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ORIGINAL RESEARCH

Comparisons of Prehospital Delay and Related Factors Between Acute Ischemic Stroke and Acute Myocardial Infarction

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BACKGROUND: Prehospital delay is an important contributor to poor outcomes in both acute ischemic stroke (AIS) and acute myocardial infarction (AMI). We aimed to compare the prehospital delay and related factors between AIS and AMI.

METHODS AND RESULTS: We identified patients with AIS and AMI who were admitted to the 11 Korean Regional Cardiocerebrovascular Centers via the emergency room between July 2016 and December 2018. Delayed arrival was defined as a prehospital delay of >3 hours, and the generalized linear mixed-effects model was applied to explore the effects of potential predictors on delayed arrival. This study included 17 895 and 8322 patients with AIS and AMI, respectively. The median value of prehospital delay was 6.05 hours in AIS and 3.00 hours in AMI. The use of emergency medical services was the key determinant of delayed arrival in both groups. Previous history, 1-person household, weekday presentation, and interhospital transfer had higher odds of delayed arrival in both groups. Age and sex had no or minimal effects on delayed arrival in AIS; however, age and female sex were associated with higher odds of delayed arrival in AMI. More severe symptoms had lower odds of delayed arrival in AIS, whereas no significant effect was observed in AMI. Off-hour presentation had higher and prehospital awareness had lower odds of delayed arrival; however, the magnitude of their effects differed quantitatively between AIS and AMI.

CONCLUSIONS: The effects of some nonmodifiable and modifiable factors on prehospital delay differed between AIS and AMI. A differentiated strategy might be required to reduce prehospital delay.

Key Words: acute ischemic stroke ■ acute myocardial infarction ■ prehospital delay

Acute ischemic stroke (AIS) and acute myocardial infarction (AMI) are 2 similar medical emergencies that require urgent revascularization. Reducing the onset to recanalization time is essential for better outcomes in both AIS and AMI; therefore, identifying and understanding the factors that affect prehospital

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CLINICAL PERSPECTIVE

What Is New?

- In a nationwide study comparing prehospital delay between patients with AIS and AMI, advanced age and female sex were significantly associated with higher odds of delayed arrival in AMI, however, age and sex had no or minimal effects on delayed arrival in AIS.
- There were lower odds of delayed arrival with use of EMS in both groups.

What Are the Clinical Implications?

- The differences in factors associated with prehospital delay between AIS and AMI should be considered to develop differentiated strategies to reduce delays in arrival.
- Strategies for improving timely hospital arrival in AMI may include educational campaigns targeting groups such as the elderly and women.
- Public education should underscore the importance of the use of EMS for both AIS and AMI.

Nonstandard Abbreviations and Acronyms

AIS	acute ischemic stroke
RCCVC	regional cardiocerebrovascular center

delay is important. For a more comprehensive understanding of prehospital delay and better planning for its reduction in patients with AIS and AMI, comparison of the 2 conditions based on prehospital delay and related factors can be helpful. However, there are limited single-center studies with small sample sizes on this topic.[1,2]

In South Korea, the Regional Cardiocerebrovascular Disease Center (RCCVC) project began in 2008 for better prevention and treatment of AIS and AMI.[3,4] The primary purpose of this project was to establish 24-hour specialized care systems for patients with AIS and AMI at the RCCVCs with the appropriate facilities and equipment satisfying the relevant standards. The RCCVC registry was launched in 2014 to monitor and improve the quality of care. Considering the availability of patient data in the registry database, we had the opportunity to analyze the nationwide data of AIS and AMI in a comparable format.

In the present study, we aimed to compare the prehospital delay and related factors in patients with AIS and AMI using the nationwide data from the RCCVC registry. Previous studies have reported variability in prehospital delay according to regions and seasons.[5,6] We analyzed both patients with AIS and AMI in the same model with adjustments for geographical (RCCVCs) and temporal factors (year-month of admission).

METHODS

The data analyzed in this study are available from the corresponding author upon reasonable request.

Participants and Data Collection

From 2008 to 2012, university hospitals at 11 provinces and large cities in South Korea (Gangwon, Daegu-Gyeongbuk, and Jeju in 2008; Gyeongnam, Gwangju-Jeonnam, and Chungbuk in 2009; Busan-Ulsan, Jeonbuk, Daejeon-Chungnam in 2010; and Gyeonggi and Incheon in 2012) were designated as RCCVCs by the Ministry of Health and Welfare (Figure 1). For this study, we identified patients with AIS and AMI from the RCCVCs registry database who were admitted to the 11 centers via the emergency room within a week of symptom onset between July 2016 and December 2018. Patients with no or inadequate information on onset time were excluded from the study. The institutional review boards of the participating centers approved this study, and the need for informed consent was waived, considering the retrospective nature of the study and minimal risk to the participants.

