Submitted: 18 November, 2022 Accepted: 20 February, 2023 Published: 08 April, 2024 DOI:10.22514/sv.2024.037

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ORIGINAL RESEARCH

Changes in epidemiology of patients visiting emergency departments during the early COVID-19 pandemic period

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Abstract

Infectious disease outbreaks have a great influence on the use of emergency departments (EDs). The purpose of this study was to analyze the effect of the early coronavirus disease outbreak (COVID-19) on ED visits, to be able to more effectively use ED resources during infectious disease outbreaks. This was a retrospective observational study conducted in three tertiary EDs. We defined the COVID-19 period as 01 December 2019, to 30 April 2020, and the control periods were defined as the same period in 2018 and 2019. All patients who visited the EDs during the study period were included. We collected visitor data on the total number, demographics, clinical data, vital signs, acuity level, cause of visit, disposition, time of visit and diagnostic code. A total of 180,192 patients were enrolled in this study. During the COVID-19 period, the number of ED visits decreased significantly. This decline was significant since mid-February when the number of COVID-19 patients surged nationwide. The proportion of critical patients and admission rate increased while the proportion of non-emergency patients decreased significantly from February ($p < 0.001$). The proportion of night-time ED visits decreased significantly from March. During the COVID-19 period and pre-COVID-19 period, the top three diagnosis areas were "abdominal and pelvis pain" "fever of other and unknown origin" and "open wound in the head" and remained unchanged. "Influenza because of an identified seasonal influenza virus" decreased during the study period. The study showed the number and characteristics of ED visits changed during the COVID-19 period compared with those of pre-COVID-19 periods.

Keywords

Emergency service hospital; Pandemics; COVID-19

1. Introduction

On 31 December 2019, a type of pneumonia with unknown origin was reported in Wuhan, the central city and the capital of Hubei Province, China. It was reported to be caused by a novel coronavirus known as severe acute respiratory syndrome coronavirus 2 and was named as coronavirus disease 2019 (COVID-19) by the World Health Organization (WHO) on 12 February 2020 [1, 2]. Since the WHO declared a pandemic on 11 March 2020, it has continued to evolve through new mutations.

In Korea, COVID-19 was first identified on 20 January 2020, from a Chinese female tourist residing in Wuhan. After the super-spreading event around mid-February, the number of confirmed cases began to rise sharply and reached more than a thousand [3]. As of 12 January 2023, a total of 660,746,894 patients and 6,692,538 deaths were reported worldwide, and 29,698,043 patients with confirmed COVID-19 and 32,821 deaths were reported in Korea [4, 5].

In recent decades, there have been several infectious disease outbreaks, including Escherichia coli 0157:H7 outbreak in the United States in 1993, the H1N1 influenza pandemic in 2009, the severe acute respiratory syndrome (SARS) outbreak in 2003 and Middle East respiratory syndrome (MERS) outbreak in 2014. These infectious diseases affected emergency room visits [6–9]. There were several studies that evaluated the pattern of ED visits during the period of COVID-19 outbreak, and these showed various patterns [1, 2, 10–18].

The emphasis on basic personal hygiene, such as wearing masks and washing hands immediately after the outbreak of COVID-19, was similar across countries. However, since each country had a different outbreak pattern, quarantine policies such as social distancing, stay at home orders, restrictions on the number of people allowed to gather, and business closures, varied greatly in each country [1, 2, 11, 16, 17].

In the early stages of infectious disease outbreaks, basic personal hygiene is emphasized to protect from infection, because it is not known what characteristics the disease might have.

Also, the state's policy and people's behavior changes depend on the infection incidence and severity of ensuing disease. Identifying changes in the characteristics of patients visiting the ED at the beginning of infectious disease epidemic will be helpful in establishing a framework for future redistribution and use of medical personnel, facilities, and equipment when a new infectious disease epidemic occurs. Therefore, this study aimed to identify the changes in epidemiological characteristics of patients visiting the ED during the early period of the COVID-19 outbreak.

2. Methods

2.1 Design and setting

This retrospective observational study was conducted on three tertiary EDs of Korea University Hospital in the metropolitan area, including the capital, Seoul. Korea University Anam Hospital and Guro Hospital are regional EDs, which have only seven EDs in Seoul, with 49,994 and 64,456 patients visiting them in 2019, respectively. Korea University Ansan Hospital is a local ED in Ansan, Gyeonggi-do, a metropolitan area and 47,933 patients visited in 2019.

The patterns of patients visiting an ED may have annual or monthly variability. Since COVID-19 was first reported on 31 December, we included December 2019 in the COVID-19 period to identify the changes in the pattern of monthly patients visiting the EDs. In addition, since patients visiting EDs may show annual variation, data from the same period in 2018 and 2019 when there was no COVID-19, were collected and compared. Therefore, to examine the effect of COVID-19 on the pattern of ED visits in the early stages of the COVID-19 outbreak, we collected the data of patients who visited the ED for 5 months from 01 December 2019, to 30 April 2020. This span is referred to as the COVID-19 period in 2020. The pattern of ED visits during this period was compared with that during the period from 01 December 2018, to 30 April 2019, and from 01 December 2017, to 30 April 2018, referred to as the pre-COVID-19 periods in 2018 and in 2019 respectively.

