FACTORS ASSOCIATED WITH HOSPITAL ARRIVAL TIME IN ISCHEMIC STROKE PATIENTS AT BUDDHASOTHORN HOSPITAL: AN AMBISPECTIVE OBSERVATIONAL COHORT STUDY

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Background: Acute ischemic stroke is a leading cause of death and disability. Timely hospital arrival is critical for effective reperfusion therapy.
Objectives: This study aimed to identify factors influencing hospital arrival time and to assess the impact of emergency medical services (EMS) use on clinical outcomes among ischemic stroke patients at Buddhasothorn Hospital.
Methods: We conducted an ambispective observational cohort study of 195 patients with acute ischemic stroke admitted between January 2023 and May 2024, incorporating both retrospective medical record reviews and prospective patient interviews. We analyzed data on baseline characteristics, mode of transport, arrival time, and National Institutes of Health Stroke Scale (NIHSS) scores. Measures of association for delayed arrival (≥4.5 hours) were assessed using multivariate logistic regression to estimate adjusted odds ratios (aORs).
Results: Among 195 patients, 76 (38.9%) arrived within 4.5 hours of symptom onset, and 33 (16.9%) used EMS. Patients arriving within 4.5 hours had significantly lower discharge NIHSS scores compared with those arriving later (3.43 vs. 4.39, $p = 0.010$). EMS utilization was independently associated with a lower likelihood of delayed hospital arrival (aOR = 0.11, 95% CI: 0.02–0.81, $p = 0.030$). Additionally, patients with timely arrival demonstrated a greater reduction in mean NIHSS score compared to those with delayed arrival (mean difference in score improvement: 0.96 points, 95% CI: 0.23–1.69).
Conclusion: Early hospital arrival within 4.5 hours is associated with better stroke outcomes, yet the majority of patients still present late. EMS use is independently associated with reduced prehospital delay but remains underutilized.

Keywords: emergency medical services, hospital arrival time, ischemic stroke, stroke outcome

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Introduction

Acute ischemic stroke (AIS), caused by cerebral arterial occlusion, is a leading cause of death and disability worldwide, with 7.6 million new cases reported in 2022.[1] Thailand faces particularly high rates of stroke-related death and illness, with AIS incidence on the rise. National data (2009–2021) indicate a significant mortality rate (5.94% to 8.33%) among these patients.[2] Intravenous recombinant tissue plasminogen activator (rt-PA) within 4.5 hours of symptom onset is the standard therapy and has been shown to improve survival and functional outcomes.[3,4] However, a previous study in Thailand found that more than half of patients presented too late for this treatment, with 60.5% arriving more than 4.5 hours after symptom onset.[5] Previous studies, both in Thailand and globally, have consistently demonstrated that Emergency Medical Services (EMS) utilization is a critical determinant of shorter prehospital transit times.[5-8] Furthermore, evidence indicates that stroke patients who activate EMS often present with higher baseline National Institutes of Health Stroke Scale (NIHSS) scores compared to those who self-transport, suggesting that greater symptom severity triggers higher ambulance utilization. Therefore, this study aimed to identify sociodemographic and clinical factors associated with delayed hospital presentation (≥4.5 hours) among AIS patients at Buddhasothorn Hospital, and to evaluate the impact of EMS utilization on prehospital delay and NIHSS scores. We hypothesized that non-EMS transport and milder initial stroke severity would be independently associated with delayed arrival, and that EMS utilization would predict shorter transit times and superior clinical outcomes, characterized by significantly lower discharge NIHSS scores compared to self-transport.

Methods

This ambispective observational cohort study tracked AIS patients from presentation to discharge at Buddhasothorn Hospital, a tertiary referral center responsible for stroke care across Chachoengsao Province, Thailand. The study included 1) a retrospective phase (January 1, 2023-March 31, 2024): baseline characteristics, prehospital variables, and clinical data were extracted from Electronic Medical Records and hospital stroke registries, and 2) a prospective phase (April 1, 2024-May 31, 2024): real-time data were collected via structured patient/caregiver interviews and clinical assessments during hospital admission.

The hospital operates a dedicated 12-bed Stroke Unit with 24/7 in-house computed tomography (CT) capabilities. Magnetic resonance imaging (MRI) was utilized via an established external referral network to clarify and confirm diagnosis in ambiguous cases. **(Figure 1)**

Sample size and sampling strategy

The sample size was calculated based on a previous study by Wannarong et al.[6], which reported that 38.2% of AIS patients arrived within 4.5 hours; the required size was 156. After adding 10% for missing data, the target was 172-180. However, we included 195 patients (all eligible cases during the period) to maximize statistical power, especially for the multivariable analysis regarding EMS use.