Outcome and Predictors

The outcome measure was prehospital delay, defined as the time interval from symptom recognition to hospital arrival. For the multivariable analysis, we used a dichotomous outcome of delayed arrival, defined as a prehospital delay of >3 hours. This cut-off (3 hours) was chosen considering the median value of prehospital delay in the included patients with AMI and the recommended time window for intravenous thrombolysis in patients with AIS.[7]

Based on the literature,[5,8,9] the predictors evaluated in this study were predetermined as follows: demographic factors (age and sex), previous history of stroke or coronary artery disease, household factors, onset time (working hours [6 AM–6 PM] versus off-hours [6 PM–6 AM] and weekday versus weekend), use of emergency medical services (EMS), interhospital transfer, and prehospital awareness. Prehospital awareness was defined as the awareness of the patient or caregiver regarding the symptoms of AIS or AMI. The severity of symptoms might be one of the important factors related to prehospital delay. However, there are no common criteria or scales that can be used for both AIS and AMI. Therefore, in the present study, we defined a milder symptom profile as a National Institutes of Health Stroke Scale score of 0–3 for AIS[10] and the absence of chest pain for AMI,[11,12] respectively.

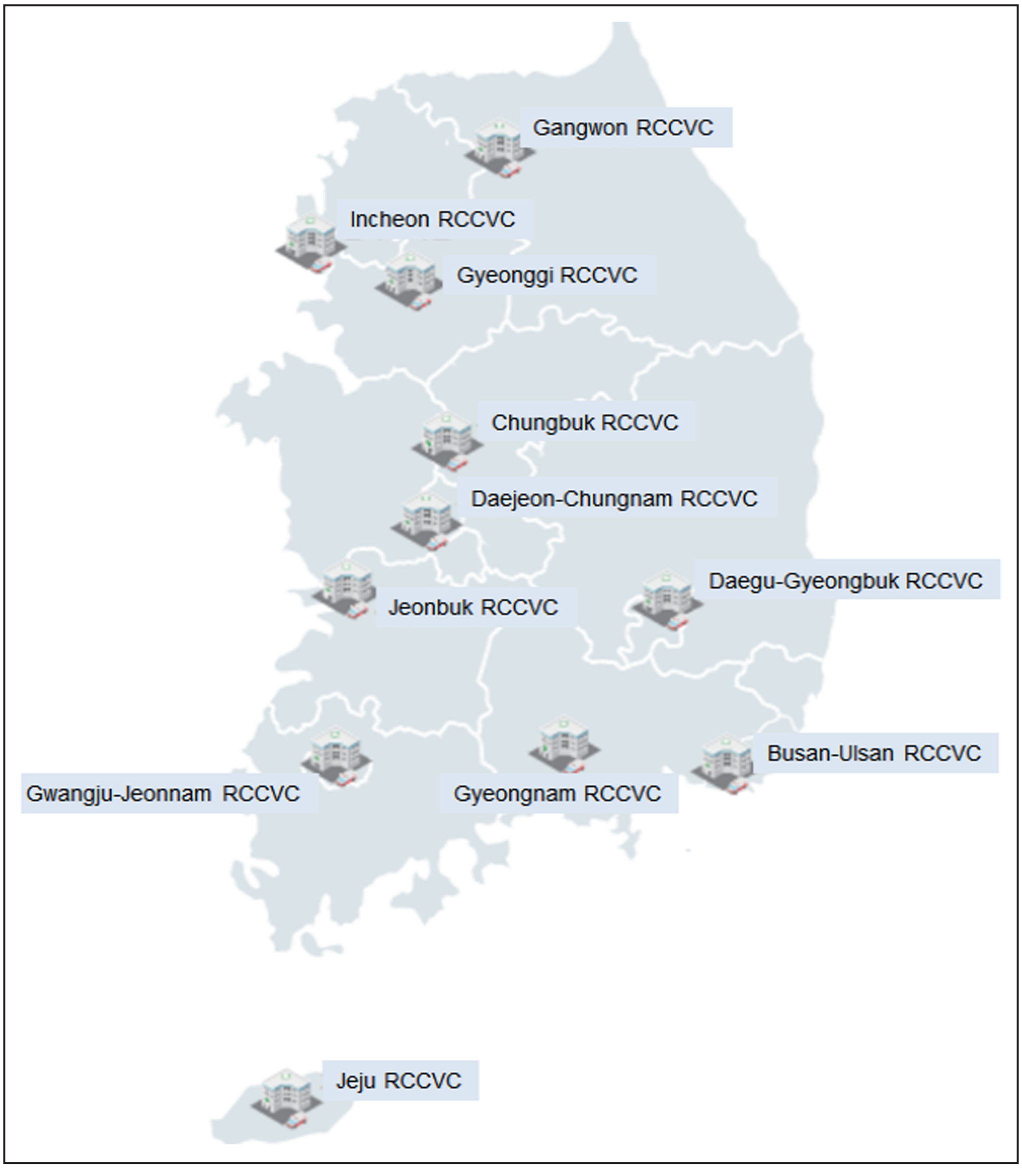

Figure 1. Locations of the 11 regional cardiocerebrovascular centers (RCCVCs) in South Korea.