2.2 Measurements

To evaluate the general characteristics of patients visiting EDs, data on sex, age, date and time of visit, initial blood pressure, heart rate, respiration rate, body temperature, level of consciousness, and disposition upon discharge were collected. The Korean Triage and Acuity Scale (KTAS) was used as a triage tool to assess the severity. KTAS has been used as a trial tool in all regional and local EDs in Korea and is divided into five levels, from KTAS1, which requires immediate treatment due to life-threatening conditions, to KTAS5, a non-emergency visit like care of chronic illness. Generally, individuals with KTAS levels from 1–2 were classified as critical patients, patients in KTAS 3 was classified as emergent patients, and those with KTAS scores 4–5 were classified as non-emergency patients [19]. To identify the changes in the pattern of disease of patients who visited the ED during the study period, the diagnosis was made using the International Classification of Diseases, 10th revision (ICD-10) codes. The extracted ICD-10 code comprised three characters, and only the primary diagnosis was recorded for each patient.

2.3 Statistical analyses

An imputation method to handling missing data was not used because there is no incomplete case data. To analyze the difference between the means of the three groups, a normality test was performed using the Kolmogorov-Smirnov test, and the homogeneity of variance was checked using the Levene's test. The test results indicated normality although not homogeneity, and the difference in the number of samples among the three groups was relatively large. Therefore, the analysis was performed using Welch's robust analysis of variance, and *post hoc* analysis was performed following the Dunnett T3 method. Chi-squared test was performed to compare categorical variables, and Bonferroni post hoc analysis was used to compare the differences in ratio among the three groups. The incidence rate ratio (IRR) was calculated to compare the incident rate of critical patients and ED visits per day in a month during pre-COVID-19 and COVID-19 periods. The continuous variables were expressed as means $\pm$ standard deviations and the categorical variables were expressed as frequencies (percentages). SPSS version 20.0 (IBM Corp., Armonk, NY, USA) and R version 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria) were used to perform all statistical analyses. A p-value < 0.05 was considered statistically significant.

3. Results

3.1 Comparison of differences in the number of patients visiting the EDs between pre-COVID-19 and COVID-19 periods

A total of 191,217 patients visited the ED during the study period. Patients whose visits were non-medical in nature, such as issuance of medical certificates, those who cancelled the reception, and those who lacked data in their medical records were excluded. Overall, 180,192 patients were enrolled in the study. 52,245 patients visited the ED during the COVID-19 period in 2020. This number was significantly reduced compared with the 64,405 and 63,542 patients during the pre-COVID-19 periods in 2018 and 2019, respectively (Fig. 1). The patterns of ED visits began to decline in February (Fig. 2). During February, incident rate of ED visits in COVID-19 period was decreased compared with the pre-COVID-19 period in 2018 (IRR, 0.68; 95%; confidence interval (CI), 0.67–0.70; $p < 0.001$) and 2019 (IRR, 0.72; 95% CI, 0.70–0.74; $p < 0.001$) and this decline continued in March and April (**Supplementary Table 1**).

3.2 Comparison of baseline characteristics between the prior and COVID-19 periods

Table 1 shows the general characteristics of each year during the study period. The mean age of patients who visited the ED during the COVID-19 period in 2020 (43.5 $\pm$ 26.1) was higher than for those who visited the ED during the pre-COVID-19 periods in 2018 and 2019 (40.2 $\pm$ 26.4, 41.1 $\pm$ 26.3) ($p < 0.001$). No significant difference was observed

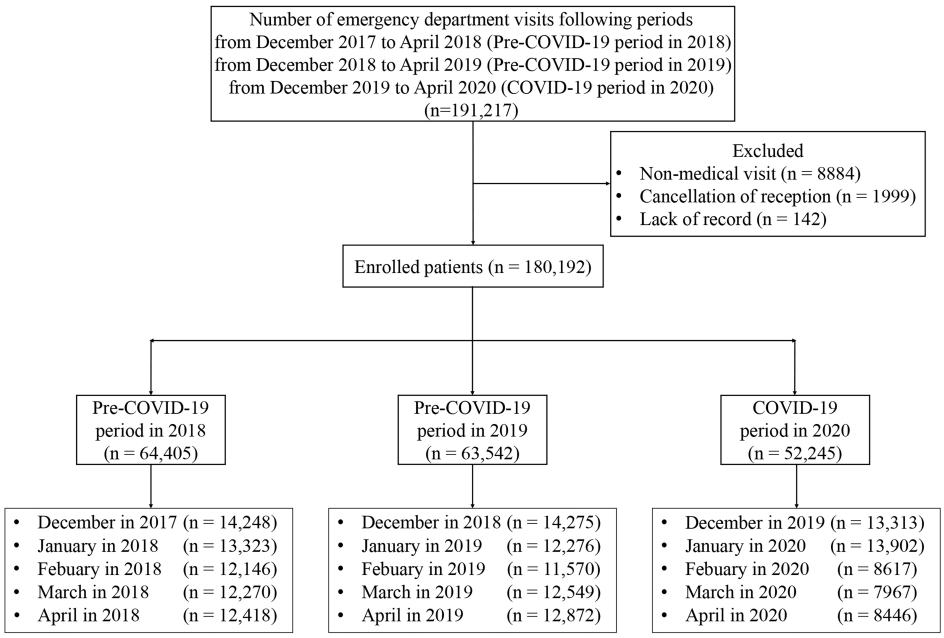

FIGURE 1. Flowchart of the study patient selection process and outcomes. COVID, the coronavirus disease.

