Epidemiological and clinical characteristics of coronavirus disease 2019 in Daegu, South Korea

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ABSTRACT

Objectives: Two Coronavirus Disease 2019 (COVID-19) outbreaks simultaneously occurred at a church and a long-term care facility in Daegu, South Korea. This study aimed to investigate the epidemiological characteristics of COVID-19 and factors related to severe outcomes.
Methods: We enrolled all inpatients diagnosed with COVID-19 between February 21 and April 2, 2020, in Daegu Dongsan Hospital. We analyzed their clinical and demographic data, laboratory parameters, radiological findings, symptoms, and treatment outcomes.
Results: Of 694 patients, severe cases accounted for 19.7% (137 patients). No severe case was observed among patients aged ≤19 years. Hypertension was the most common comorbidity (27%), and cough was the most common symptom (59%). Asymptomatic patients accounted for 14.4% of cases. Lymphopenia, lactate dehydrogenase, C-reactive protein, and albumin were associated with severe outcomes. The first outbreak was mostly associated with younger age groups, and asymptomatic patients mostly showed mild progression. In the second outbreak involving a long-term care facility, both the number of severe patients and the mortality rate were higher.
Conclusions: The overall mortality in Daegu was low, which might have resulted from large scale mass screening to detect patients and starting appropriate treatment, including hospitalization for severe cases, and quarantine for asymptomatic patients.
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Introduction

The coronavirus disease 2019 (COVID-19) is a respiratory tract infection caused by a new emerging coronavirus, currently named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The first case of COVID-19 was reported in Wuhan, Hubei Province, China, in December 2019. Now, COVID-19 has spread to over 200 countries within only four months (Hui et al., 2020; World Health Organization, 2020a). In South Korea, the first case infected with SARS-CoV-2, a Chinese visitor from Wuhan, was reported on January 20, 2020 (Kim et al., 2020). On February 18, 2020, a COVID-19 outbreak in South Korea started in Daegu, and it is worth noting that the coronavirus had spread mainly among a religious group called Shincheonji (Park et al., 2020). As of June 30, 2020, the number of confirmed cases increased rapidly, reaching 12,757 cases, including 282 deaths (The Korea Centers for Disease Control & Prevention, 2020). Daegu was at the hub of the COVID-19 outbreak, with the highest number of cases in South Korea (6906 out of 12,757 cases nationwide (54.1%).

Investigating the epidemiological characteristics of patients with COVID-19 in Daegu is useful to gain insight into the situation and characteristics of the disease in South Korea. Unlike other regions nationwide, Daegu was hit by two COVID-19 outbreaks at

the same time, of which the largest outbreak was related to a religious meeting and the other one to a long-term care facility. Consequently, the epidemiological characteristics of COVID-19 in Daegu may differ from those in other regions. Moreover, SARS-CoV-2 is a newly emerging virus, and its epidemiological characteristics remain inadequately described (Wang et al., 2020a). Therefore, it is vital to examine the aspects and factors related to severe outcomes to enable appropriate treatment and prevention.

Methods

Patients

This study was approved by the institutional ethics board of Keimyung University Dongsan Hospital (No. 2020-03-027). After receiving approval, we retrospectively collected data from all inpatients diagnosed with SARS-CoV-2 infection from February 21, 2020, to April 2, 2020, in Daegu Dongsan Hospital. The requirement for informed consent was waived due to the retrospective nature of the study. Clinical manifestations and outcomes of the patients had also been monitored as of April 2, 2020. During the outbreak, this hospital was designated as a specialized hospital with 465 beds for COVID-19 patients.

In this study, we used real-time reverse transcription polymerase chain reaction (RT-PCR), which has been widely used to diagnose COVID-19. Protocols used to diagnose COVID-19 vary according to country; in South Korea, RT-PCR is used to detect severe acute respiratory virus syndrome coronavirus-2 (SARS-CoV-2) through the identification of RdRp, E, and N genes (Corman et al., 2020).

