International Journal of Infectious Diseases 96 (2020) 399–407

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

The relationship between trends in COVID-19 prevalence and traffic levels in South Korea

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ARTICLE INFO

Article history:
Received 23 April 2020
Received in revised form 5 May 2020
Accepted 7 May 2020

Keywords:
Traffic level
COVID-19 prevalence
VDS
Social distancing
South Korea

ABSTRACT

Objective: The World Health Organization (WHO) declared a COVID-19 pandemic on March 12, 2020. Several studies have indicated that densely populated urban environments and the heavy dependence on traffic could increase the potential spread of COVID-19. This study investigated the association between changes in traffic volume and the spread of COVID-19 in South Korea.
Methods: This study analyzed the daily national traffic and traffic trend for 3 months from January 1, 2020. Traffic data were measured using 6307 vehicle detection system (VDS). This study analyzed the difference in traffic levels between 2019 and 2020. Non-linear regression was performed to analyze the change in traffic trend in 2020. The relationship between traffic and confirmed COVID-19 cases was analyzed using single linear regression.
Results: The mean daily nationwide level of traffic for the first 3 months of 2020 was 143 655 563 vehicles, which was 9.7% lower than the same period in 2019 (159 044 566 vehicles). All regions showed a decreasing trend in traffic in February, which shifted to an increasing trend from March. In Incheon there was a positive, but insignificant, linear relationship between increasing numbers of newly confirmed cases and increasing traffic (β = 43 146; p = 0.056).
Conclusions: Numbers of newly confirmed COVID-19 patients have been decreasing since March, while the traffic has been increasing. The fact that traffic is increasing indicates greater contact between people, which in turn increases the risk of further COVID-19 spread. Therefore, the government will need to devise suitable policies, such as total social distancing.

Introduction

Following the first COVID-19 case in Wuhan, China in December 2019, the disease spread rapidly to over 60 countries in early 2020. Consequently, the World Health Organization (WHO) declared a pandemic on March 12, 2020, within 71 days of the first case (Zhu et al., 2020; World Health Organization, 2020c,d,e). As of March 31, COVID-19 was present in 206 countries, with 770 138 confirmed patients and 36 796 deaths worldwide (WHO, 2020b). Different countries are employing diverse methods to manage and prevent the further spread of COVID-19 (WHO, 2020a). Most countries are limiting contact between citizens, most notably China, where Wuhan was placed under lockdown within just 23 days of the outbreak, and contact with neighboring cities was forbidden (Lin et al., 2020). France, Switzerland, and Austria closed their borders on March 17, while France, Spain, Italy, Germany, and some states in the US have been implementing strict policies to limit contact between citizens, including nationwide stay-at-home orders, thereby preventing the domestic spread of COVID-19 (Kinross et al., 2020).

South Korea's total population is 51.8 million, of which a large proportion resides or is active in the capital and the surrounding Gyeonggi Province. Of the total population, 13.28 million (26.0%), 9.73 million (18.7%), and 2.95 million (5.7%) reside in Gyeonggi Province, Seoul, and Incheon, respectively (Resident, 2020). Several

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https://doi.org/10.1016/j.ijid.2020.05.031
1201-9712/

studies have indicated that these densely populated urban environments and the heavy dependence on public transport could increase the potential spread of COVID-19 (Choi and Ki, 2020; Korean Society of Infectious Diseases et al., 2020; BBC News, 2020; Shim et al., 2020). On March 2, the South Korean government initially postponed the commencement of elementary, middle, and high schools for 4 weeks until April 6, and of university classes until March 16, before switching to online classes until April 16. Some schools decided to conduct online classes for the entire first semester (Koh and Hoenig, 2020). Due to joint efforts, including public institutions, private enterprises, and other companies implementing work-from-home systems to minimize travel, preventive education for citizens via social distancing campaigns, availability of disinfectant in every building and street, and transparency of information regarding the movements and locations of confirmed patients, a decreasing trend is being observed in the daily number of new COVID-19 patients.

Based on existing studies, although the number of new COVID-19 patients in South Korea shows a decreasing trend, the global number of COVID-19 cases, including South Korea, is forecast to eventually increase again, possibly due to genetic mutations in the virus, re-influx from overseas, and decreasing compliance by the public (Liu et al., 2020; Verity et al., 2020; Zhan et al. 2020). In particular, unlike in Spain, the US, and the UK, outdoor excursions are not restricted in South Korea. Therefore, it is predicted that, as citizens adapt to COVID-19, activity levels will increase and adherence will decrease for measures such as staying indoors, social distancing, and mask wearing, resulting in a secondary outbreak of COVID-19 (Zhan et al., 2020). Research analyzing 10 years of data has found a strong correlation between infectious diseases and traffic volume; specifically, increased traffic during an infectious disease outbreak is associated with greater spread (Meloni et al., 2009; Wu et al., 2019). An analysis of 10 types of influenza from the last 300 years showed a very close association with traffic. A disease that took 1 year to spread 300 years ago would now be able to reach anywhere in the world within a day, due to developments in travel (Rodrigue et al., 2020).