Statistical Analysis

Baseline characteristics were compared between patients with AIS and AMI using the Pearson χ^2 test for categorical variables and Student *t* test for numeric variables. The prehospital delay between the χ^2 groups was compared using the Wilcoxon rank-sum test and Pearson χ^2 test. In addition, comparison of the prehospital delay stratified by AIS and AMI were made by Wilcoxon rank-sum test or Kruskal–Wallis test according to baseline characteristics. Some additional subgroup analyses were conducted. The Cochran-Armitage test for trend was used to assess age-related changes in the symptom profile and household structure in AMI. The Pearson χ^2 test was applied for the comparison of the proportion of cases using EMS according to prehospital awareness.

To examine the effect of each predictor on delayed arrival, the generalized linear mixed-effects model was applied with hospital and year-month of admission as random effects to adjust for their clustering. The multivariable generalized linear mixed-effects regression analysis for estimating odds ratio included all 10 potential predictors of the prehospital delay (predetermined by literature review). The adjusted odds ratios for each factor were presented in 2 ways, with a separate reference in each disease group and with a single common reference group in both disease groups (taken as a stratum with the shortest prehospital delay in both diseases). We examined an interaction effect of each factor on delayed arrival by disease (AIS versus AMI) using interaction terms between disease group and each factor in the generalized linear mixed-effect model, which tested a multiplicative interaction. As a post-hoc analysis, we also assessed additive interaction using the Relative Excess Risk because of Interaction. Relative Excess Risk because of Interaction with 95% CIs was calculated using the method described by Hosmer and Lemeshow.[13]

Missing data were found on household structure (n=1), prehospital awareness (n=7), interhospital transfer (n=1), and symptom profile (n=1) and were imputed with the mode. All statistical analyses were performed using SAS software (version 9.4; SAS Institute, USA). Two-tailed *P* values were reported, and a *P* value <0.05 was considered statistically significant.

RESULTS

Of the 26 826 patients initially screened for eligibility, 609 patients (2.3%) were excluded because of no or inadequate information regarding the onset time. Finally, 17 895 patients with AIS and 8322 patients with AMI were analyzed. The baseline characteristics of patients with AIS and AMI are shown in Table 1. Patients with AMI were predominantly men and likely to be younger than those with AIS. Prehospital awareness and use of EMS were more frequent in patients with AIS than in those with AMI, whereas interhospital transfer and off-hour presentation were more frequent in patients with AMI.

The distribution of prehospital delay was right-skewed (Figure 2). The median (interquartile range) was 6.05 (1.83–24.65) hours for AIS and 3.00 (1.25–7.92) hours for AMI. The delay was significantly longer in patients with AIS than in those with AMI (*P*<0.001). The proportion of patients with a delay of <3 hours was one third (35.3%) of the total cases of AIS and half (49.7%) of the total cases of AMI (Table 2). About one fourth of the patients with AIS were hospitalized after >24 hours of symptom onset, as opposed to 10% of the patients with AMI.

Prehospital delay was compared based on the baseline characteristics of patients with AIS and AMI (Table 3). Prehospital delay decreased and increased with age in patients with AIS and AMI, respectively. Elderly patients with AMI were more likely to have vague symptoms other than chest pain and tend to live alone (Table S1). The delay did not differ by sex in patients with AIS; however, it was longer in women than in men with AMI. Female patients with AMI showed older age (73.8±11.1 years versus 62.6±12.4 years, *P*<0.001), more frequent atypical presentations other than chest pain (17.0% versus 9.5%, *P*<0.001), higher proportion of individuals living alone (30.5% versus 14.3%, *P*<0.001), and lower prehospital awareness (12.1% versus 18.8%, *P*<0.001) compared with male patients. In both AIS and AMI, prehospital delay was marginally but significantly longer in patients with a previous history of the condition than in those without it, although prehospital awareness was significantly higher in patients with previous history compared with those without in both AIS (31.7% versus 18.3%, *P*<0.001) and AMI (49.4% versus 13.7%, *P*<0.001). Off-hour presentation and milder symptoms were associated with longer prehospital delay in patients with AIS, and weekday presentation and 1-person households were associated with the delay in those with AMI. Prehospital awareness and use of EMS were associated with shorter prehospital delay and interhospital transfer with longer prehospital delay in both AIS and AMI. There was an association between prehospital awareness and the use of EMS in both AIS and AMI (Table S2).