Data collection

We collected different types of data, including clinical and demographic information, laboratory parameters, radiological findings, and outcomes from patients' medical records and attending doctors. Symptoms during hospitalization were collected daily, and all data were collected retrospectively.
We investigated whether oxygen supply, mechanical ventilation, or extracorporeal membrane oxygenation (ECMO) had been prescribed. We also collected patients' treatment outcomes using retrospective chart reviews, i.e., whether they died or were discharged alive. As recommended by the World Health Organization (WHO), a severe case was defined as a patient who met at least one of the following criteria:

(1) Shortness of breath, respiratory rate ≥ 30 breaths/min;
(2) oxygen saturation at rest $\leq 93\%$; or
(3) partial pressure of arterial oxygen (PaO_2)/fraction of inspiration oxygen (FiO_2) ≤ 300 mmHg or
(4) a requirement of mechanical ventilation (World Health Organization, 2020b).

All the other cases, including those with simple upper respiratory tract disease and pneumonia, were classified into the mild group.
Data on symptoms were collected daily during the patients' hospital stay, and those who manifested the most symptoms on a given day were selected for analysis.
Chest computed tomography (CT) findings were divided into two categories: positive and negative CT scans. A patient was classified as a positive CT scan if he or she had any consolidation or ground-glass opacity (GGO) in CT findings during hospitalization. A patient with no consolidations or GGO in his/her CT findings during the hospitalization was classified to have a negative CT scan.

Statistical analyses

Categorical variables were analyzed using Fisher's exact test and presented as frequencies and percentages. Continuous variables were analyzed using the independent t-test if the data were normally distributed, otherwise the Mann–Whitney test was used. Continuous variables were then expressed as means and standard deviations. Two-sided *p* values of ≤ 0.05 were considered to be statistically significant. All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 23.0 software (IBM Corp., Armonk, NY, USA).

Results

In our study, 694 cases infected with SARS-CoV-2 were enrolled, including 137, 14, and three patients who required oxygen therapy, ventilation therapy, and ECMO therapy, respectively, for hypoxia. In total, 18 patients died due to COVID-19, while 137 patients were classified as severe cases.

Demographic and epidemiological data

Patients ages ranged from 19 months to 98 years, with the age group ≥ 60 years being the most affected. No patients aged under 19 years were identified as severe cases. Meanwhile, in the age group of over 80 years, severe cases constituted 74.5% (41/55) of the cases (Figure 1).

Hypertension was the most common comorbid disease (131 cases). The number of severe cases was significantly higher among patients with hypertension, diabetes, stroke, dementia, and chronic kidney disease; more comorbid diseases were found in the severe cases group. No patients in the group of severe cases were asymptomatic. Coughing was the most prevalent symptom, occurring in 328 cases. The proportions of fever, chill, cough, sore throat and dyspnea were higher in severe cases than in mild cases. Eighty patients in the group of mild cases were asymptomatic.

The most common transmission source consisted of 280 cases who were followers of the religious group at the Shincheonji Church of Jesus. The proportion of hospital-transmitted SARS-CoV-2 infections was higher in severe cases (19.7%) than in mild cases (4.3%). The actual proportion could have been higher as the transmission source was not clearly identified (Table 1).

Radiological and laboratory findings

The white blood cell count, neutrophil count, C-reactive protein (CRP), procalcitonin, aspartate transaminase (AST), alanine transaminase (ALT), lactate dehydrogenase (LDH), and albumin were correspondingly higher in severe cases than in mild cases. However, the lymphocyte count and estimated glomerular filtration rate (eGFR) were correspondingly lower in severe cases than those in mild cases (Table 2).

CT scans were performed for 369 patients. Both symptoms and CT scans were surveyed in 300 cases. Among those with positive CT scans, 22.7% and 57.3% suffered from fever and cough, respectively, while 13.8% did not have any symptoms (Table 3).

Discussion

In our study, the mortality rate among COVID-19 patients was 2.6% (18 cases), which almost is similar to the pooled mortality rate in South Korea (2.3%) (The Korea Centers for Disease Control & Prevention, 2020). Compared to the global mortality rates, this low mortality rate might have resulted from large scale mass screening to detect patients and starting appropriate treatment. In the beginning, all confirmed cases were hospitalized for medical
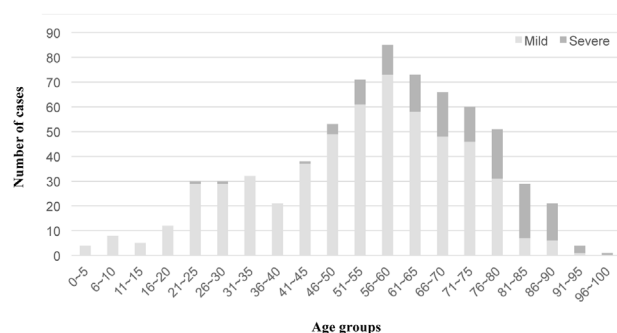
Fig. 1. Number of coronavirus 2019 cases by age groups and severity.

treatment, regardless of the severity of the disease. However, after the large outbreak began, only patients whose conditions were severe and, therefore, in dire need of hospital treatment, were admitted to the hospital. Meanwhile, to prevent transmission, asymptomatic patients or mild cases were referred to dormitories,

where they were managed in groups. Among these patients, those with severe symptoms were hospitalized after they were identified by using simple tests and questionnaires.

