

# Changes in Stroke Patients' Health-Seeking Behavior by COVID-19 Epidemic Regions: Data from the Korean Stroke Registry

Han-Yeong Jeong<sup>a</sup> Eung-Joon Lee<sup>b</sup> Min Kyoung Kang<sup>c</sup> Ki-Woong Nam<sup>b</sup>  
Jeonghoon Bae<sup>b</sup> Kipyoun Jeon<sup>b</sup> Keun-Hwa Jung<sup>b</sup> Sang-Bae Ko<sup>b</sup>  
Mi Sun Oh<sup>d</sup> Ji Sung Lee<sup>e</sup> Jaechun Hwang<sup>f</sup> Eunhwan Jeong<sup>g</sup> Jun Lee<sup>h</sup>  
Jin-Kuk Do<sup>i</sup> Sung-Il Sohn<sup>j</sup> Sun U. Kwon<sup>k</sup> Hee-Joon Bae<sup>l</sup> Byung-Woo Yoon<sup>b, c</sup>  
Jong-Moo Park<sup>c</sup>

<sup>a</sup>Department of Neurology, Emergency Medical Center, Seoul National University Hospital, Seoul, Republic of Korea; <sup>b</sup>Department of Neurology, Seoul National University Hospital, Seoul, Republic of Korea; <sup>c</sup>Department of Neurology, Uijeongbu Eulji Medical Center, Eulji University, Uijeongbu, Republic of Korea; <sup>d</sup>Department of Neurology, Hallym University Sacred Heart Hospital, Anyang, Republic of Korea; <sup>e</sup>Clinical Research Center, Asan Medical Center, Seoul, Republic of Korea; <sup>f</sup>Department of Neurology, Kyungpook National University Chilgok Hospital, Daegu, Republic of Korea; <sup>g</sup>Department of Neurology, S. Pohang Stroke and Spine Center, Pohang, Republic of Korea; <sup>h</sup>Department of Neurology, Yeungnam University Medical Center, Daegu, Republic of Korea; <sup>i</sup>Department of Neurology, Daegu Catholic University Medical Center, Daegu, Republic of Korea; <sup>j</sup>Department of Neurology, Keimyung University Dongsan Medical Center, Daegu, Republic of Korea; <sup>k</sup>Department of Neurology, University of Ulsan Asan Medical Center, Seoul, Republic of Korea; <sup>l</sup>Department of Neurology, Cerebrovascular Center, Seoul National University College of Medicine, Seoul National University Bundang Hospital, Seongnam, Republic of Korea

## Keywords

Stroke · Transient ischemic attack · Coronavirus disease 2019 · Health-seeking behavior · Stroke registry

## Abstract

**Introduction:** The coronavirus disease 2019 (COVID-19) pandemic has led to changes in stroke patients' healthcare use. This study evaluated changes in Korean stroke patients' health-seeking behaviors and stroke care services using data from the Korean Stroke Registry (KSR). **Methods:** We reviewed data from patients with acute stroke and transient ischemic attack (TIA) during 2019 (before COVID-19 period) and 2020 (COVID-19 period). Outcomes included patient

characteristics, time from stroke onset to hospital arrival, and in-hospital stroke pathways. Subgroup analyses were performed for an epidemic region (Daegu city and Gyeongsangbuk-do region, the D-G region). **Results:** The study included 1,792 patients from the pre-COVID-19 period and 1,555 patients from the COVID-19 period who visited hospitals that contribute to the KSR. During the COVID-19 period, the D-G region had two-thirds the number of cases (vs. the pre-COVID-19 period) and a significant decrease in the proportion of patients with TIA (9.97%–2.91%). Unlike other regions, the median onset-to-door time increased significantly in the D-G region (361 min vs. 526.5 min,  $p = 0.016$ ), and longer onset-to-door times were common for patients with mild symptoms and who were in their 60s or 70s. The number of pa-

tients who underwent intravenous thrombolysis also decreased during the COVID-19 period, although the treatment times were not significantly different between the 2 periods. **Discussion/Conclusion:** Korean stroke patients in a COVID-19 epidemic region exhibited distinct changes in health-seeking behaviors. Appropriate triage system and public education regarding the importance of early treatment are needed during the COVID-19 pandemic.