To minimize potential seasonal variations and ensure a balanced temporal distribution of data across the 17-month study period, a non-probability consecutive quota sampling method was employed. Each calendar month was designated as a temporal stratum with a fixed enrollment quota (approximately 11–12 patients per month). Each month, consecutive eligible patients who met the inclusion criteria were enrolled until the monthly quota was reached, yielding a final cumulative sample of 195 patients.

Participants

The inclusion criteria included patients diagnosed with AIS based on acute focal neurological deficits and confirmed by neuroimaging (routinely performed brain CT upon presentation or brain MRI from a referral center for ambiguous clinical or initial CT findings). The exclusion criteria included patients or relatives who were unable to provide reliable information or those with incomplete or inconsistent symptom-onset data. These exclusions minimized recall and measurement errors in arrival time, though they introduced an acknowledged risk of non-random selection bias.

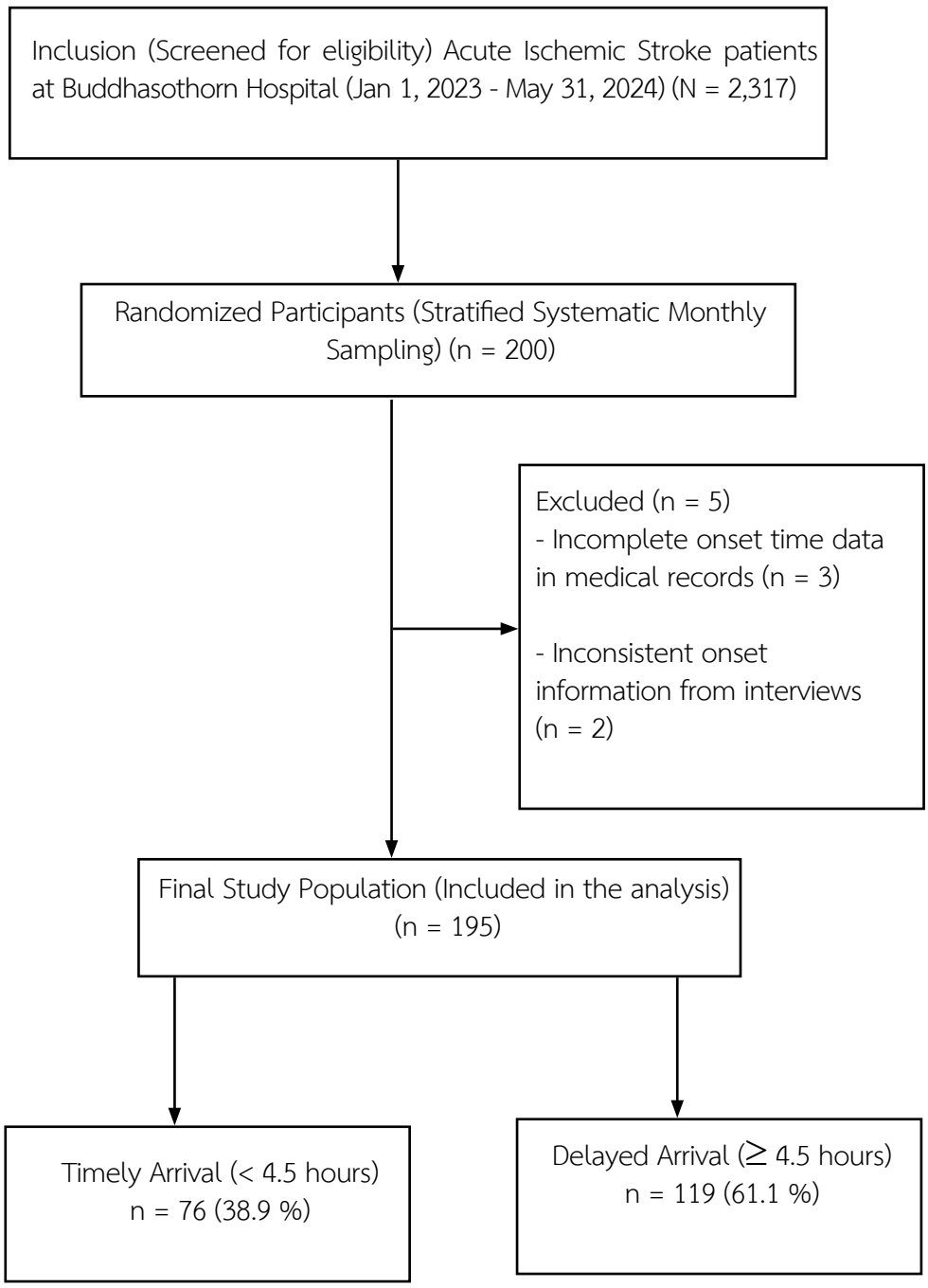

Figure 1: The study flow diagram

Variables and data sources

The primary outcome was delayed hospital arrival, defined as ≥4.5 hours from symptom onset to emergency department presentation (the standard therapeutic window for intravenous thrombolysis). The main exposure was transport mode: EMS (ambulance/rescue vehicles) versus non-EMS (self-transport or brought by relatives). Onset time was defined as the "Last Known Well" or witnessed onset time, extracted from Electronic Medical Records and verified through interviews. Covariates and potential confounders included age, sex, education, income, living arrangements, arrival time, and stroke-related knowledge. Stroke severity at admission was assessed using the NIHSS.

Statistical analysis

Baseline demographic and clinical characteristics were presented as frequencies with percentages for categorical variables, and as means ± standard deviation (SD) or medians with interquartile ranges (IQR) for continuous variables. Categorical variables were compared using

the Chi-square test or Fisher's exact test, while continuous variables were compared using Student's t-test or the Mann–Whitney U test, as appropriate.

To identify independent predictors of delayed arrival, variables with $p < 0.20$ in univariable analyses, along with clinically relevant confounders identified from the literature (selected regardless of their univariable statistical significance to minimize residual confounding), were entered into a multivariable logistic regression model. Multicollinearity among candidate variables was assessed using variance inflation factors (VIFs); variables with problematic collinearity (VIF > 5) were not included in the final model simultaneously.