In line with a previous study (Li et al., 2020), our study found no severe case in the pediatric age group. The number of overall patients and those with serious outcomes increased above the age of 45 years. This implies that careful monitoring should be performed among patients in this older age group.

In Daegu, South Korea, most COVID-19 patients were identified as members of a religious group called Shincheonji, after a mass outbreak of COVID-19 occurred in Shincheonji, Daegu. By June 30, 4265 (61.8%) patients were found to be related to Shincheonji out of a total of 6906 confirmed cases in Daegu, while 540 (7.8%) patients were related to a long-term care facility. Religious activities in confined spaces may have led to the outbreak of COVID-19 in the same manner as in cruise ships or prisons (Kinner et al., 2020; Mizumoto and Chowell, 2020).

The comorbidities contributing to increasing the severity of COVID-19 in our study included hypertension, diabetes, stroke,

Table 1
General characteristics of coronavirus 2019 cases.

Characteristics		Mild case (*n* = 557)	Severe case (*n* = 137)	*p*-value
Age, mean (standard deviation), years		52.10 (18.29)	71.41 (13.17)	0.000
Gender	Male	155 (27.8%)	57 (41.6%)	0.003
	Female	402 (72.2%)	80 (58.4%)	
Comorbidity	Hypertension	86 (22.4%)	45 (44.6%)	0.000
	Diabetes mellitus	48 (12.5%)	33 (32.7%)	0.000
	Coronary artery disease	11 (2.9%)	6 (5.9%)	0.137
	Stroke	9 (2.3%)	8 (7.9%)	0.012
	Asthma	13 (3.4%)	1 (1.0%)	0.319
	Chronic obstructive pulmonary disease	2 (0.5%)	2 (2.0%)	0.193
	Old tuberculosis	2 (0.5%)	0 (0.0%)	1.000
	Heart failure	6 (1.6%)	4 (4.0%)	0.228
	Chronic kidney disease	1 (0.3%)	4 (4.0%)	0.008
	Liver disease	2 (0.5%)	3 (3.0%)	0.063
	Thyroid disease	6 (1.6%)	2 (2.0%)	0.674
	Dementia	5 (1.3%)	5 (5.0%)	0.037
	Cancer	18 (4.7%)	5 (5.0%)	1.000
	Other diseases	20 (5.2%)	8 (7.9%)	0.336
	Total disease count	0.60 (0.85)	1.25 (1.10)	0.000
Symptoms	No symptoms	80 (16.8%)	0 (0.0%)	0.000
	Fever	80 (16.8%)	31 (38.3%)	0.000
	Chill	97 (20.4%)	29 (35.8%)	0.004
	Cough	262 (55.2%)	66 (81.5%)	0.000
	Sputum	244 (51.4%)	50 (61.7%)	0.092
	Rhinorrhea	141 (29.7%)	21 (25.9%)	0.597
	Sore throat	124 (26.1%)	31 (38.3%)	0.031
	Myalgia	93 (19.6%)	22 (27.2%)	0.137
	Headache	115 (24.2%)	25 (30.9%)	0.214
	Diarrhea	134 (28.2%)	32 (39.5%)	0.048
	Dyspnea	58 (12.2%)	33 (40.7%)	0.000
	Chest pain	75 (15.8%)	14 (17.3%)	0.744
	Symptoms count	2.99 (2.31)	4.37 (2.29)	0.000
Chest X-ray results	Positive	275 (49.5%)	128 (93.4%)	0.000
	Negative	281 (50.5%)	9 (6.6%)	
CT scan results	Positive	192 (68.6%)	81 (91.0%)	0.000
	Negative	88 (31.4%)	8 (9.0%)	
Exposure history	Within Family	87 (15.6%)	13 (9.5%)	0.077
	From a co-worker or friend	57 (10.3%)	5 (3.6%)	0.012
	At Shincheonji Church of Jesus	258 (46.4%)	22 (16.1%)	0.000
	In-hospital	24 (4.3%)	27 (19.7%)	0.000
	Overseas	3 (0.5%)	1 (0.7%)	0.587
	Others	3 (0.5%)	1 (0.7%)	0.587
	Unknown	124 (22.3%)	68 (49.6%)	0.000

All % present the proportions of characteristics in the mild or severe case group, excluding the missing values. *P* values were analyzed using the *t*-test or Mann–Whitney test for continuous variables and Fisher's exact test for categorical variables.