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## Introduction

The coronavirus disease 2019 (COVID-19) pandemic, which is caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) virus, started at the end of 2019 [1]. This crisis has strained healthcare systems worldwide, which has increased the risks of patients with acute myocardial infarction and stroke not receiving appropriate acute therapy [2–4]. There is some evidence that the number of stroke patients seeking treatment decreased during the early pandemic period in the USA [5]. Studies from Chinese and Spanish stroke registries have also revealed a decrease in the number of stroke-related admissions during the pandemic period, relative to the corresponding period during the previous year [3, 6]. However, there are insufficient high-quality clinical registry data to confirm these trends and their causes [7].

Between late February and March 2020, COVID-19 was epidemic in the Daegu city and the surrounding Gyeongsangbuk-do region (the D-G region), which is located in southeastern Korea. The Daegu city (urban area, total population 2.43 million, population density 2,738/km<sup>2</sup>) is the 4th largest city in South Korea. Gyeongsangbuk-do region (rural area, total population 2.66 million, population density 140/km<sup>2</sup>) is composed of a mountainous area and surrounds the Daegu city. The first patient was diagnosed on February 18, and by late February, there had been an explosive increase in the number of COVID-19 patients, making the D-G region the epicenter of the outbreak in Korea (shown in Fig. 1). COVID-19 began to spread intensively in the Daegu city, and it spread to the surrounding Gyeongsangbuk-do region [8]. Therefore, given the potential relationship between the COVID-19 pandemic and changes in health-seeking behaviors, we analyzed stroke patients and stroke care services according to the Korean region using data from the Korean Stroke Registry (KSR) [9, 10].

## Materials and Methods

### Registry Characteristics

The KSR is a representative multicenter, prospective, hospital-based stroke registry in Korea. The KSR core system currently collects data from 47 secondary and tertiary hospitals, which submit records via a web-based system ([www.strokedb.or.kr](http://www.strokedb.or.kr)) [9, 10]. The registry's guidelines and procedures were approved by the Institutional Review Board of the Seoul National University Hospital as a delegate of the participating hospitals (Reg. No. H-1009-062-332).

### Data Acquisition

All data were acquired between January 2019 and May 2020. The exclusion criteria were missing demographic data, missing data regarding stroke diagnosis, duplicate records, age of <16 years, and protocol violations. We reviewed data from patients with acute stroke and transient ischemic attack (TIA) who were registered during the epidemic period in 2020 (the COVID-19 period, February 18–March 31, 2020) and the corresponding period in 2019 (the pre-COVID-19 period, February 18–March 31, 2019). The pre-COVID-19 period data were collected from 40 hospitals that had been participating in the KSR core system before 2019. The outcomes of interest were patient characteristics, time from stroke onset to hospital arrival (onset-to-door time), and in-hospital stroke pathways. We also performed subgroup analyses of the D-G region.