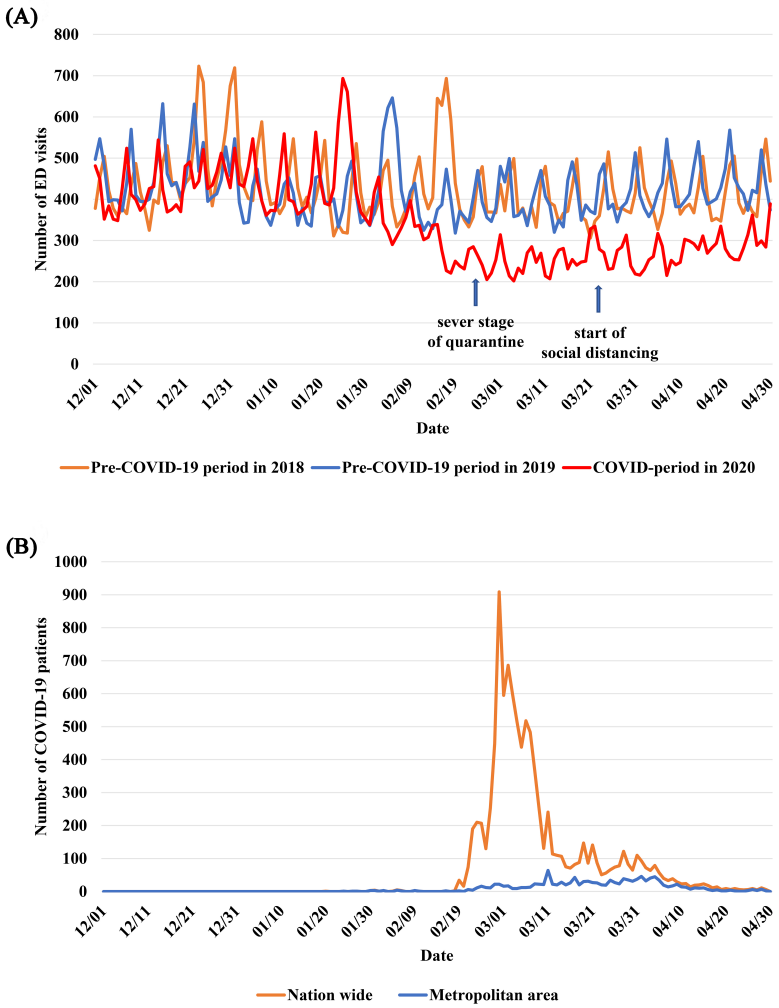

FIGURE 2. Number of daily emergency department visits and COVID-19 patients in Korea. (A) Number of daily emergency department visits during pre-COVID-19 and COVID-19 period. (B) Number of new daily cases of COVID between nationwide and metropolitan area. COVID, the coronavirus disease.

TABLE 1. Demographic and epidemiological characteristics of the pre-COVID-19 and COVID-19 periods.

Characteristic	Pre-COVID period in 2018	Pre-COVID period in 2019	COVID-19 period in 2020	*p*-value
Number of Patients, n	64,405	63,542	52,245	
Age (years), Mean ± SD	40.2 ± 26.4	41.1 ± 26.3	43.5 ± 26.1	<0.001
Gender				
Male, n (%)	32,790 (50.9%)	32,481 (51.1%)	26,633 (51.0%)	0.756
Reason for visiting				
Medical disease, n (%)	47,680 (74.0%)	47,692 (75.1%)	40,360 (77.3%)	<0.001
Non-medical disease, n (%)	16,725 (26.0%)	15,850 (24.9%)	11,885 (22.7%)	
Consciousness				
Alert, n (%)	61,489 (95.5%)	60,586 (95.3%)	49,217 (94.2%)	
Verbal, n (%)	1534 (2.4%)	1596 (2.5%)	1609 (3.1%)	<0.001
Pain, n (%)	977 (1.5%)	987 (1.6%)	1022 (2.0%)	
Unresponsive, n (%)	405 (0.6%)	373 (0.6%)	397 (0.8%)	
Initial KTAS				
KTAS 1, n (%)	749 (1.2%)	697 (1.1%)	732 (1.4%)	
KTAS 2, n (%)	4074 (6.3%)	3761 (5.9%)	3644 (7.0%)	
KTAS 3, n (%)	32,440 (50.4%)	32,697 (51.5%)	28,379 (54.3%)	<0.001
KTAS 4, n (%)	19,279 (29.9%)	19,414 (30.6%)	14,644 (28.0%)	
KTAS 5, n (%)	7863 (12.2%)	6973 (11.0%)	4846 (9.3%)	
SBP (mmHg), Mean ± SD	130.8 ± 24.5	132.5 ± 25.0	134.9 ± 25.6	<0.001
DBP (mmHg), Mean ± SD	79.6 ± 14.9	79.3 ± 15.4	80.8 ± 15.7	<0.001
RR (rate), Mean ± SD	21.7 ± 4.9	21.4 ± 4.8	20.7 ± 5.0	<0.001
HR (rate), Mean ± SD	96.8 ± 25.2	96.4 ± 24.7	96.4 ± 24.9	0.006
BT (°C), Mean ± SD	36.8 ± 1.7	36.8 ± 1.6	36.8 ± 1.8	0.001
Disposition				
Admission, n (%)	12,528 (19.5%)	13,277 (20.9%)	12,156 (23.3%)	
Transfer out, n (%)	1645 (2.6%)	1573 (2.5%)	1235 (2.4%)	
Expire, n (%)	302 (0.5%)	294 (0.5%)	304 (0.6%)	<0.001
Discharge, n (%)	49,394 (76.7%)	48,009 (75.6%)	38,214 (73.1%)	
Escape, n (%)	536 (0.8%)	389 (0.6%)	336 (0.6%)	