In the multivariable models for the determinants of delayed arrival, age, sex, off-hour presentation, more severe symptoms, and prehospital awareness demonstrated differential effects between AIS and AMI (Table 4). In AIS, compared with patients aged

Table 1. Comparison of Baseline Characteristics Between Acute Ischemic Stroke and Acute Myocardial Infarction

	AIS N=17 895	AMI N=8322	*P* value*
Age, mean±SD, y	69.6±12.7	65.3±13.0	<0.001
Male, N (%)	10 538 (58.9)	6258 (75.2)	<0.001
Previous stroke, N (%)	4036 (22.6)	599 (7.2)	<0.001
Previous coronary artery disease, N (%)	1570 (8.8)	806 (9.6)	0.02
One-person household, N (%)	3156 (17.6)	1528 (18.4)	0.15
Onset time, N (%)			<0.001
Working hour (6 AM–6 PM)	11 710 (65.4)	4993 (60.0)	
Off-hour (6 PM–6 AM)	6185 (34.6)	3329 (40.0)	
Onset day, N (%)			0.14
Weekday	11 885 (66.4)	5604 (67.3)	
Weekend	6010 (33.6)	2718 (32.7)	
Prehospital awareness, N (%)†			<0.001
Yes	3823 (21.4)	1426 (17.1)	
No	11 835 (66.1)	6433 (77.3)	
Not applicable	2237 (12.5)	456 (5.5)	
Use of EMS, N (%)	6067 (33.9)	2166 (26.3)	<0.001
Interhospital transfer, N (%)	5974 (33.4)	4246 (51.0)	<0.001
NIHSS, median (IQR)	4 (2–8)		
NIHSS ≥4	9472 (52.9)		
Predominant chest pain, N (%)		7377 (88.6)	

AIS indicates acute ischemic stroke; AMI, acute myocardial infarction; EMS, emergency medical services; IQR, interquartile range; and NIHSS, National Institutes of Health Stroke Scale.

*Two-sample *t* test or Pearson χ^2 test, as appropriate.

†Defined as the awareness of the patient or caregiver regarding the disease symptoms.

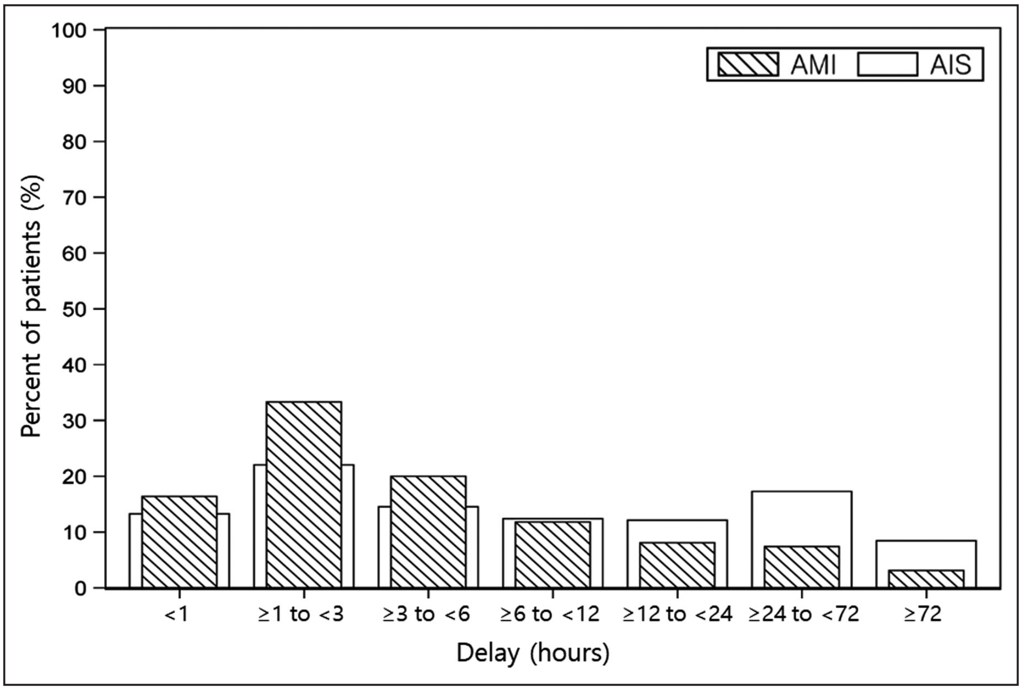

Figure 2. Prehospital delay in patients with acute ischemic stroke (AIS) and acute myocardial infarction (AMI).

<55 years, those in the older age groups were significantly associated with delayed arrival except for those aged ≥85 years. However, there was no significant trend of higher odds of delayed arrival with age. In contrast, there was a significant trend of higher odds of delayed arrival with age in patients with AMI. Female sex was associated with delayed arrival only in patients with AMI. Only in AIS, patients with more severe symptoms were less likely to arrive at the hospital >3 hours after the onset. Off-hour presentation had higher and prehospital awareness had lower odds of delayed arrival; however, the magnitude of their effects differed quantitatively between AIS and AMI.