The magnitudes of association were expressed as Odds Ratios (OR) and Adjusted Odds Ratios (aOR) with 95% Confidence Intervals (CI). Missing data were managed using complete-case analysis. Statistical significance was defined as a two-tailed p-value ≤ 0.05. This multivariable analysis was primarily exploratory, aimed at identifying factors associated with delayed presentation, rather than developing a formal predictive model.

Ethical approval

The study complied with the Declaration of Helsinki and was approved by the Buddhasothorn Hospital Institutional Review Board (BSH-IRB No. 021/2567). The committee waived informed consent because de-identified, routinely collected clinical data were used, posing minimal risk to subjects. Confidentiality was strictly maintained throughout the data handling and analysis process.

Results

A total of 2,317 acute ischemic stroke patients at Buddhasothorn Hospital were screened for eligibility between January 1, 2023, and May 31, 2024. From this pool, 200 participants were selected using stratified systematic monthly sampling. Of these, 5 patients were excluded: 3 due to incomplete onset time data in medical records and 2 due to inconsistent onset information from interviews. Consequently, a final study population of 195 patients was included in the analysis. This sample consisted of 76 patients (38.9%) in the timely arrival group (<4.5 hours) and 119 patients (61.1%) in the delayed arrival group (≥4.5 hours), as detailed in the study flow diagram **(Figure 1)**.

Patients with delayed (≥4.5 hours) and non-delayed (<4.5 hours) presentation were comparable in demographic, socioeconomic, and clinical characteristics (all $p > 0.05$). No significant differences were observed in gender distribution, mean age, educational attainment, income levels, time of hospital arrival, transfer procedures, or stroke-related knowledge of patients and transporters. The pre-treatment NIHSS score was also similar between the two groups ($p = 0.476$). Regarding acute treatment, a significantly higher proportion of patients in the delayed arrival group received rtPA therapy compared to those in the non-delayed group (100.0% vs. 84.2%, $p < 0.001$). However, the post-treatment NIHSS score was significantly lower in the non-delayed group (3.43 ± 4.10) than in the delayed group (4.39 ± 4.36; $p = 0.010$). The change in NIHSS (ΔNIHSS) favored the non-delayed group (−1.70 ± 3.24 vs. −0.74 ± 1.93), although the difference did not reach statistical significance ($p = 0.056$) (**Table 1**).