COVID, the coronavirus disease; KTAS, Korean Triage and Acuity Scale; SBP, systolic blood pressure; DBP, diastolic blood pressure; RR, respiration rate; HR, heart rate; BT, body temperature; SD, standard deviation.

in gender during the study period (p = 0.0756). However, significant differences were observed in terms of the reason for visiting with a medical or non-medical disease, the level of consciousness, initial KTAS, and disposition ($p < 0.001$). Approximately 77.3% of the patients had medical illness during the COVID-19 period in 2020. This proportion was different from those reported during the pre-COVID-19 periods in 2018 and 2019 (74.0% and 75.1% respectively). The proportion of alert patients during the COVID-19 period in 2020 was around 94.2%, which was different from those who visited the ED during the pre-COVID-19 periods in 2018 and 2019 (95.5% and 95.3%, respectively). During the COVID-19 period in 2020, non-emergency patients with KTAS scores of 4–5 were approximately 37.3% which was different from those reported during the pre-COVID-19 periods in 2018 and 2019 (42.1% and 41.6%, respectively). In contrast, the admission percentage during the COVID-19 period in 2020 increased to 23.3%, compared with during the pre-COVID-19 periods (19.5% and 20.9%) (Table 1).

3.3 Comparison of the monthly characteristic differences between the prior and COVID-19 periods

From February to April during the COVID-19 period in 2020, the proportion of alert patients started to significantly decline compared to the pre-COVID-19 periods in 2018 and 2019. The mean ages of patients who visited the ED and the proportion of admissions during COVID-19 significantly increased during the same period compared with the pre-COVID-19 periods (Table 2). In addition, the proportion of non-emergency patients with KTAS levels 4–5 significantly decreased during

TABLE 2. Comparison of monthly changes in admission, alert mentality, and mean age between pre-COVID-19 and COVID-19 periods.

Variable	Pre-COVID-19 period in 2018	Pre-COVID-19 period in 2019	COVID-19 period in 2020	P^1	P^2	P^3
Admission, n (%)						
December	14,248 (18.3%)	14,275 (20.2%)	13,313 (21.6%)	<0.001	0.019	<0.001
January	13,323 (19.5%)	12,276 (20.9%)	13,902 (20.1%)	0.687	0.423	0.025
February	12,146 (18.4%)	11,570 (19.7%)	8617 (23.6%)	<0.001	<0.001	0.053
March	12,270 (20.3%)	12,549 (21.5%)	7967 (26.7%)	<0.001	<0.001	0.069
April	12,418 (20.8%)	12,872 (22.2%)	8446 (27.6%)	<0.001	<0.001	0.021
Alert, n (%)						
December	13,871 (96.0%)	13,637 (95.5%)	12,697 (95.4%)	0.031	1.000	0.145
January	12,720 (95.5%)	11,701 (95.3%)	13,230 (95.2%)	0.723	1.000	1.000
February	11,568 (95.2%)	11,025 (95.3%)	8127 (94.3%)	0.010	0.006	1.000
March	11,689 (95.3%)	11,952 (95.2%)	7356 (92.3%)	<0.001	<0.001	1.000
April	11,841 (95.4%)	12,271 (95.3%)	7807 (92.4%)	<0.001	<0.001	1.000
Age (years), Mean ± SD						
December	38.72 ± 26.80	39.42 ± 26.50	40.04 ± 27.13	0.010	0.997	0.940
January	41.34 ± 26.25	42.16 ± 25.98	41.92 ± 26.68	1.000	1.000	0.724
February	41.17 ± 26.20	42.70 ± 25.68	44.92 ± 25.01	<0.001	<0.001	<0.001
March	40.44 ± 26.04	41.45 ± 26.39	46.79 ± 24.72	<0.001	<0.001	0.243
April	39.55 ± 26.47	40.18 ± 26.85	46.73 ± 25.26	<0.001	<0.001	0.998

COVID, the coronavirus disease; SD, standard deviation. P^1 = pre-COVID-19 period in 2018 vs. COVID-19 period in 2020, P^2 = pre-COVID-19 period in 2019 vs. COVID-19 period in 2020, P^3 = pre-COVID-19 period in 2018 vs. pre-COVID-19 period in 2019.