Table 2
Laboratory findings of coronavirus 2019 cases.

Variables	Total (n = 694)	Mild case (n = 557)	Severe case (n = 137)	p value
White blood cell count, $\times10^3/\mu$L	5.39 (2.11)	5.19 (1.71)	6.22 (3.15)	0.000
Neutrophil count, $\times10^3/\mu$L	3.25 (1.92)	2.93 (1.36)	4.57 (3.00)	0.000
Lymphocyte count, $\times10^3/\mu$L	1.59 (0.71)	1.70 (0.71)	1.13 (0.52)	0.000
Monocyte count, $\times10^3/\mu$L	0.45 (0.17)	0.45 (0.16)	0.47 (0.24)	0.449
Hemoglobin, g/dL	12.62 (1.52)	12.72 (1.47)	12.22 (1.62)	0.001
Hematocrit, %	37.95 (4.28)	38.31 (4.10)	36.47 (4.66)	0.000
Platelet count, $\times10^3/\mu$L	235.65 (85.37)	240.46 (83.17)	215.87 (91.56)	0.003
Glucose, mg/dL	123.37 (62.56)	117.36 (54.44)	148.09 (84.30)	0.000
Creatine phosphokinase, U/L	90.53 (121.14)	82.42 (118.17)	124.15 (127.83)	0.001
C-reactive protein, mg/dL	2.00 (4.10)	0.86 (1.85)	6.66 (6.69)	0.000
Procalcitonin, ng/mL	2.00 (2.64)	1.62 (2.23)	3.31 (3.41)	0.000
Aspartate transaminase, U/L	26.36 (16.49)	23.87 (11.62)	36.63 (26.60)	0.000
Alanine transaminase, U/L	24.78 (18.50)	23.88 (17.45)	28.50 (22.01)	0.024
Lactate dehydrogenase, U/L	496.29 (250.19)	447.55 (124.11)	695.19 (455.13)	0.000
Albumin, g/dL	4.00 (0.48)	4.12 (0.39)	3.53 (0.50)	0.000
Blood urea nitrogen, mg/dL	14.68 (7.00)	13.58 (4.83)	19.20 (11.40)	0.000
Creatinine, mg/dL	0.78 (0.34)	0.74 (0.22)	0.96 (0.57)	0.000
Estimated glomerular filtration rate, mL/min/1.73 m^2	94.48 (25.59)	99.01 (23.82)	75.87 (24.24)	0.000

All data are presented as means (standard deviations). The estimated glomerular filtration rate is calculated using the Chronic Kidney Disease-Epidemiology Collaboration equation. *P* values are analyzed using the *t*-test or Mann–Whitney test.

Table 3
The proportion of patients by symptoms and computed tomography scan results.

Symptoms	CT negative (n = 75)	CT positive (n = 225)	p-Value
No symptoms	19 (25.3%)	31 (13.8%)	0.031
Fever	4 (5.3%)	51 (22.7%)	0.000
Chills	6 (8.0%)	56 (24.9%)	0.002
Cough	30 (40.0%)	129 (57.3%)	0.011
Sputum	31 (41.3%)	113 (50.2%)	0.230
Rhinorrhea	18 (24.0%)	63 (28.0%)	0.550
Sore throat	17 (22.7%)	52 (23.1%)	1.000
Myalgia	4 (5.3%)	45 (20.0%)	0.002
Headache	9 (12.0%)	62 (27.6%)	0.007
Diarrhea	18 (24.0%)	78 (34.7%)	0.115
Dyspnea	4 (5.3%)	41 (18.2%)	0.005
Chest pain	9 (12.0%)	38 (16.9%)	0.363

Each % presents the proportion of patients with a certain type of symptom or no symptoms in either the CT negative group or the CT positive group. *P* values are calculated using Fisher's exact test.

chronic kidney disease, dementia, and comorbidity counts. Comorbidities are a risk factor for severe outcomes in patients with COVID-19 (Huang et al., 2020; Wang et al., 2020a).