NIHSS scores at discharge were not significantly different between patients transported by EMS and non-EMS (4.39 ± 4.62 vs. 3.95 ± 4.21, $p = 0.681$). However, the change in NIHSS indicated greater improvement in the EMS group (−1.74 ± 2.77 vs. −0.99 ± 2.51), though not statistically significant ($p = 0.092$) (**Table 2**).

In multivariable logistic regression analysis, transport by EMS was independently associated with a lower likelihood of delayed presentation (OR 0.11, 95% CI 0.02–0.81; $p = 0.030$). Self-transfer showed a borderline association with non-delayed presentation (OR 0.17, 95% CI 0.03–1.10, $p = 0.063$), but did not reach statistical significance. Other factors, including education, income, and knowledge of stroke or stroke symptoms, were not significantly associated with delayed presentation (all $p > 0.05$)(**Table3**).

Table 1. Baseline characteristics of patients with delayed (≥4.5 hours) and non-delayed (<4.5 hours) stroke presentation

Characteristics	Delayed stroke (≥4.5 hr), N (%)	Not delayed stroke (<4.5 hr) N (%)
Sex		
Male	67 (56.30)	43 (56.58)
Female	52 (43.70)	33 (43.42)
Age (mean +/-SD)	62.51 (13.60)	62.51 (13.60)
Education		
Lower primary school	7 (5.88)	4 (5.26)
Upper primary school	67 (56.30)	42 (55.26)
Lower secondary school	15 (12.61)	11 (14.48)
Upper secondary school	12 (10.09)	9 (11.84)
Tertiary level	4 (3.36)	3 (3.95)
Others	14 (11.76)	7 (9.21)
Income (Baht/ month)		
0 – 5000	26 (21.85)	12 (15.79)
5001 – 10000	22 (18.49)	15 (19.73)
10001 – 20000	48 (40.34)	36 (47.37)
20001 – 30000	13 (10.92)	10 (13.16)
Over 30001	10 (8.40)	3 (3.95)
Period to hospital		
Morning (08.00 a.m.-04.00 p.m.)	67 (56.30)	39 (51.31)
Evening (04.00 p.m.-00.00 a.m.)	41 (34.46)	29 (38.16)
Midnight (00.00 a.m.-08.00 a.m.)	11 (9.24)	8 (10.53)
Family number (mean+/-SD)	3.67 (2.10)	3.83 (1.98)
Transfer procedures		
By themselves	10 (8.40)	2 (2.63)
Brought by relatives	90 (75.63)	58 (76.32)
By ambulance (EMS)	17 (14.29)	14 (18.42)
By rescue truck (EMS)	2 (1.68)	0 (0.00)
Others	0 (0.00)	2 (2.63)
Persons reporting the transfer		
Themselves	43 (36.13)	23 (30.26)
Relatives	75 (63.03)	47 (61.84)
Friends	0 (0.00)	3 (3.95)
Others	1 (0.84)	3 (3.95)
Patients know about stroke		
Yes	55 (46.22)	38 (50.00)
No	64 (53.78)	38 (50.00)
Patients know about symptoms of stroke		
Yes	55 (46.22)	38 (50.00)
No	64 (53.78)	38 (50.00)

Table 1. Baseline characteristics of patients with delayed (≥4.5 hours) and non-delayed (<4.5 hours) stroke presentation (Cont.)

Characteristics	Delayed stroke (≥4.5 hr), N (%)	Not delayed stroke (<4.5 hr) N (%)
Transporters know about symptoms of stroke		
Yes	61 (51.26)	32 (42.11)
No	58 (48.74)	44 (57.89)
Received rtPA		
Yes	0 (0.00)	64 (84.20)
No	119 (100.00)	12 (15.80)
Pre-treatment NIHSS (mean+/-SD)	5.13 (4.65)	5.13 (4.93)
Post-treatment NIHSS(mean+/-SD)	4.39 (4.36)	3.43 (4.10)
Delta NIHSS(mean+/-SD)	-0.74 (1.93)	-1.70 (3.24)

Abbreviations: EMS - emergency medical services, NIHSS - National Institutes of Health Stroke Scale, rtPA - Recombinant Tissue Plasminogen Activator.

Table 2. Comparison of NIHSS outcomes between patients transported by EMS and non-EMS

	EMS	Non-EMS	*p*-value
NIHSS at discharge (mean+/-SD)	4.39(4.62)	3.95(4.21)	0.681
Change in NIHSS (mean+/-SD)	-1.74(2.77)	-0.99(2.51)	0.092

Abbreviations: EMS, emergency medical services; NIHSS, National Institutes of Health Stroke Scale.