Table 2. Comparisons of Prehospital Delay Between Acute Ischemic Stroke and Acute Myocardial Infarction

	AIS N=17 895	AMI N=8322	*P* value
Onset to door time, median (IQR) (h)	6.05 (1.83–24.65)	3.00 (1.25–7.92)	<0.001*
Time distribution, N (%)			<0.001†
<1 h	2372 (13.3)	1363 (16.4)	
≥1 to <3 h	3940 (22.0)	2770 (33.3)	
≥3 to <6 h	2600 (14.5)	1663 (20.0)	
≥6 to <12 h	2218 (12.4)	981 (11.8)	
≥12 to <24 h	2167 (12.1)	672 (8.1)	
≥24 to <72 h	3089 (17.3)	615 (7.4)	
≥72 h	1509 (8.4)	258 (3.1)	

AIS indicates acute ischemic stroke; AMI, acute myocardial infarction; and IQR, interquartile range.

*Wilcoxon rank-sum test.

†Pearson χ^2 test.

Previous history, 1-person household, weekday presentation, use of EMS, and interhospital transfer were independently associated with delayed arrival in both AIS and AMI without interaction by disease (all *P* for interaction on a multiplicative scale ≥0.05) (Table 4). Previous history of each disease, 1-person household, weekday presentation, and interhospital transfer had higher odds, whereas use of EMS had lower odds of delayed arrival.

Interaction effect analyses showed almost similar results in significance between multiplicative and additive scales, but use of EMS and interhospital transfer showed additional significance in additive interaction analysis compared with multiplicative interaction analysis (Table 5). Regarding use of EMS and interhospital transfer, additive interaction with disease (AIS>AMI) was seen on the risk of delayed arrival. Notably, the odds of delayed arrival for patients with AIS using EMS were lower than the odds for patients with AMI not using EMS (Table 5).

DISCUSSION

This is the first nationwide study to directly compare prehospital delay between patients with AIS and AMI. The large number of patients and the multicenter design are the main strengths of our study. Previous reports have shown a large variability in prehospital delay by countries and regions, ranging

Table 3. Comparisons of Prehospital Delay According to Baseline Characteristics Stratified by Acute Ischemic Stroke and Acute Myocardial Infarction

	AIS		AMI	
	Onset to door time, median (IQR) (hours)	*P* value*	Onset to door time, median (IQR) (hours)	*P* value*
Nonmodifiable factors				
Age, y		<0.0001†		<0.0001†
<55	7.90 (2.05–27.45)		2.18 (1.00–5.64)	
55–64	7.38 (1.95–26.60)		2.58 (1.07–6.23)	
65–74	6.13 (1.85–25.17)		3.22 (1.37–8.25)	
75–84	5.48 (1.82–22.82)		3.85 (1.77–11.33)	
≥85	4.07 (1.56–17.89)		4.37 (2.03–14.05)	
Sex		0.29		<0.0001
Male	6.20 (1.83–24.88)		2.75 (1.12–7.02)	
Female	5.85 (1.85–24.08)		3.87 (1.75–11.53)	
Previous history‡		0.04		0.01
Yes	1.91 (1.88–1.93)		1.26 (1.23–1.29)	
No	1.85 (1.80–1.90)		1.13 (1.04–1.23)	
Type of household		0.08		<0.0001
One-person household	6.15 (2.03–24.96)		3.51 (1.50–8.30)	
Multiperson household	6.02 (1.80–24.61)		2.93 (1.18–7.83)	
Onset time		<0.0001		0.31
Working hour (6 AM–6 PM)	5.32 (1.82–24.73)		3.00 (1.28–7.43)	
Off-hour (6 PM–6 AM)	7.67 (1.92–24.00)		3.00 (1.20–8.52)	
Onset day		0.78		0.04
Weekday	6.15 (1.85–24.27)		3.05 (1.28–7.98)	
Weekend	5.93 (1.83–25.47)		2.81 (1.18–7.83)	
Symptom profile		<0.0001		0.54
Milder§	9.27 (2.73–30.10)		2.92 (1.05–9.27)	
More severe	4.07 (1.35–18.57)		3.00 (1.28–7.83)	
Modifiable factors				
Prehospital awareness‖		<0.0001		<0.0001
Yes	3.82 (1.33–16.55)		2.33 (1.00–5.47)	
No	7.27 (2.10–26.47)		3.17 (1.38–8.82)	
Not applicable	5.05 (1.77–23.22)		2.42 (1.11–6.48)	
Use of EMS		<0.0001		<0.0001
Yes	1.75 (0.85–7.17)		1.22 (0.72–2.78)	
No	10.49 (3.38–32.20)		3.93 (1.87–10.56)	
Interhospital transfer		<0.0001		<0.0001
Yes	11.29 (3.78–37.43)		4.18 (2.13–10.52)	
No	4.23 (1.23–18.63)		1.77 (0.88–5.00)	

AIS indicates acute ischemic stroke; AMI, acute myocardial infarction; EMS, emergency medical services; and IQR, interquartile range.
*Wilcoxon rank-sum test or Kruskal–-Wallis test, as appropriate.
†*P* for trend obtained by regression analysis with log-transformed prehospital delay time.
‡Previous history of stroke in patients with AIS and previous history of coronary artery disease in patients with AMI.
§Defined as a National Institutes of Health Stroke Scale score of 0–3 in patients with AIS and no chest pain in patients with AMI.
‖Defined as the awareness of the patient or caregiver regarding the disease symptoms.