This study investigated the association between changes in traffic volume and the spread of COVID-19 in South Korea, and provides predictive data that may be required to guide future infectious disease prevention policies.

Methods

Study design

This quasi-experimental serial study analyzed the daily national traffic in South Korea for 3 months between January 1 and March 31, 2020, since the first COVID-19 patient in South Korea was observed in January. The data were compared with those for the same period the previous year to investigate the changes in traffic.

Data source and collection

The following secondary data were used to analyze the nationwide traffic alongside the trends in COVID-19. First, a suitable data set was constructed using point data for traffic provided in the public data portal of the Korea Expressway Corporation (http://data.ex.co.kr/portal/fdwn/view?type=VDS&num=37&requestfrom=dataset#) and public data on confirmed COVID-19 patients released by the Korea Centers for Disease Control and Prevention (KCDC) (KCDC, 2020).

Traffic data were based on vehicle detection systems (VDS), which measure the traffic passing over specific points. These systems use both in-ground and above-ground sensors (Figures 1 and 2). The data set included information collected from 7488 VDS nationwide. Data from 1181 of these were excluded as they lacked GIS WGS84 coordinates, leaving a total of 6307 VDS. The map in Figure 3 displays the included VDS as round dots.

COVID-19 patient trends in South Korea were analyzed using the statistics from the KCDC on 'daily new confirmed patient count' and 'cumulative number of individuals released from isolation'.

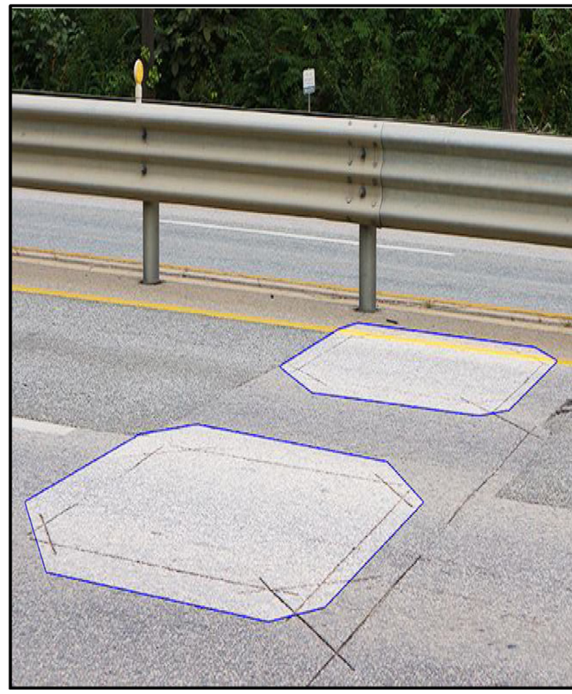

Figure 1. In-ground VDS.

Figure 2. Above-ground VDS.