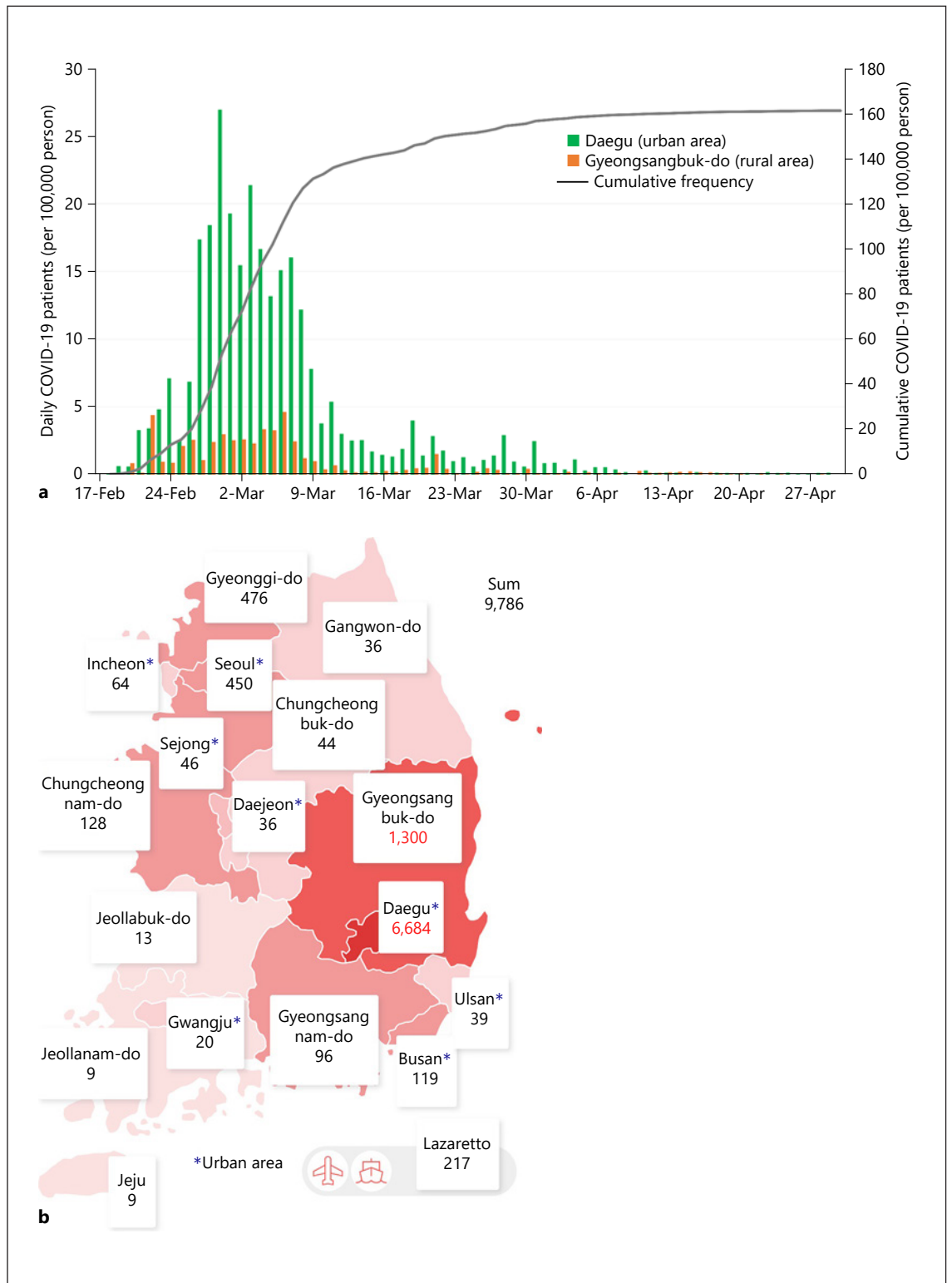
### Statistical Analyses

Baseline characteristics were reported as mean  $\pm$  standard deviation for continuous variables or as number (percentage) for categorical variables. Intergroup comparisons were performed using the  $\chi^2$  test or Fisher's exact test for categorical variables and Student's *t* test or the Wilcoxon rank-sum test for continuous variables. All analyses were performed using SAS software (version 9.4; SAS Institute, Cary NC, USA), and statistically significant differences were considered present at  $\alpha = 0.05$ .

## Results

### Overall Changes

A total of 22,842 patients were registered in the KSR during the study period. After excluding 717 patients, 22,125 patients enrolled for the entire period (between January 2019 and May 2020). The study evaluated data from 1,792 patients during the pre-COVID-19 period and 1,555 patients during the COVID-19 period. The mean patient age was  $68.3 \pm 13.4$  years, and 59.1% (1,978 cases) of the patients were male (Table 1). Relative to the pre-COVID-19 period, fewer patients were enrolled in the KSR during the COVID-19 period (February and March 2020) (shown in online suppl. Fig. 1; for all online suppl. material, see [www.karger.com/doi/10.1159/000519093](http://www.karger.com/doi/10.1159/000519093)). Most regions exhibited decreasing patient registration, although the D-G region had a sharp decrease of 35.8% during the COVID-19 period (shown in online suppl. Fig. 2).



**Fig. 1.** Cumulative number of COVID-19 cases in the Daegu and Gyeongsangbuk-do region (per 100,000 persons) between February 18, 2020, and April 31, 2020 (a) and in the Republic of Korea until April 31, 2020 (b).

**Table 1.** Clinical characteristics, risk factors, and stroke classification during the pre-COVID-19 and COVID-19 periods