from 1.5 to 16.0 hours in patients with AIS and 2 to 6.5 hours in those with AMI.[5,14–18] The median value of prehospital delay in our study was ≈6 hours in patients with AIS and 3 hours in those with AMI. In South Korea, prehospital delay has not changed in patients with AIS, and has decreased marginally in those with AMI since 2005.[19,20] Studies from other countries have reported insignificant changes in prehospital delay over time, supporting the difficulty of reducing it.[21,22]

Table 4. Predictors of Delayed Arrival (>3 Hours) in Each Disease Group (Multivariable Analysis)

	AIS		AMI		
	N (Delayed/Early arrival)	Adjusted OR (95% CI)	N (Delayed/Early arrival)	Adjusted OR (95% CI)	*P* for interaction on a multiplicative scale
Age, y					
<55	1564/765	Reference	738/1090	Reference	<0.0001
55–64	2271/1134	1.15 (1.02–1.30)	944/1193	1.26 (1.10–1.45)	
65–74	3029/1607	1.15 (1.02–1.29)	1046/956	1.84 (1.60–2.11)	
75–84	3764/2185	1.12 (1.01–1.25)	1077/779	2.14 (1.85–2.47)	
≥85	917/659	0.98 (0.84–1.14)	313/186	2.39 (1.91–2.99)	
Sex					
Male	6816/3722	Reference	2926/3332	Reference	<0.0001
Female	4729/2628	0.93 (0.86–1.00)	1192/872	1.33 (1.19–1.49)	
Previous history[*]					
No	8974/4885	Reference	3744/3776	Reference	0.05
Yes	2571/1465	1.10 (1.02–1.20)	374/428	1.32 (1.13–1.56)	
Type of household					
Multiperson household	9464/5275	Reference	3284/3510	Reference	0.52
One-person household	2081/1075	1.19 (1.08–1.30)	834/694	1.24 (1.10–1.41)	
Onset time					
Working hour (6 AM–6 PM)	7411/4299	Reference	2462/2531	Reference	0.001
Off-hour (6 PM–6 AM)	4134/2051	1.35 (1.26–1.45)	1656/1673	1.11 (1.01–1.22)	
Onset day					
Weekend	3840/2170	Reference	1283/1435	Reference	0.28
Weekday	7705/4180	1.09 (1.01–1.13)	2835/2769	1.12 (1.02–1.24)	
Symptom profile					
Milder[†]	6142/2281	Reference	449/496	Reference	<0.0001
More severe	5403/4069	0.63 (0.59–0.67)	3669/3708	1.14 (0.98–1.33)	
Prehospital awareness[‡]					
Yes	2126/1697	Reference	590/836	Reference	<0.0001
No	9419/4653	1.76 (1.62–1.92)	3528/3368	1.19 (1.05–1.35)	
Use of EMS					
Yes	2345/3722	Reference	496/1670	Reference	0.09
No	9200/2628	4.20 (3.89–4.52)	3622/2534	3.74 (3.32–4.21)	
Interhospital transfer					
No	6681/5240	Reference	1469/2607	Reference	0.83
Yes	4864/1110	1.86 (1.71–2.03)	2649/1597	1.84 (1.672.02)	

AIS, acute ischemic stroke; AMI, acute myocardial infarction; EMS, emergency medical services; and OR, odds ratio .
[*]Previous history of stroke in patients with AIS and previous history of coronary artery disease in patients with AMI.
[†]Defined as a National Institutes of Health Stroke Scale score of 0–3 in patients with AIS and no chest pain in patients with AMI.
[‡]Defined as the awareness of the patient or caregiver regarding the disease symptoms.

The first step towards better planning of reducing prehospital delay at a national level might be by differentiating the related modifiable and nonmodifiable factors. Three modifiable factors were identified in the present study: prehospital awareness, use of EMS, and interhospital transfer. Prehospital awareness reduced the odds of delayed arrival in both AIS and AMI; however, the magnitude of the effect differed quantitatively between the 2 diseases, with a larger effect in AIS than in AMI. Compared with AMI, AIS presents with more diverse symptoms and there is a difference in public awareness according to the symptoms. In AIS, hospital visits can be delayed, especially for symptoms not well known to the public. Use of EMS and interhospital transfer were significant predictors of prehospital delay in both AIS and AMI; they showed additive interaction

Table 5. Analysis of Additive Interaction Between Each Factor and Disease on the Risk of Delayed Arrival (>3 Hours)