Cough was the most common symptom among patients with COVID-19 in our study (55.2% among mild cases and 81.5% among severe cases). The proportion of patients with fever was not as high as those reported in China (20% vs. 90%) (Huang et al., 2020; Wang et al., 2020a). According to a report from Europe, this rate was 45.4%, with headache (70.3%) and loss of smell (70.2%) as the most common symptoms (Lechien et al., 2020).

The present study included 80 asymptomatic cases, accounting for 14.4% of all cases. During each quarantine day, all asymptomatic patients were checked for the development of symptoms; no patients showed symptoms until their release from quarantine. This might have resulted from the higher proportion of mild cases being identified by the relatively broad-based screening tests for SARS-CoV-2 in South Korea. By June 30, in total, 1,273,766 PCR tests were conducted for the diagnosis of SARS-CoV-2. Due to the epidemic associated with Shincheonji, the government conducted large-scale screening tests for more than 10,000 Shincheonji church members, regardless of symptoms. Because of this screening, several confirmed but asymptomatic cases were found early and were isolated in facilities and hospitals to suppress transmission.

Asymptomatic patients are crucial factors in controlling the COVID-19 outbreak. Furthermore, in the early stage of this outbreak in South Korea, everyone who had close contact with confirmed cases received a SARS-CoV-2 test. Therefore, we believe that there were a relatively large number of asymptomatic patients included our data compared to other studies. It is believed that antibody-based follow-up studies would be needed to determine the extent to which asymptomatic patients potentially contributed to the transmission in this COVID-19 pandemic.

In our study, patients with in-hospital exposure to SARS-CoV-2 were more likely to have severe outcomes, which might be because they already had a poor general condition, suffered from comorbidities, and belonged to older age groups. This highlights the need for preventing in-hospital transmission. Patients who were not aware of infection sources also reported more severe outcomes, which might have been affected by the time until diagnosis. The efficacy of mass SARS-CoV-2 screening requires further research.

More patients with lymphopenia were observed in the severe cases group. This may be a characteristic of SARS-CoV-2 infection, as this was also reported in two previous studies (Huang et al., 2020; Wang et al., 2020b). Similarly, lactate dehydrogenase, CRP, and albumin were also correlated with severe outcomes in this study.

We contrasted patients' symptoms with CT scan results and found that 31 patients were asymptomatic, although they had positive CT scan results (13.8% of all patients with CT scans). These patients might have had a potential role in SARS-CoV-2 transmission, as reported in several other studies (Bai et al., 2020; Chan et al., 2020; Wang et al., 2020c). Therefore, we speculate that a careful approach toward asymptomatic individuals is required to prevent a further upsurge in the outbreak.

This study has several limitations that need to be addressed. First, it was a retrospective study with missing data, possibly leading to multivariate analysis errors. Second, we only collected initial laboratory data; there might be some deviations in laboratory findings due to temporal differences. Finally, certain symptoms might not have been documented because we only collected data on symptoms during the patients' hospital stay. This means that if certain symptoms occurred before the patients were hospitalized, the proportion of asymptomatic patients might not reflect the actual one.

The strength of this study lies in its large sample of patients (694 cases). Moreover, as data collection was conducted at an early stage of the outbreak, we collected clinical data of all types of cases, including severe, mild, and asymptomatic cases.

In conclusion, compared to the global mortality rates, the mortality rate in Daegu was low, which might have resulted from large scale mass screening to detect patients and starting appropriate treatment, including hospitalization for severe cases, and quarantine for asymptomatic patients who were regularly screened for severe disease using simple tests and questionnaires. Our study's findings help provide an insight into COVID-19 and inform its future prevention. Severe cases were more often observed beyond the age of 45 years. This indicates that careful observations should be performed in this age group. We also suggest that future studies investigate the role of asymptomatic patients in transmission and factors associated with them for the prevention of the outbreak.

Declaration of interest

All authors declare to have no conflicts of interest. All authors have submitted the ICMJE form for disclosure of potential conflicts of interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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Ethical approval

This study was approved by the institutional ethics board of Keimyung University Dongsan Hospital (No. 2020-03-027).

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