the same period between the pre- and COVID-19 periods. However, the proportion of critical patients with KTAS level 1–2 scores significantly increased in the same period during COVID-19 compared with pre-COVID-19 in 2018 and 2019 (Table 3). During February, IRR of critical patients during COVID-19 compared with pre-COVID-19 period in 2018 was 0.82 (95% CI, 0.75–0.91; $p < 0.001$) and this decline in IRR continued in March and April. Compared with the pre-COVID-19 period in 2019, the IRR of critical patients in the COVID-19 period during February was 0.95 (95% CI, 0.86–1.06; $p = 0.360$), showing no statistical difference. However, in March and April, the incidence of critical patients during COVID-19 decreased compared with 2019 (IRR, 0.88; 95% CI, 0.79–0.97; $p = 0.009$ and IRR, 0.74; 95% CI, 0.68–0.82; $p < 0.001$) (Table 4).

3.4 Comparison of the monthly change of daytime and night-time ED visits between the prior and COVID-19 periods

Comparing the pattern of patients visiting the ED by time zone, the number of patients coming to the ED decreased during the COVID-19 period from February to April (Fig. 3). Until February, the proportion visiting the ED at night-time (18:00 to 06:00) was not statistically different between before and during COVID-19 period. However, in March, the proportion of ED visits at night-time in the COVID-19 period was 47.8% which was decreased from 2018 (50.2%). Also, during the COVID-19 period, night-time ED visits in April were 45.9% in contrast to 48.9% and 48.3% reported during pre-COVID-19 period in 2018 and 2019 respectively (Table 5).

3.5 Comparison of changes in disease patterns between pre-COVID-19 and COVID-19 periods

The three most common diagnoses prompting an ED visit during the COVID-19 period and pre-COVID-19 period were “abdominal and pelvis pain”, “fever of other and unknown origin”, and “open wound in the head” and this remained unchanged during the study period. During the COVID-19 period, the number of patients who were diagnosed with “influenza because of an identified seasonal influenza virus” decreased (1507 (2.88%)), compared with those (2157 (3.35%) and 2131 (3.35%)) reported in the pre-COVID-19 periods in 2018 and 2019, respectively (Table 6). Some patients were diagnosed with “influenza because of an identified seasonal influenza virus” after February during the pre-COVID-19 period in 2018 and 2019. However, during COVID-19 period, there were very few diagnostic cases after February (Fig. 4).

TABLE 3. Comparison of monthly changes in numbers/percentages of non-emergency and critical patients during pre-COVID-19 and COVID-19 periods.

Variable	Pre-COVID-19 period in 2018	Pre-COVID-19 period in 2019	COVID-19 period in 2020	P^1	P^2	P^3
Non-emergency patients, n (%)						
December	14,248 (44.0%)	14,275 (41.0%)	13,313 (37.4%)	<0.001	<0.001	<0.001
January	13,323 (41.2%)	12,276 (41.7%)	13,902 (40.1%)	0.165	0.022	1.000
February	12,146 (42.0%)	11,570 (42.0%)	8617 (38.3%)	<0.001	<0.001	1.000
March	12,270 (40.4%)	12,549 (42.7%)	7967 (34.2%)	<0.001	<0.001	<0.001
April	12,418 (42.8%)	12,872 (40.3%)	8446 (34.4%)	<0.001	<0.001	<0.001
Critical patients, n (%)						
December	14,248 (7.2%)	14,275 (6.6%)	13,313 (8.0%)	0.054	<0.001	0.168
January	13,323 (7.6%)	12,276 (7.2%)	13,902 (7.6%)	1.000	0.459	0.486
February	12,146 (7.3%)	11,570 (6.6%)	8617 (8.8%)	<0.001	<0.001	0.130
March	12,270 (7.6%)	12,549 (6.6%)	7967 (9.1%)	<0.001	<0.001	0.007
April	12,418 (7.8%)	12,872 (8.1%)	8446 (9.2%)	<0.001	0.017	1.000

COVID, the coronavirus disease. P^1 = pre-COVID-19 period in 2018 vs. COVID-19 period in 2020, P^2 = pre-COVID-19 period in 2019 vs. COVID-19 period in 2020, P^3 = pre-COVID-19 period in 2018 vs. pre-COVID-19 period in 2019.

TABLE 4. Comparisons of incident rates of critical patients in the COVID-19 period.

Variable	Comparing Pre-COVID-19 period in 2018		Comparing Pre-COVID-19 period in 2019	
	IRR (95% CI)	*p*-value	IRR (95% CI)	*p*-value
Month				
December	1.03 (0.95–1.13)	0.456	1.12 (1.03–1.22)	0.010
January	1.04 (0.96–1.14)	0.323	1.21 (1.10–1.32)	<0.001
February	0.82 (0.75–0.91)	<0.001	0.95 (0.86–1.06)	0.360
March	0.78 (0.71–0.86)	<0.001	0.88 (0.79–0.97)	0.009
April	0.80 (0.73–0.88)	<0.001	0.74 (0.68–0.82)	<0.001

COVID, the coronavirus disease; IRR, incidence rate ratio; CI, confidence interval.