	Adjusted OR (95% CI)		RERI (95% CI)*
	AIS	AMI	
Age, y			
<55	3.23 (2.80–3.73)	Reference†	…
55–64	3.71 (3.25–4.24)	1.26 (1.10–1.45)	0.22 (−0.23, 0.66)
65–74	3.71 (3.26–4.21)	1.84 (1.60–2.11)	−0.36 (−0.81, 0.09)
75–84	3.60 (3.18–4.08)	2.14 (1.85–2.47)	−0.77 (−1.24, −0.30)
≥85	3.16 (2.70–3.70)	2.39 (1.91–2.99)	−1.46 (−2.17, −0.75)
Sex			
Male	2.46 (2.28–2.66)	Reference†	−0.51 (−0.73, −0.29)
Female	2.28 (2.10–2.48)	1.33 (1.19–1.49)	
Previous history‡			
No	2.25 (2.10–2.42)	Reference†	−0.09 (−0.38, 0.19)
Yes	2.48 (2.26–2.73)	1.32 (1.13–1.56)	
Type of household			
Multiperson household	2.22 (2.07–2.39)	Reference†	0.17 (−0.11, 0.44)
One-person household	2.63 (2.37–2.92)	1.24 (1.10–1.41)	
Onset time			
Working hour (6 AM–6 PM)	2.04 (1.89–2.21)	Reference†	0.61 (0.41, 0.81)
Off-hour (6 PM–6 AM)	2.76 (2.52–3.02)	1.11 (1.01–1.22)	
Onset day			
Weekend	2.30 (2.07–2.56)	Reference†	−0.01 (−0.21, 0.19)
Weekday	2.41 (2.19–2.66)	1.12 (1.02–1.24)	
Symptom profile			
Milder§	3.59 (3.08–4.17)	Reference†	−1.47 (−1.89, −1.06)
More severe	2.26 (1.94–2.62)	1.14 (0.98–1.33)	
Prehospital awareness‖			
Yes	1.60 (1.39–1.84)	Reference†	1.03 (0.85, 1.21)
No	2.82 (2.48–3.20)	1.19 (1.05–1.35)	
Use of EMS			
Yes	2.03 (1.80–2.28)	Reference†	3.74 (3.17, 4.30)
No	8.50 (7.57–9.54)	3.74 (3.32–4.21)	
Interhospital transfer			
No	2.19 (2.01–2.38)	Reference†	1.05 (0.73, 1.37)
Yes	4.08 (3.69–4.51)	1.84 (1.67–2.02)	

AIS indicates acute ischemic stroke; AMI, acute myocardial infarction; EMS, emergency medical services; OR, odds ratio; and RERI, relative excess risk because of interaction.

*The adjusted RERI and 95% CI using the method described by Hosmer and Lemeshow (Hosmer and Lemeshow, 1992). The RERI is a test for additive interaction and is interpreted as follows: RERI >0 indicated superadditive interaction between the factor and disease (AIS compared with AMI); RERI<0 indicated subadditive interaction between the factor and disease (AIS compared with AMI). There is no statistical significance when the 95% CI of RERI contains 0.

†Defined as a stratum with the shortest prehospital delay in both diseases.

‡Previous history of stroke in patients with AIS and previous history of coronary artery disease in patients with AMI.

§Defined as a National Institutes of Health Stroke Scale score of 0–3 in patients with AIS and no chest pain in patients with AMI.

‖Defined as the awareness of the patient or caregiver regarding the disease symptoms.

by disease (AIS>AMI) but no multiplicative interaction. Because AIS often causes physical disability including hemiparesis, we speculated that the effect of EMS use would be greater in AIS than in AMI. The use of EMS reduced the odds of delayed arrival to about one quarter and interhospital transfer increased it by approximately twice. As expected, the use of EMS was the strongest modifiable factor; however, only one third of the patients with AIS and one fourth of those with AMI in our study used the services. Further public efforts to encourage the use of EMS should be made at a national level. In this study, we found an association between prehospital awareness and the use of EMS. Therefore, public education and campaigns for improvement of prehospital awareness would be helpful in promoting the use of EMS. Interhospital transfer is sometimes inevitable considering the variability in distance from the scene to acute care hospitals and their treatment capacities. In our study, interhospital transfer occurred in one third of the patients with AIS and in more than half of those with AMI. A well-organized regional triage and referral system is crucial for reducing interhospital transfer and shortening prehospital delay.[23,24] Additionally, screening and identification of patients who are likely to benefit from direct transfer to intervention-capable hospitals are essential in AIS and AMI.[25–28] In some cases, part of the treatment could be started in a small local hospital before transfer or in an ambulance before hospital arrival. This should be taken into account when considering the relationship with prehospital delay.

Among the nonmodifiable factors, age, sex, off-hour presentation, and more severe symptoms had significant but differential effects on delayed arrival in patients with AIS and AMI. Age and sex had nonsignificant or minimal effects on delayed arrival in patients with AIS. However, in AMI, female sex and advanced age were associated with higher odds of delayed arrival. Our findings emphasize that intensive education and message delivery specifically targeted at the elderly and women are important in reducing prehospital delay in AMI.