Table 3. Univariable and multivariable analyses of factors associated with delayed (≥4.5 hours) stroke presentation

Characteristics	Univariable analysis		Multivariable analysis	
	Crude Odds Ratio (cOR)(95% CI)	*p*-value	Adjusted Odds Ratio (aOR) (95% CI)	*p*-value
Transfer procedures (vs. Non-EMS)				
- By themselves	0.31 (0.07,1.47)	0.140	0.17 (0.03,1.10)	0.063
- EMS	0.24 (0.05,1.30)	0.098	0.11 (0.02,0.81)	0.030
Education (vs. other/tertiary)				
Lower primary school	0.91 (0.26, 3.30)	0.888	0.71 (0.17, 2.88)	0.628
Upper primary school	0.77 (0.19, 3.33)	0.737	0.61 (0.12,3.16)	0.556
Lower secondary school	0.77 (0.17,3.43)	0.723	0.39 (0.07,2.19)	0.285
Upper secondary school	0.77 (0.11, 5.29)	0.783	0.23 (0.02,2.39)	0.219
Tertiary level	1.14 (0.25,5.27)	0.864	0.77 (0.15, 4.04)	0.760
Income (vs. Over 30.001 Baht)				
0 – 5000	0.67 (0.26, 1.74)	0.420	0.52 (0.18,1.49)	0.222
5001 – 10000	0.61 (0.27, 1.38)	0.240	0.52 (0.21,1.29)	0.160
10001 – 20000	0.60 (0.20, 1.76)	0.350	0.49 (0.15, 1.63)	0.245
20001 – 30000	1.53 (0.36,6.62)	0.563	1.28 (0.26,6.20)	0.757

Table 3. Univariable and multivariable analyses of factors associated with delayed (≥4.5 hours) stroke presentation (Cont.)

Characteristics	Univariable analysis		Multivariable analysis	
	Crude Odds Ratio (cOR)(95% CI)	*p*-value	Adjusted Odds Ratio (aOR) (95% CI)	*p*-value
Period to hospital (vs. Midnight)				
Midnight (00.00 a.m.-08.00 a.m.)		NA	- -	NA
Morning (08.00 a.m.-04.00 p.m.)	0.82 (0.45, 1.52)	0.537	0.59 (0.29,1.18)	0.134
Evening (04.00 p.m.-00.00 a.m.)	0.80 (0.29,2.16)	0.660	0.45 (0.14,1.44)	0.179
Family number	0.97 (0.83,1.11)	0.603	1.06 (0.90, 1.26)	0.466
Person reporting the transfer (vs Relatives)				
Themselves	0.86 (0.46, 1.59)	0.619	1.15 (0.55, 2.40)	0.708
Patients know about stroke (vs. Unknown)	1.17 (0.66, 2.07)	0.606	2.87 (0.93,8.90)	0.067
Known symptom of stroke (vs. Unknown)	0.79 (0.45,1.43)	0.436	0.42 (0.14,1.29)	0.131
Caregivers know about stroke (vs. Unknown)	0.70 (0.39, 1.23)	0.213	0.71 (0.32,1.58)	0.399

Abbreviations: *aOR, adjusted odds ratio; CI, confidence interval; OR, odds ratio.*

Notes: Missing data are handled using complete-case analysis; no missing values were present among the final analyzed variables (n = 195). The multivariable logistic regression model adjusted for transfer procedures, educational attainment, income levels, hospital arrival period, family size, reporting person, and stroke-related knowledge components.