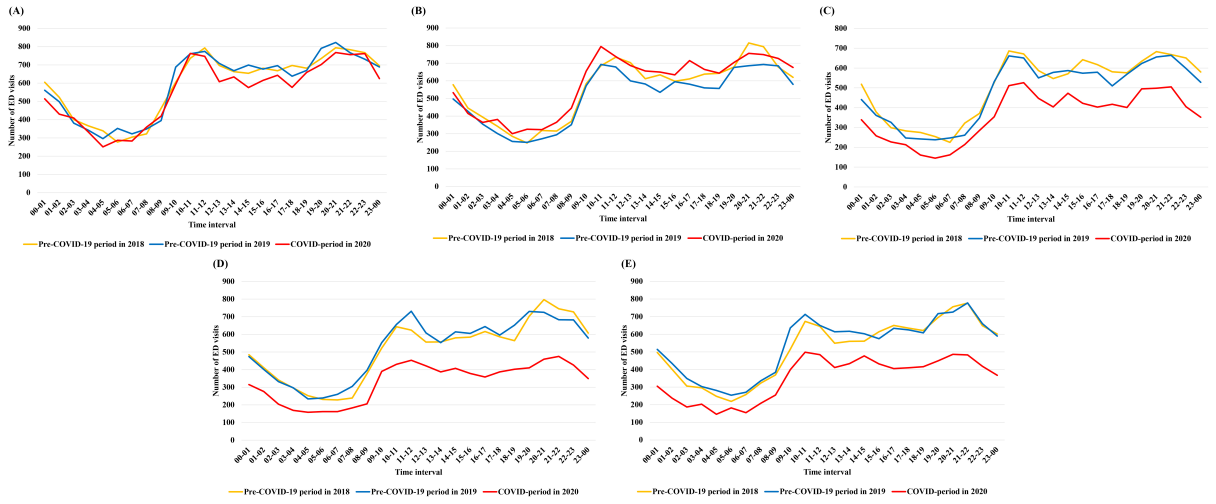

FIGURE 3. The number of patients visiting the ED by time zone each month during pre-COVID-19 and COVID-19 periods. (A) December. (B) January. (C) February. (D) March. (E) April. COVID, the coronavirus disease; ED, emergency department.

TABLE 5. Comparisons of monthly changes in night-time patients during pre-COVID-19 and COVID-19 periods.

Variable	Pre-COVID-19 period in 2018	Pre-COVID-19 period in 2019	COVID-19 period in 2020	P^1	P^2	P^3
Night-time patients, n (%)						
December	14,248 (48.9%)	14,275 (48.3%)	13,313 (48.8%)	1.000	1.000	1.000
January	13,323 (48.9%)	12,276 (48.6%)	13,902 (47.3%)	0.020	0.116	1.000
February	12,146 (47.7%)	11,570 (47.5%)	8617 (46.4%)	0.178	0.408	1.000
March	12,270 (50.2%)	12,549 (48.0%)	7967 (47.8%)	0.002	1.000	0.002
April	12,418 (48.9%)	12,872 (48.3%)	8446 (45.9%)	<0.001	0.003	1.000

COVID, the coronavirus disease. P^1 = pre-COVID-19 period in 2018 vs. COVID-19 period in 2020, P^2 = pre-COVID-19 period in 2019 vs. COVID-19 period in 2020, P^3 = pre-COVID-19 period in 2018 vs. pre-COVID-19 period in 2019.

TABLE 6. Comparisons of the top 10 diagnoses during pre-COVID-19 and COVID-19 periods.

	Total Study Period (n = 180,192)	Pre-covid period in 2018 (n = 64,405)	Pre-covid period in 2019 (n = 63,542)	COVID-19 period in 2020 (n = 52,245)
Diagnosis (n, %)				
1	Abdominal and pelvic pain (14,205, 7.9%)	Abdominal and pelvic pain (4526, 7.0%)	Abdominal and pelvic pain (4979, 7.8%)	Abdominal and pelvic pain (4700, 9.0%)
2	Fever of other and unknown origin (13,149, 7.3%)	Fever of other and unknown origin (4225, 6.6%)	Fever of other and unknown origin (4412, 6.9%)	Fever of other and unknown origin (4512, 8.6%)
3	Open wound of head (10,758, 6.0%)	Open wound of head (3866, 6.0%)	Open wound of head (3827, 6.0%)	Open wound of head (3065, 5.9%)
4	Dizziness and giddiness (5984, 3.3%)	Other gastroenteritis and colitis of infectious and unspecified origin (2476, 3.8%)	Dizziness and giddiness (2194, 3.5%)	Dizziness and giddiness (1703, 3.3%)
5	Influenza due to identified seasonal influenza virus (5795, 3.2%)	Influenza due to identified seasonal influenza virus (2157, 3.4%)	Influenza due to identified seasonal influenza virus (2131, 3.4%)	Pain in throat and chest (1672, 3.2%)
6	Pain in throat and chest (5371, 3.0%)	Dizziness and giddiness (2087, 3.2%)	Other gastroenteritis and colitis of infectious and unspecified origin (2018, 3.2%)	Influenza due to identified seasonal influenza virus (1507, 2.9%)
7	Other gastroenteritis and colitis of infectious and unspecified origin (4909, 2.7%)	Pain in throat and chest (1841, 2.9%)	Pain in throat and chest (1858, 2.9%)	Pain, not elsewhere classified (1464, 2.8%)
8	Superficial injury of head (4335, 2.4%)	Superficial injury of head (1754, 2.7%)	Superficial injury of head (1550, 2.4%)	Abnormalities of breathing (1209, 2.3%)
9	Headache (3659, 2.0%)	Headache (1253, 2.0%)	Headache (1348, 2.1%)	Headache (1058, 2.0%)
10	Open wound of wrist and hand (3374, 1.9%)	Nausea and vomiting (1204, 1.9%)	Open wound of wrist and hand (1232, 1.9%)	Superficial injury of head (1031, 2.0%)