	Pre-COVID-19 (n = 1,792)	COVID-19 (n = 1,555)	p value
Age, mean±SD, years	68.46±13.61	68.08±13.12	0.414 <sup>†</sup>
Male sex, n (%)	1,034 (57.70)	944 (60.71)	0.078 <sup>‡</sup>
Risk factors, n (%)			
Hypertension	1,174 (65.51)	980 (63.02)	0.134 <sup>‡</sup>
Diabetes mellitus	594 (33.15)	531 (34.15)	0.541 <sup>‡</sup>
Hyperlipidemia	685 (38.23)	615 (39.55)	0.433 <sup>‡</sup>
Coronary artery disease	175 (9.77)	167 (10.74)	0.355 <sup>‡</sup>
Atrial fibrillation	346 (19.31)	308 (19.81)	0.717 <sup>‡</sup>
Ever-smokers	597 (33.31)	508 (32.67)	0.692 <sup>‡</sup>
Stroke classification, n (%)			
Ischemic stroke	1,617 (90.23)	1,444 (92.86)	0.007 <sup>‡</sup>
Large artery atherosclerosis*	512 (32.67)	425 (33.68)	<0.001 <sup>‡</sup>
Small vessel occlusion*	328 (20.93)	249 (19.73)	
Cardioembolism*	332 (21.19)	255 (20.21)	
Other etiologies*	68 (4.34)	55 (4.36)	
Undetermined etiology*			
Two or more etiologies	74 (4.72)	86 (6.81)	
Negative results	136 (8.68)	148 (11.73)	
Incomplete workup	117 (7.47)	44 (3.49)	
Hemorrhagic stroke	50 (2.79)	37 (2.38)	0.456 <sup>‡</sup>
Transient ischemic attack	125 (6.98)	74 (4.76)	0.007 <sup>‡</sup>
Stroke severity, median (IQR)			
Premorbid mRS	0 (0–0)	0 (0–0)	0.724 <sup>§</sup>
Baseline NIHSS	3 (1–7)	3 (1–8)	0.275 <sup>§</sup>
Discharge mRS	2 (1–3)	2 (1–4)	0.002 <sup>§</sup>
Discharge NIHSS	2 (0–5)	2 (1–5)	0.041 <sup>§</sup>

COVID-19, coronavirus disease 2019; SD, standard deviation; mRS, modified Rankin scale; IQR, interquartile range; NIHSS, National Institutes of Health Stroke Scale. \* Only included patients with ischemic stroke (pre-COVID-19: 1,567 patients; COVID-19: 1,262 patients). <sup>†</sup> t test. <sup>‡</sup>  $\chi^2$  test. <sup>§</sup> Wilcoxon rank-sum test.

During the COVID-19 period, there was a higher proportion of ischemic stroke cases and a lower proportion of TIA cases (Table 1). In addition, relative to the pre-COVID-19 period, higher National Institutes of Health Stroke Scale (NIHSS) and modified Rankin scale (mRS) scores at discharge were observed during the COVID-19 period. The D-G region had a significantly higher proportion of patients with vascular risk factors, such as hypertension, hyperlipidemia, and coronary artery disease (online suppl. Table 1). Furthermore, the D-G region had a significant decrease in the proportion of TIA cases (9.97% to 2.91%) and an increase in the proportion of ischemic stroke cases (84.11% to 93.20%). Moreover, the D-G region had increased NIHSS and mRS scores at discharge during the COVID-19 period.

#### Onset-to-Door Time

In the D-G region, the median onset-to-door time was significantly increased during the COVID-19 period, relative to during the pre-COVID-19 period (526.5 min vs.

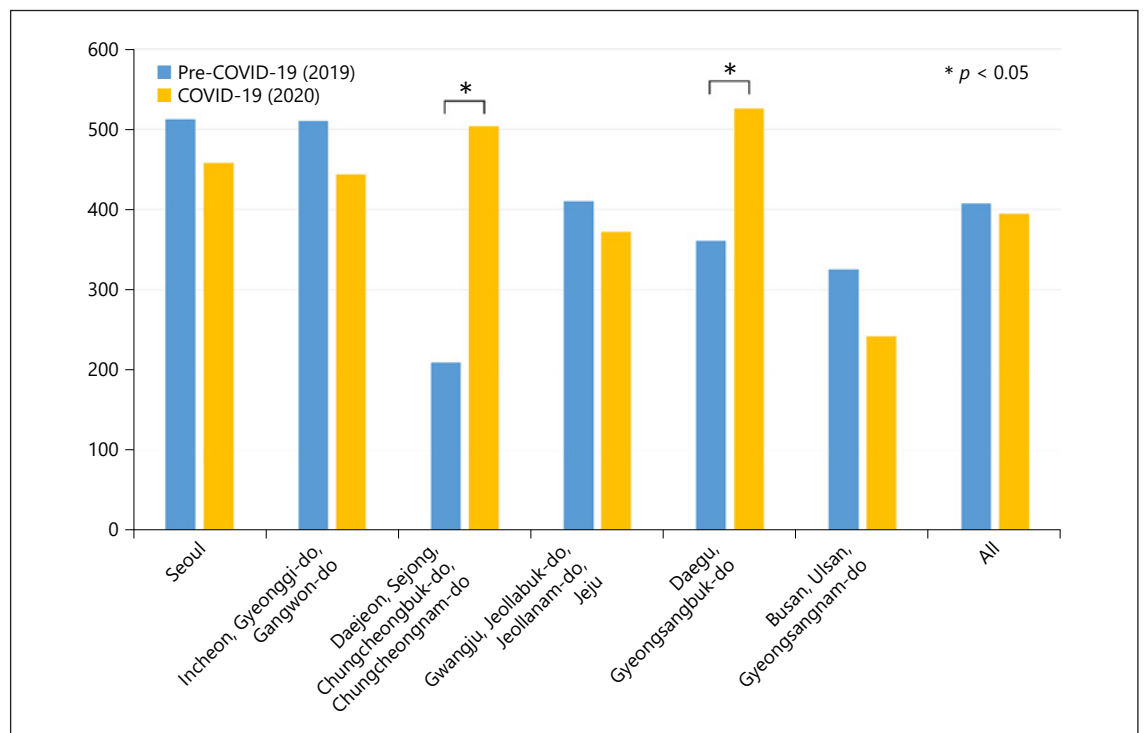
361 min,  $p = 0.016$ ). In addition, the proportion of patients in the D-G region who visited the hospital within 3 h after symptom onset decreased significantly during the COVID-19 period (36.5% to 28.2%,  $p = 0.049$ ). The median onset-to-door times tended to decrease in the other regions (shown in Table 2; Fig. 2).