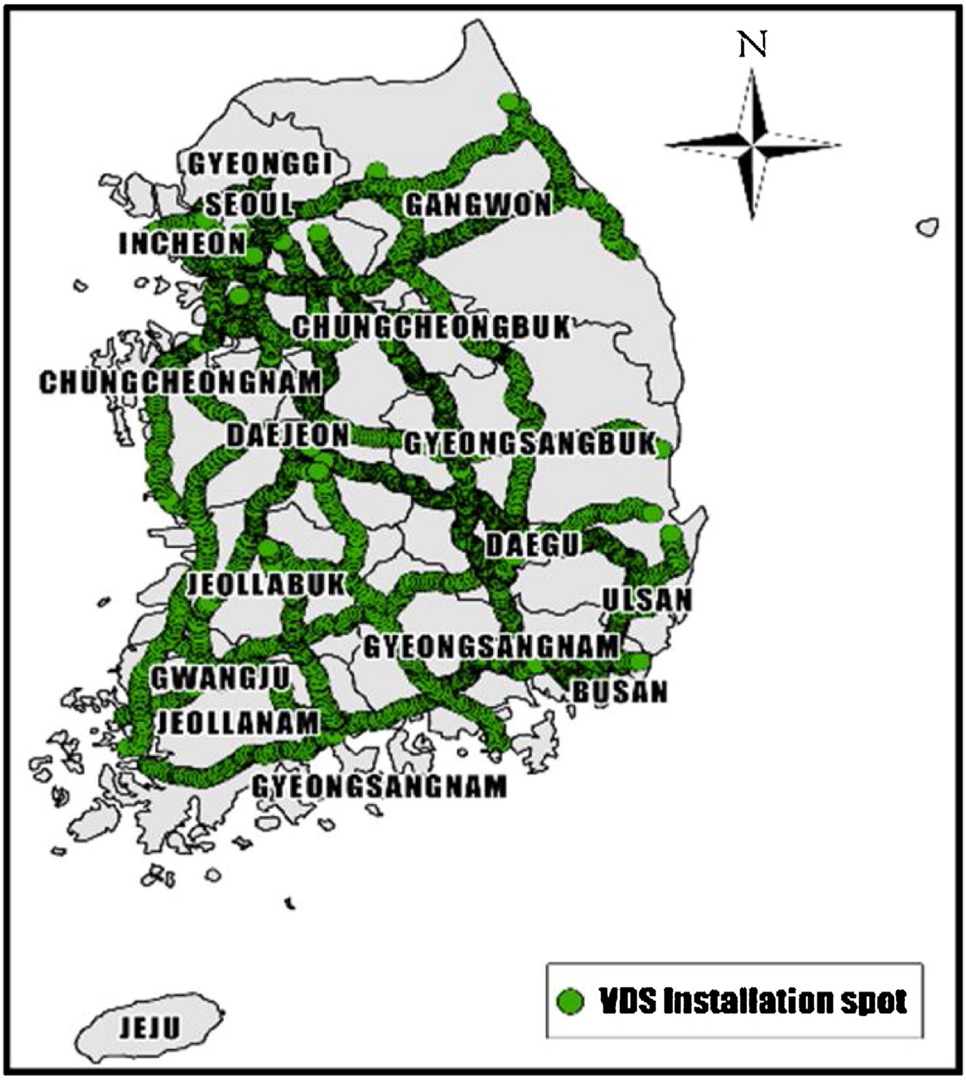

Figure 3. VDS installation spots.

The regional statistics for daily new confirmed patients and cumulative number of individuals released from isolation were obtained by visiting the individual city/province/county's homepage. A suitable data set was then constructed for this study.

Statistical analysis

First, the mean daily nationwide traffic was calculated for each week, starting from January 1, 2020, to compare traffic volumes between 2019 and 2020. A daily average was used because the 2020 data included the date of February 29. Mean daily nationwide traffic was compared between 2019 and 2020 using the following equation:

$$\text{gap} = \text{mean daily traffic in 2019} - \text{mean daily traffic in 2020} \quad (1)$$

Second, trends in nationwide traffic and in COVID-19 cases were analyzed for 2020. For the trends in nationwide traffic in 2020, non-linear regression was performed to analyze the change in traffic over time. Trends for COVID-19 were analyzed using the numbers of daily new confirmed cases. The relationship between traffic and COVID-19 patients was analyzed using single linear regressions. The resulting regression coefficient, t-ratio, and p-value were used to evaluate the correlation between traffic and the number of daily new confirmed cases.

Results

Comparison of traffic (2019 vs 2020)

Our study analyzed traffic volumes alongside trends in the spread of COVID-19 after the first COVID-19 patient in South Korea was detected. Traffic was analyzed in terms of the number of vehicles operating nationwide. The difference in nationwide traffic between 2019 and 2020 is displayed as 'Traffic gap (2019 vs 2020)' in Figure 4, corresponding to the gray shaded area.

During the first 3 weeks of 2020, the traffic was around 7% lower than in 2019 (first week −6.7%, second week −0.4%, third week −2.6%). However, following the first confirmed COVID-19 case in South Korea on January 19, 2020, the fourth week of January in 2020 showed a 17.3% increase in nationwide traffic compared with 2019.

In the first week of February, nationwide traffic was 23.3% lower than in 2019. Thereafter, nationwide traffic continued to decrease – in the fourth week of February it was 26.1% lower than in 2019.

