, the clinical group's ability to recognize classic symptoms, such as facial weakness (93.1%) and limb weakness (93.9%), was significantly higher. These "red flag" symptoms are crucial for the rapid initiation of the "FAST" protocol in emergency settings [13]. Interestingly, less common symptoms like double vision remained poorly recognized by junior students (21.6%), whereas nearly half of the clinical students correctly identified them. This suggests that while basic symptoms are part of common knowledge, the identification of more subtle neurological deficits is a specific competency acquired through bedside teaching and direct patient interaction.

Our findings also highlight a critical link between direct experience and knowledge retention. Clinical students were twice as likely to have witnessed a stroke patient in a hospital setting compared to their juniors. This firsthand experience likely serves as a "clinical anchor," making theoretical knowledge about symptoms and risk factors more memorable and practically applicable. This trend aligns with the "experiential learning theory," where the transformation of experience leads to the creation of higher-level professional knowledge.

The transition from recognizing symptoms to taking appropriate action is a critical link in the stroke survival chain. Our results indicate that 72.8% of the participants correctly identified the need for immediate emergency transport (Table 2). Although this rate is higher in clinical students (77.1%) compared to pre-clinical students (67.0%), the lack of a statistically significant difference ($p = 0.096$) suggests that the urgency of stroke is a concept partially grasped even in early medical training. Interestingly, this finding is superior to the 58.5% reported in the Nepalese study [11], potentially reflecting the impact of digital health literacy and public health campaigns in Vietnam that emphasize the "Fast" response. However, a concerning finding is the persistence of traditional, non-scientific beliefs among a small segment of medical students. Approximately 6.1% of the sample—primarily in the pre-clinical years (9.3%)—still favored "finger-prick bloodletting" as an intervention. This traditional practice remains a significant hurdle in community health within Asian cultures, and its presence among medical students underscores the necessity of explicitly addressing and debunking such myths early in the medical curriculum to prevent the dissemination of misinformation to their future patients [14]. Regarding the prognosis of stroke, there was a significant shift in perspective between academic levels ($p = 0.044$). Clinical students were more optimistic about the treatability of stroke (77.1%) compared to pre-clinical students (64.9%). This shift likely stems from exposure to modern neuro-interventional techniques during clinical rotations. Furthermore, the high recognition of physiotherapy as a vital component of recovery (95.2%) is encouraging, as it aligns with the multidisciplinary approach required for long-term stroke rehabilitation.

A disparity was observed in the perception of disability: pre-clinical students were significantly more likely to perceive stroke as a "death sentence" or a state of permanent bed-riddenness compared to their seniors. This suggests that while junior students focus on the devastating outcomes of the disease, clinical education successfully shifts the focus toward management, recovery, and the potential for functional improvement. Finally, the consensus on the best means for public awareness highlights community and school-based programs (88.6%) as the preferred channel (Table 2). This aligns with the participants' own identity as students and reinforces the idea that educational institutions are powerful hubs for disseminating life-saving health information.

The most striking finding of our study lies in the significant deficiency of knowledge regarding thrombolytic therapy, even among students in their clinical years (Table 3). While medical students at Dai Nam University demonstrated high proficiency in recognizing stroke symptoms, their understanding of definitive emergency treatment remained suboptimal. Only 46.1% of the total sample had heard of thrombolysis, a figure that is significantly higher than the 23.8% reported in the Nepalese study, yet still insufficient for a cohort of future medical professionals [11]. The critical "time window" for intravenous thrombolysis, often referred to as the "golden hour," is perhaps the most vital piece of information for reducing stroke-related morbidity. However, our data revealed that only 19.7% of the participants correctly identified the 4.5-hour window. Even within the clinical group, where students have participated in hospital rotations, the recognition rate was surprisingly low at 28.2%.

A significant finding in our study was that among students who failed to identify the correct therapeutic window, a substantial majority incorrectly selected "within 3 hours" instead of the current 4.5-hour standard. This misconception is not a random error but is deeply rooted in the clinical history of thrombolytic therapy. Historically, the 3-hour window was the original protocol established by the landmark NINDS (National Institute of Neurological Disorders and Stroke) trial in 1995 [15], which led to the first FDA approval of alteplase for acute ischemic stroke. It was not until the ECASS III study in 2008 that this window was officially extended to 4.5 hours, demonstrating that treatment remains beneficial and safe within this expanded timeframe [16]. Several factors may explain this prevailing misconception among students. First, certain medical textbooks and lecture

materials, particularly older or translated editions, may still emphasize the 3-hour window as the conventional timeframe. Second, clinical practice strongly prioritizes the "earlier is better" principle. Although the formal limit is 4.5 hours, clinicians often target the initial 3 hours—the "golden period"—to maximize neuronal salvage. This clinical emphasis may lead students to perceive 3 hours as an absolute cutoff rather than the official limit. Third, students may be confused by the varying windows for different interventions, such as the 4.5-hour limit for intravenous thrombolysis versus the extended window (up to 24 hours in specific cases) for endovascular thrombectomy. Failure to recognize the full 4.5-hour window could result in flawed clinical judgment, where a student or future intern might prematurely disqualify a patient arriving at the 3.5-hour mark, believing they are already "out of window." Consequently, it is essential for the medical curriculum to explicitly address the evolution of stroke guidelines, ensuring students understand that every minute remains critical up to the 4.5-hour threshold.

The identification of ischemic stroke as the primary indication for thrombolysis showed a stark contrast between pre-clinical (18.6%) and clinical students (62.6%). This improvement demonstrates that as students progress to specialized neurology or internal medicine rotations, they begin to differentiate between stroke phenotypes. However, the fact that nearly one-third of clinical students could not correctly identify the appropriate stroke type for this therapy indicates a need for more focused clinical simulation or case-based learning.

Despite the valuable insights gained, this study has several limitations that should be acknowledged. Firstly, the use of a convenience sampling method at a single private university may limit the generalizability of the findings to the broader population of medical students in Vietnam. Students at other public or regional medical universities may have different levels of exposure to stroke management based on their specific clinical environments and curricula. Secondly, there was a significant disparity in the participation rates across academic years. The very low response rate from third-year students (3.9%) was due to their off-campus clinical rotations, which may have skewed the comparisons between pre-clinical and clinical groups. Thirdly, as the study relied on a self-administered questionnaire, there is a possibility of social desirability bias, where students might have selected answers they perceived as "correct" or "professional" rather than reflecting their true clinical instinct. Finally, the study measured "Practice" through hypothetical scenarios rather than direct observation in a clinical setting. Therefore, a high score in the survey does not necessarily guarantee the same level of performance when faced with a real-life medical emergency.

5. CONCLUSIONS

Our study reveals a high general awareness of stroke among medical students at Dai Nam University, with a clear progression of knowledge from pre-clinical to clinical years. Out of 228 participating students, 97.4% had heard of stroke, and clinical students demonstrated significantly higher proficiency in identifying correct anatomical structures, risk factors, and warning signs compared to their juniors. However, only 46.1% of the total sample were aware of thrombolytic therapy, and a mere 19.7% could correctly identify the 4.5-hour "golden hour" window. Furthermore, while most students favored evidence-based emergency actions, a small proportion still adhered to unscientific traditional practices like finger-prick bloodletting. These findings underscore the urgent need for medical curricula to place a stronger emphasis on acute stroke management and the time-sensitive nature of modern interventions.

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During the preparation of this manuscript, the authors used Large Language Models (Gemini, Google) in order to improve the language, clarity, and grammatical accuracy of the text. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the scientific integrity and accuracy of the final manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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