Subgroup analyses of patients in the D-G region revealed that patients in their 60s and 70s had significantly prolonged median onset-to-door times during the COVID-19 period (60s: 271 min–774 min,  $p = 0.020$ ; 70s: 405 min–1,399 min,  $p = 0.004$ ). Men and women both had increased onset-to-door times, and the sex-related difference was not statistically significant. Subgroup analyses according to stroke severity revealed a significantly increased onset-to-door time among patients with a mild initial NIHSS score (0–3 points: 502 min–1,070 min,  $p = 0.012$ ) and nonsignificant increases among patients with a moderate and severe initial NIHSS score. The magnitude of the delay in onset-to-door times tended to decrease with increasing stroke severity (shown in Table 3; Fig. 3).

**Table 2.** Onset-to-door times and stroke treatments during the pre-COVID-19 and COVID-19 periods

	Pre-COVID-19 (n = 1,792)	COVID-19 (n = 1,555)	p value <sup>†</sup>
All (n = 3,347)			
Median onset-to-door time, min (IQR)	408 (104–1,576.5)	395 (103–1,606)	0.830
Onset-to-door within 3 h, n (%)	635 (35.44)	556 (35.76)	0.847
Intravenous thrombolysis, n (%)*	174 (10.76)	145 (10.04)	0.516
Median door-to-needle time, min (IQR)	38 (28–51)	36 (28–53)	0.909
Mechanical thrombectomy, n (%)*	158 (9.77)	156 (10.80)	0.348
Median door-to-puncture time, min (IQR)	99 (73–133)	98.5 (75–137)	0.908
Daegu and Gyeongsangbuk-do region (n = 527)			
Median onset-to-door time, min (IQR)	361 (106–1,429)	526.5 (157–2,175)	0.016
Onset-to-door within 3 h, n (%)	117 (36.45)	58 (28.16)	0.049
Intravenous thrombolysis, n (%)*	25 (9.26)	12 (6.25)	0.240
Median door-to-needle time, min (IQR)	45 (29–52)	53 (28–67)	0.606
Mechanical thrombectomy, n (%)*	21 (7.78)	18 (9.38)	0.543
Median door-to-puncture time, min (IQR)	95 (69–136)	79.5 (67–110)	0.345
Other regions (n = 2,820)			
Median onset-to-door time, min (IQR)	421 (103–1,602)	380 (95–1,550)	0.492
Onset-to-door within 3 h, n (%)	518 (35.21)	498 (36.92)	0.347
Intravenous thrombolysis, n (%)*	149 (11.06)	133 (10.62)	0.719
Median door-to-needle time, min (IQR)	37.5 (27–51)	36 (28–52)	0.855
Mechanical thrombectomy, n (%)*	137 (10.17)	138 (11.02)	0.481
Median door-to-puncture time, min (IQR)	99 (73–132.5)	100 (76.5–145.5)	0.629

COVID-19, coronavirus disease 2019; IQR, interquartile range. \* Only included patients with ischemic stroke (all: 3,061 patients, Daegu and Gyeongsangbuk-do region: 462 patients, and other regions: 2,599 patients). † Wilcoxon rank-sum test for continuous variables and  $\chi^2$  test for categorical variables.