COVID, the coronavirus disease.

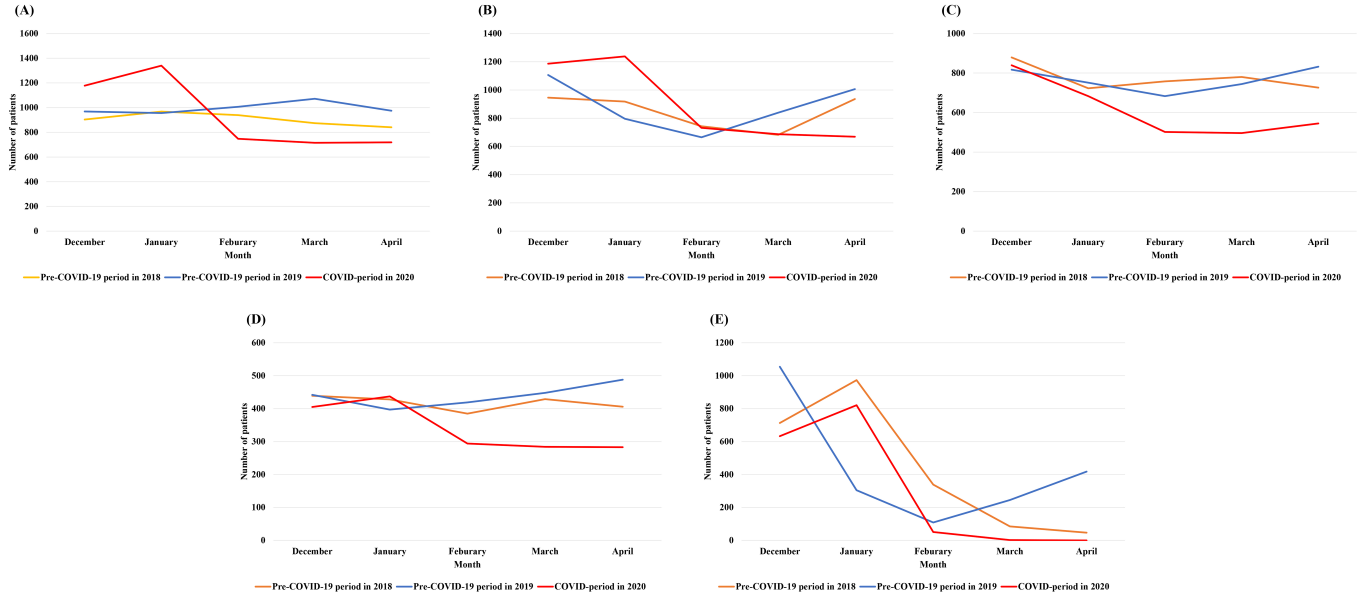

FIGURE 4. Monthly changes in top 5 diagnoses of the entire study period during pre-COVID-19 and COVID-19 periods. (A) Abdominal and pelvis pain. (B) Fever of other and unknown origin. (C) Open wound of head. (D) Dizziness and giddiness. (E) Influenza due to identified seasonal influenza virus. COVID, the coronavirus disease.

Comparing the change in top five diagnoses of the total study period between pre- and COVID-19 periods, it seems that all of the diagnoses decreased during the COVID-19 period from February to April (Fig. 4). "Other gastroenteritis and colitis of infectious and unspecified origin", which was included in the top 10 diagnoses prompting an ED visit during the pre-COVID-19 period, was not included in the top 10 diagnoses during the COVID-19 period (Table 6).

4. Discussion

To the best of our knowledge, this is the first study to show the monthly changes of epidemiology and characteristics of patients visiting the ED during the early COVID-19 period and prior equivalent COVID-19 periods. Similar to other studies [1, 10–15, 20], during the COVID-19 period, the total number of patients visiting the ED decreased. We showed a reduced proportion of non-emergency patients, and instead, the proportion of critical patients and admission rate increased during COVID-19. This became apparent after February when the number of patients were strikingly increased. From March 22 to May 5 in 2020, the government implemented the social distancing policy in Korea. This social distancing recommended that people stay at home but was not mandatory. Therefore, there was no obvious difference compared with visits in February.