The age-related trend in AMI has also been reported previously.[29] The reason for this trend is not clear; however, there are some possible explanations. Unlike AIS, the major presenting symptom of AMI is pain, and the perception of pain may change with age. In a previous study, the perception of pain from myocardial ischemia in the elderly was significantly less severe and delayed compared with younger patients.[30] In addition to changes in pain perception, as people age, they tend to accept pain as a natural and unavoidable part of life that does not require attention. Furthermore, because elderly patients usually have several comorbidities, they may have a greater chance of misinterpreting their pain as that of noncardiac origin. As shown in our result, elderly patients are more likely to have vague symptoms other than severe chest pain and tend to live alone, which could also affect the age-related trend in AMI, although symptom profiles and type of household were adjusted in the multivariable models in our study.

Longer prehospital delay in women compared with men with AMI has been consistently reported previously[31–33]; however, the reasons for this phenomenon are not fully understood. Older age, more frequent atypical presentations other than chest pain, higher proportion of individuals living alone, and lower prehospital awareness in women compared with men could be attributed to this phenomenon; however, the delay remained significant even after adjusting for all these factors. Women tend to underestimate their risk of experiencing AMI and hesitate to bother others with their problems; therefore, they may not recognize the seriousness of their symptoms initially and tend to cope with it by themselves.[34,35]

In AIS, the median value of prehospital delay decreased with age in the unadjusted analysis, which was in contrast to the results of AMI (Table 3). However, this tendency in AIS disappeared in the multivariable analysis. Sex did not affect prehospital delay in both the unadjusted and adjusted analyses. Previous studies have reported inconsistent findings regarding the effect of age and sex on prehospital delay in patients with AIS.[36–38]

Off-hour presentation was significantly associated with delayed arrival in both AIS and AMI; however, its effect was much larger in patients with AIS. Symptoms of stroke might be less detectable at night or during sleep. If stroke symptoms occur during sleep at night, many patients with AIS realize stroke symptoms after waking up from sleep. However, onset time might have less effect on the prehospital delay in AMI, which is mostly manifested as severe pain that is hard to endure even during sleep at night. Only in AIS, more severe symptom profile was related to earlier hospital visit, which might be caused by a perceived urgency by the patient or caregiver.

Unexpectedly, patients who had experienced stroke or coronary artery disease previously were more likely to wait in case of recurrence compared with those with no prior experience. In our study, prehospital awareness was higher in patients with previous history compared with those without in both AIS and AMI. However, this awareness did not seem to lead to faster action and earlier arrival. This finding shows the need to pay attention to such high-risk patients for behavior change during the next event.

One-person household was associated with delayed arrival in both AIS and AMI. Living with family or housemates may be crucial for better detection of symptoms and earlier arrival. The negative association between weekend presentation and delayed arrival might be explained by the fact that patients were more likely to be with their families and housemates during weekends, even if they otherwise live alone. Intensive education or campaigns for individuals living alone and the application of smart home technology could be one of the solutions.[39–41]

The limitations of our study should be noted. One of the main limitations was that we only included patients with AIS because of a lack of data on patients with hemorrhagic stroke. In addition, we did not have detailed information on the socioeconomic status of the patients, including education, medical insurance, occupation, and annual income. Accurate paramedic recognition of the disease is one of the key factors associated with earlier arrival; however, we had insufficient data on it. Finally, only Korean patients were included in this study, which could limit the generalizability of the study results because there might be large variability in prehospital delay according to geographical and cultural factors.

In conclusion, our study revealed some differences in the effects of various factors on prehospital delay in cases of AIS and AMI. These differences should be considered to develop differentiated and detailed strategies to reduce prehospital delay, including education or campaigns for AMI targeting vulnerable groups, such as the elderly and women. The use of EMS for both AIS and AMI should be the key message. Attention to people with a previous history of the diseases or those living alone and reorganizing the regional systems of care for AIS and AMI should also be emphasized.

ARTICLE INFORMATION

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Supplemental Material

Tables S1–S2

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SUPPLEMENTAL MATERIAL

Table S1. Association of age with symptom profile and household structure in acute myocardial infarction

	Milder symptom profile*, N (%)	$p^{\dagger}$	One-person household, N (%)	$p^{\dagger}$
Age (years)		< .001		< .001
< 55 (N = 1,828)	101 (5.5)		314 (17.2)	
55-64 (N = 2,137)	166 (7.8)		291 (13.6)	
65-74 (N = 2,002)	190 (9.5)		300 (15.0)	
75-84 (N = 1,856)	360 (19.4)		451 (24.3)	
≥ 85 (N = 499)	128 (25.7)		172 (34.5)	

*Defined as no chest pain in AMI patients

†*p* for trend obtained by Cochran-Armitage test

Table S2. Association between prehospital awareness and use of emergency medical services in acute ischemic stroke and acute myocardial infarction

	Prehospital awareness (+)	Prehospital awareness (-)	p^*
Acute ischemic stroke	N = 3,823	N = 11,835	
Use of EMS, N (%)	1,401 (36.6)	3,853 (32.6)	< .001
Acute myocardial infarction	N = 1,426	N = 6,433	
Use of EMS, N (%)	478 (33.5)	1,545 (24.0)	< .001

EMS, Emergency medical services
*Pearson's chi-squared test