**Fig. 2.** Changes in the median onset-to-door times for stroke patients according to the region.

**Table 3.** Subgroup analyses of onset-to-door times in the Daegu and Gyeongsangbuk-do region

	Pre-COVID-19 (n = 321)*	COVID-19 (n = 206)*	p value <sup>†</sup>
Age, years			
<60	698 (139–2,198)	486.5 (131–1,824)	0.621
60–69	271 (79–1,196)	774.5 (191–2,061)	0.020
70–79	405 (128–1,429)	1,399 (282–4,656)	0.004
≥80	265.5 (88–698)	265.0 (113–669)	0.649
Sex			
Male	380 (112–1,814)	602 (142–3,083)	0.143
Female	346 (90–1,232)	448 (181–1,753)	0.053
NIHSS score			
0–3	502 (152–1,874)	1,070 (215–3,295)	0.012
4–7	361 (115–1,704)	723 (258–1,660)	0.226
≥8	114 (60–432)	174 (69–343.5)	0.264

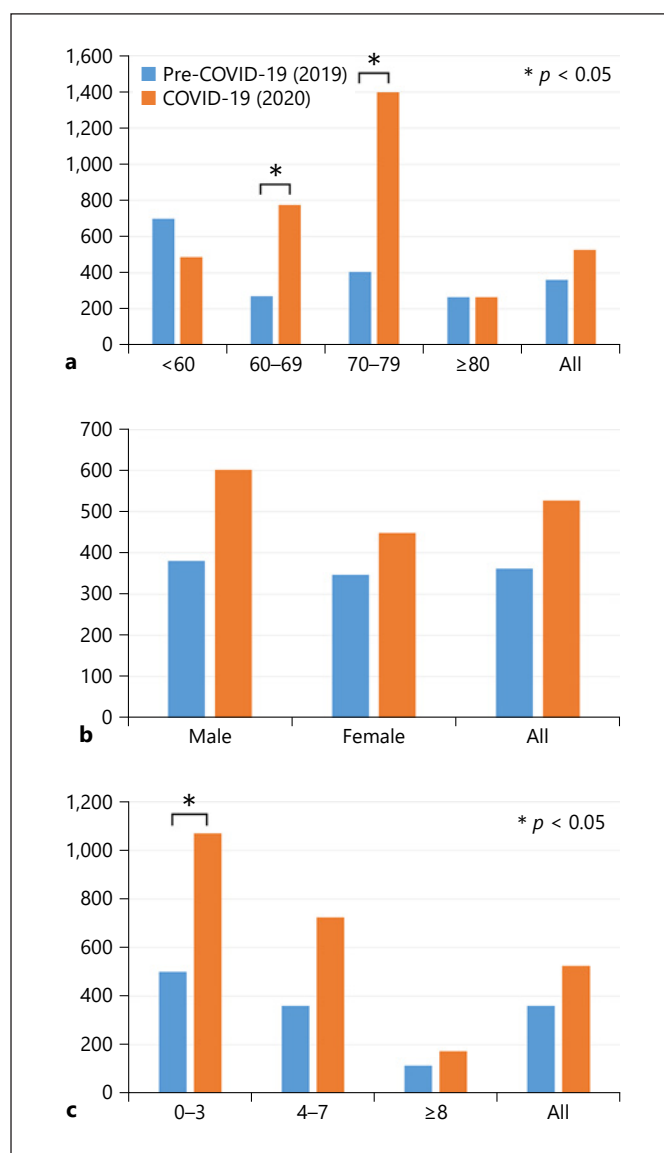
COVID-19, coronavirus disease 2019; NIHSS, National Institutes of Health Stroke Scale. \* Data are presented as median times (min) with interquartile ranges. <sup>†</sup>Wilcoxon rank-sum test.

### Intravenous Thrombolysis and Intra-Arterial Thrombectomy

Relative to the pre-COVID-19 period, the proportion of patients who underwent intravenous thrombolysis (IVT) decreased by 16.7% during the COVID-19 period, with a 52.0% decrease observed in the D-G region (shown in online suppl. Fig. 3). The proportional change in patients who underwent intra-arterial thrombectomy (IAT) varied substantially according to the region, with an overall decrease of 1.3% and a decrease of 14.3% in the D-G region (shown in online suppl. Fig. 4). The proportion of patients who underwent IVT or IAT and the times from hospital visit to treatment were not significantly different between the pre-COVID-19 and COVID-19 periods (Table 2).