Discussion

The present study provides compelling evidence that utilization of the Emergency Medical Services (EMS) system is a strong and independent predictor of timely hospital arrival among patients with acute ischemic stroke. This finding is consistent with reports from many countries[8-10], further supporting the crucial role of EMS in acute stroke care. Importantly, earlier hospital presentation was directly associated with improved clinical outcomes, as patients arriving within 4.5 hours demonstrated significantly better neurological status at discharge.[9,11,12] Despite the Thai EMS system being widely accessible and free of charge, the proportion of patients utilizing EMS in our cohort was substantially lower than that reported in developed nations, although comparable to previous Thai studies.[3,13] This discrepancy underscores a persistent gap in public awareness and effective communication regarding the appropriate use of the national EMS system. The low rate of EMS utilization suggests that many patients and families may lack sufficient knowledge to recognize stroke symptoms and seek immediate EMS activation promptly. These findings highlight the urgent need for targeted, nationwide public health campaigns to improve stroke recognition and promote early EMS utilization. An intriguing finding in this context was that all patients in the delayed-arrival group received rtPA, whereas 15.8% of those in the timely-arrival group did not ($p < 0.001$). This paradox reflects our clinical selection protocol at Buddhasothorn Hospital: delayed patients were highly selected individuals who met the criteria for extended-window thrombolysis based on advanced neuroimaging. Conversely, the primary reason for withholding rtPA in the timely group was a high prevalence of minor strokes, with absolute contraindications or patient refusal accounting for only a minority of cases. Notably, despite full rtPA coverage in the delayed group, their post-treatment NIHSS scores were significantly higher than those of the timely group (4.39 ± 4.36 vs. 3.43 ± 4.10, $p = 0.010$). This underlines that while extended-window strategies are valuable, they cannot fully mitigate time-dependent neuronal loss, reinforcing the 'Time is Brain' paradigm.

Our findings suggest a trend toward delayed hospital arrival among patients living alone, although this association did not reach statistical significance. This observation aligns with reports from Western countries[14,15], where the presence of cohabitants or bystanders facilitates timely presentation. By contrast, studies from India[16] have reported no difference in arrival time across living arrangements, suggesting that joint-family structures do not influence arrival time. This issue is particularly relevant in Thailand, which has entered an Aged Society and is experiencing a demographic transition from extended families to nuclear and single-person households. As a result, the number of elderly individuals living alone—and therefore at risk of treatment delays—is increasing. Addressing this emerging challenge requires not only general awareness campaigns but also targeted interventions, including prehospital care planning and community-based support systems, to ensure early recognition of stroke symptoms and prompt hospital transfer for vulnerable groups.

This study found no significant difference in ischemic stroke knowledge between patients and transporters, and this disparity did not influence transport speed. Based on these observations, general symptom literacy alone may be insufficient to prompt rapid presentation, and an awareness of therapeutic urgency—specifically, the understanding that time-dependent interventions yield superior outcomes[17] [18]—might play a more critical role. However, because our study did not directly measure patients' or caregivers' perceptions of therapeutic urgency, further studies are needed to rigorously explore this relationship. Consequently, while public health strategies should continue to promote basic symptom recognition, future educational interventions might benefit from incorporating stronger behavioral emphasis on the necessity of immediate action and the concept of time-critical intervention.

This study encountered several limitations. First, this study lacks long-term follow-up data and detailed geographic information (urban vs. rural). Second, relying on patient or relative recall for symptom onset time introduces potential recall bias. Third, excluding patients who were unreachable or unable to provide consistent onset data may have led to selection bias. Lastly, given the observational design and the relatively small EMS user subgroup, the study is susceptible to unmeasured confounding, and a formal post hoc power justification or sensitivity analysis was not performed to confirm the robustness of these statistical associations.

Conclusion

Early hospital arrival within 4.5 hours is significantly associated with better neurological outcomes at discharge, and EMS utilization independently predicts a lower likelihood of delayed presentation. However, EMS remains substantially underutilized. Given the observational design and small EMS subgroup, these associations warrant cautious interpretation. Future multi-center studies with sensitivity analyses are needed to confirm these findings. Additionally, these results highlight an urgent need for targeted public health campaigns to enhance stroke awareness and promote immediate EMS integration.

Conflicts of interest: The authors declare that they have no conflicts of interest.

Author contribution: S. S. (Sirinapa Saneemanomai): Conceptualization, Methodology, Formal Analysis, Writing—Original Draft Preparation, Writing—Review & Editing, Supervision, Project Administration, P. R. (Phatchapong Rurgring): Data Curation, Investigation, T. N. (Thinnapat Ninthasuk): Data Curation, Investigation, J. R. (Juthatip Rooyoo): Data curation, Investigation, J. B. (Jidaporn Burenoi): Data curation, Investigation, N. K. (Neera Krasaesoontorn): Data Curation, Investigation, B. S. (Benjawan Saengluan): Data Curation, Investigation, N. Kh. (Nunnaphat Khantiviriyapanich): Data Curation, Investigation, and K. N. (Kanokporne Nakboon): Data Curation, Investigation.
Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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