Admission rates and the proportion of non-emergency versus severe patients during the COVID-19 period vary in several studies [1, 2, 10, 11, 14–16]. During the SARS outbreak in 2009, the infection spread in the hospital. Similarly, when the MERS outbreak occurred in Korea in 2015, one patient with confirmed MERS infected 81 patients in the ED [9, 21, 22]. Super-spreading events also occurred during the COVID-19 period. Before patient #31 was confirmed as having the infection on February 18, only 30 patients had confirmed COVID-19 nationwide. However, the number of COVID-19 patients in North Gyeongsang Province (NGP) and Daegu increased dramatically after patient #31 visited Daenam Hospital in NGP and Shincheonji Church in Daegu before their infection was confirmed. On 26 February, 1146 patients were reported, exceeding 1000 patients for the first time [3]. Because of the high infectivity of COVID-19 and possible infection from non-specific people, EDs and hospitals were no longer considered safe locations. Instead, they are considered hot zones [9, 23]. Consequently, non-emergency patients were thought to visit EDs less frequently. Some studies also showed that critical patients were not visiting hospitals during the COVID-19 period [11, 15]. We showed the same result in that the incidence of critical patients during COVID-19 patients decreased, especially from February compared to pre-COVID-19 periods. However, the reduction in ED visits by non-emergency patients was greater, thus demonstrating an increase in admission rates and an increase in the proportion of critical patients visiting ED.

Interestingly, the three EDs were in the Metropolitan area, and the incidence of COVID-19 in these areas was well controlled compared with nationwide (Fig. 2). The number of ED visits was not affected by the number of COVID-19 patients in the Metropolitan area but was affected by the total number of COVID-19 patients occurring nationwide. This effect is thought to be the result of extensive media coverage. In the early period of COVID-19, the movement of confirmed patients and the status of confirmed cases across the country were transparently announced through the media. Therefore, even if there were no patients in the actual residential area there would still have been a reluctance to visit medical facilities due to the fear of COVID-19.

In Korea, the incidence of influenza normally shows bimodal patterns during winter and spring. In our study, the number of influenza cases decreased since February during the

COVID-19 period. Similarly, Noh *et al*. [24] reported that influenza rarely occurred during the spring of 2020. During the COVID-19 period, several studies reported reductions in infectious disease and respiratory disease [1, 10, 16, 18]. This was almost certainly because of enhanced widespread mask-wearing, and improved hand hygiene practices [24, 25]. These behaviors were thought to have helped prevent influenza.

Some studies showed a difference in the number of patients and severity of the condition of patients visiting the ED according to the time of day [26, 27]. During COVID-19 period, there was one study showing that more pregnancy patients come to the ED at night-time due to obstetric emergencies [28], and in another study, that the number of urological emergency patients also increased at night-time [29]. Also, because there is no place except ED to receive treatment at night, we predicted that the proportion of patients visiting the EDs in the night-time during the COVID-19 period would increase compared to the pre-COVID-19 period. However, this study showed a decreased proportion of night-time patients from March during the COVID-19 period. An explanation might be that non-emergency patients who could go to the outpatient clinic, visited the ED in the night-time during the pre-COVID-19 period, but in the COVID-19 period, because of fear of COVID-19 infection, they did not visit the ED at night-time. There is a lack of data on the daily cycle of ED visiting during COVID-19, so additional study is needed.

5. Limitations

This study has the following limitations. First, only three university hospitals in Seoul and Gyeonggi Province were involved. Hence, our results do not reflect the statistics of all ED patients in Korea. However, since it is a multi-center study of three hospitals in metropolitan areas, we would expect a certain level of representation. Second, only one primary diagnosis was recorded; and therefore, does not involve all accompanying diagnoses. In some cases, the sub-diagnosis is important. However, in the ED, the patient is classified mainly according to their primary diagnosis. This study only analyzed the overall trend; hence, it would not have significantly affected our results.

6. Conclusions

During the COVID-19 period, the proportion and total number of patients visiting the ED decreased including non-emergency patients. These changes were noticeable after February when COVID-19 patients increased strikingly. Also, the number of patients visiting ED at night time decreased in COVID-19 period after March. Overall, the disease pattern of patients who visited ED was similar. However, during COVID-19, the number of patients with diagnostic criteria of "Other gastroenteritis and colitis of infectious and unspecified origin," and "influenza because of an identified seasonal influenza virus" decreased.

The epidemiology of patients visiting the ED was related to the trend of COVID-19 outbreak and the quarantine policy for disease prevention according to the characteristics of COVID-19. This study is expected to help improve the efficiency of ED operations when a new infectious disease epidemic occurs in the future, and based on this study, more general results can be obtained through multi-center research or nationwide research.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

HSP—conceptualization, writing-original draft. ESL—data curation, visualization. SJP—formal analysis. JYK—funding acquisition, writing-review & editing. JYL—investigation, software. YHY—methodology. HSP and YHY—validation.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was reviewed and approved by the Institutional Review Board of Korea University in June 2020. The requirement for informed consent was waived (IRB no.: 2020GR0208).

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/1777218538435428352/attachment/Supplementary%20material.docx.

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How to cite this article: Sung Joon Park, Young-Hoon Yoon, Ji Young Lee, Eu Sun Lee, Hong Seok Park, Jung-Youn Kim. Changes in epidemiology of patients visiting emergency departments during the early COVID-19 pandemic period. Signa Vitae. 2024; 20(4): 15-24. doi: 10.22514/sv.2024.037 .