### Discussion

This study revealed changes in the health-seeking behaviors of stroke patients, especially among patients from the D-G region, which was an epicenter of the Korean COVID-19 outbreak during late February and March 2020. During the COVID-19 period, there was a decrease in the overall number of patients who were admitted to KSR-registered hospitals (vs. the pre-COVID-19 period), and this decrease was very pronounced in the D-G region. It may be possible that the incidence of stroke itself decreased because of reduced air pollution during this period [11]; however, it is plausible that stroke patients might have avoided



**Fig. 3.** Changes in the median onset-to-door times for stroke patients in the Daegu and Gyeongsangbuk-do region according to the age group (a), sex (b), and National Institutes of Health Stroke Scale score (c).

or delayed hospital visits because of the COVID-19 epidemic, which is supported by the sharp decrease in the proportion of TIA patients in the D-G region. In addition, the proportion of stroke patients with vascular risk factors increased in the D-G region during the COVID-19 period. Thus, patients might have avoided visiting hospitals if they did not have many known risk factors or stroke symptoms. The COVID-19 pandemic has caused lifestyle changes in South Korea driven by stay-at-home strategies and social distancing between people. In a Korean survey, there was

a significant decrease in physical and other activities such as daily life, leisure, social activities, and education [12]. A similar phenomenon was observed in other countries including India and the Netherlands [13, 14]. This change could reduce the number of patients visiting hospitals in the COVID-19 outbreak.

During the COVID-19 pandemic, other countries have also observed decreases in the number of stroke patients. A comprehensive stroke center in Barcelona experienced 23% and 24% decrease in the number of stroke admissions and thrombectomies, respectively [3]. A Chinese study revealed a 40% decrease in hospital admissions and a 25% decrease in thrombolysis/thrombectomy cases [6]. Previous studies from France and Egypt have also identified similar trends [15, 16], although these studies were unable to clarify the cause of these trends. Our study of national registry data revealed that the COVID-19-associated decrease in the number of stroke patients was related to decreased numbers of patients being hospitalized with mild symptoms or few vascular risk factors.

Unlike in other Korean regions, the D-G region exhibited a significant increase in the onset-to-door time during the COVID-19 period (vs. the corresponding pre-COVID-19 period). This suggests the possibility that patients might have been reluctant to visit a hospital if their symptoms resolved, which might be related to the local COVID-19 epidemic, especially in their 60s/70s. A brief report from Hong Kong identified a prolonged time from stroke onset to hospital arrival, as well as a significant reduction in the proportion of patients who arrived at the hospital within 4.5 h [17]. The COVID-19 mortality rate increases significantly at ages of  $\geq 60$  years, which might cause patients in their 60s/70s to modify their activity and potentially delay hospital visits [18, 19]. Patients in their 60s/70s also have relatively mild symptoms (vs. patients who are in their 80s), which might have also contributed to the prolonged onset-to-door time in this age group. A previous Chinese study has also indicated that fears among patients and their families regarding SARS-CoV-2 virus infection might also lead to prehospital delays and decreased admission for stroke care [6]. Thus, the emphasis on social distancing might have inappropriately caused patients with acute stroke to avoid seeking medical care. Furthermore, increasing social isolation might delay the identification of stroke patients by family members. This could explain the absence of a prolonged onset-to-door time among patients who were  $\geq 80$  years old, as these individuals are likely to live with family members even during the COVID-19 pandemic. Therefore, our findings may suggest that patients initially delayed hospital visits

if their symptoms were mild and only visited hospitals if their symptoms persisted.

Our study suggests that many stroke patients who could have received adequate treatment if COVID-19 had not been prevalent would have missed the adequate treatment. According to data from Statistics Korea, the healthy life years, which is the period that can be spent in a healthy state without illness or accident, was 64.0 years for men (81.6% of the life expectancy of 79.7 years) and 64.9 years for women (76.4% of the life expectancy of 85.7 years) [20]. The patients who experience stroke in their 60s/70s will suffer from sequelae for the rest of their life if they do not receive adequate treatment and secondary prevention, and it leads to social loss and reduced quality of life. Therefore, even during the COVID-19 pandemic, a triage system that quickly guides patients to a hospital that can adequately treat them should be maintained. Besides, appropriate public education is needed to communicate that hospitals and regional healthcare systems can safely and adequately manage serious acute diseases, such as stroke.

This study has a few limitations. First, while the KSR data are collected from 47 hospitals across Korea, the results might not be completely representative of all Korean stroke patients. Second, the registry only collects data from secondary and tertiary hospitals, and the results might vary if data from smaller hospitals were incorporated. Also, there is no total number of emergency rescues or rejections performed for all stroke patients in the KSR. Nevertheless, the KSR is currently the largest stroke registry in Korea, and the results provide some insights regarding the changes in health-seeking behaviors of stroke patients during the COVID-19 pandemic.

## Conclusion

During the COVID-19 pandemic, Korean stroke patients residing in an epidemic region exhibited distinct changes in their health-seeking behaviors. Appropriate triage system and public education regarding the importance of early treatment are needed during the COVID-19 pandemic.

## Acknowledgments

This study used the Korean Stroke Registry database, which is supported by the Korean Stroke Society. The centers that contribute to the Korean Stroke Registry are presented in alphabetical order: Asan Medical Center, Seoul; Bundang Jesaeng Hospital, Bundang; Changwon Fatima Hospital, Changwon; Chonnam National Uni-

versity Hospital, Gwangju; Chung-Ang University Hospital, Seoul; Chungbuk National University Hospital, Cheongju; Chungnam National University Sejong Hospital, Sejong; Daegu Catholic University Medical Center, Daegu; Daejeon Eulji Medical Center, Eulji University, Daejeon; Dong-A University Hospital, Busan; Dongguk University Ilsan Hospital, Goyang; Nowon Eulji Medical Center, Eulji University, Seoul; Gachon University Gil Medical Center, Incheon; Gangnam Severance Hospital, Seoul; Gyeonggi Provincial Medical Center Icheon Hospital, Icheon; Gyeongsang National University Hospital, Jinju; Gyeongsang National University Changwon Hospital, Changwon; Hallym University Chuncheon Sacred Heart Hospital, Chuncheon; Hallym University Dongtan Sacred Heart Hospital, Hwaseong; Hallym University Sacred Heart Hospital, Anyang; Hanyang University Hospital, Seoul; Inha University Hospital, Incheon; Inje University Busan Paik Hospital, Busan; Inje University Ilsan Paik Hospital, Goyang; Jeju National University Hospital, Jeju; Kangdong Sacred Heart Hospital, Seoul; Kangwon National University Hospital, Chuncheon; Keimyung University Dongsan Hospital, Daegu; Konkuk University Medical Center, Seoul; Korea University Guro Hospital, Seoul; Kosin University Gospel Hospital, Busan; Kyung Hee University Medical Center, Seoul; Kyungpook National University Chilgok Hospital, Daegu; Mokpo Jung-Ang Hospital, Mokpo; S Pohang Stroke and Spine Hospital, Pohang; Samsung Medical Center, Seoul; Seongsu Medical Foundation Incheon Paik Hospital, Incheon; Seoul Medical Center, Seoul; Seoul National University Bundang Hospital, Seoul; Seoul National University Hospital, Seoul; Severance Hospital, Seoul; SMG-SNU Boramae Medical Center, Seoul; Soonchunhyang University Hospital, Seoul; Ulsan University Hospital, Ulsan; Yeungnam University Medical Center, Daegu; Yonsei S Hospital, Changwon; and Yuseon Sun Hospital, Daejeon.

## Statement of Ethics

All participants provided informed consent, and the registry's guidelines and procedures were approved by the Institutional Review Board of Seoul National University Hospital as a delegate of the participating hospitals (IRB No. H-1009-062-332).

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## Conflict of Interest Statement

The authors have no conflicts of interest to declare.

## Funding Sources

This research was supported by a fund (2020ER620200#) by Research of Korea Centers for Disease Control and Prevention, Republic of Korea.

## Author Contributions

H.-Y.J., E.-J.L., and M.K.K. contributed to conceptualization. H.-Y.J., E.-J.L., M.K.K., K.-H.J., and B.-W.Y. contributed to methodology. All authors contributed to data curation and investigation. H.-Y.J., M.K.K., and J.S.L. contributed to formal analysis. H.-Y.J. contributed to writing – original draft. K.-H.J., B.-W.Y., and J.-M.P. contributed to writing – review and editing. K.-H.J., H.-J.B., B.-W.Y., and J.-M.P. contributed to project administration. B.-W.Y. and J.-M.P. contributed to supervision.

## Data Availability Statement

The data that support the findings of this study are not publicly available but are available from the corresponding author (J.-M.P.) and the data sharing committee of the Korean Stroke Registry (ksr.core@stroke.or.kr) upon reasonable request.



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