In March 2020, nationwide traffic shifted back to an increasing trend from March 7 onwards, as shown by the 2020 traffic trend curve, displayed as a red line in Figure 4. Compared with the same period in 2019, however, traffic was lower throughout March (first

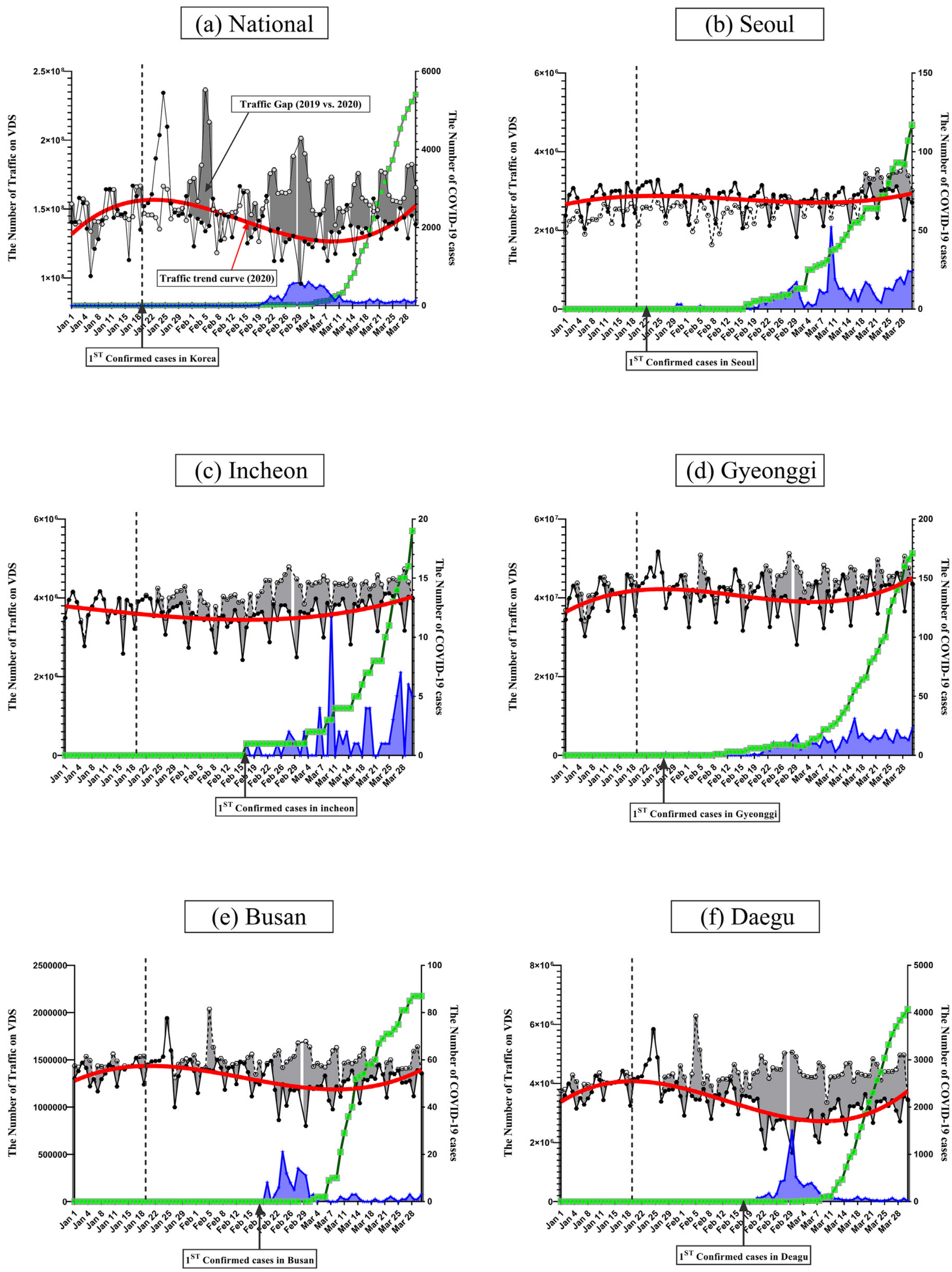

Figure 4. Traffic trends based on VDS in 2019 and 2020, and COVID-19 trends in 2020 by region. Data are presented from January 1 to March 31, 2020, on (a) national and (b–f) regional scales. The left *y*-axis corresponds to traffic and the right *y*-axis corresponds to the number of confirmed COVID-19 patients. The bold red line corresponds to the traffic trend curve for 2020, and January 19 indicates the first confirmed case in South Korea. The gray dotted line is the difference in traffic between 2019 and 2020, the blue data points are the newly confirmed COVID-19 cases, and the green data points are the cumulative numbers released from isolation.

week −25.1%, second week −14.6%, third week −13.7%, fourth week −14.0%, fifth week −22.0%).

The mean daily nationwide traffic between January 1 and March 31 was 143 655 563 vehicles, which was 9.7% lower than the same period in 2019 (159 044 566 vehicles) (Table 1).

As shown by the regional traffic trend curves in Figure 4, all regions showed a decreasing trend for traffic in February, which shifted to an increasing trend from March. In particular, there was almost no change in traffic in Seoul, while Incheon showed a continuous decrease in traffic from January that shifted to an

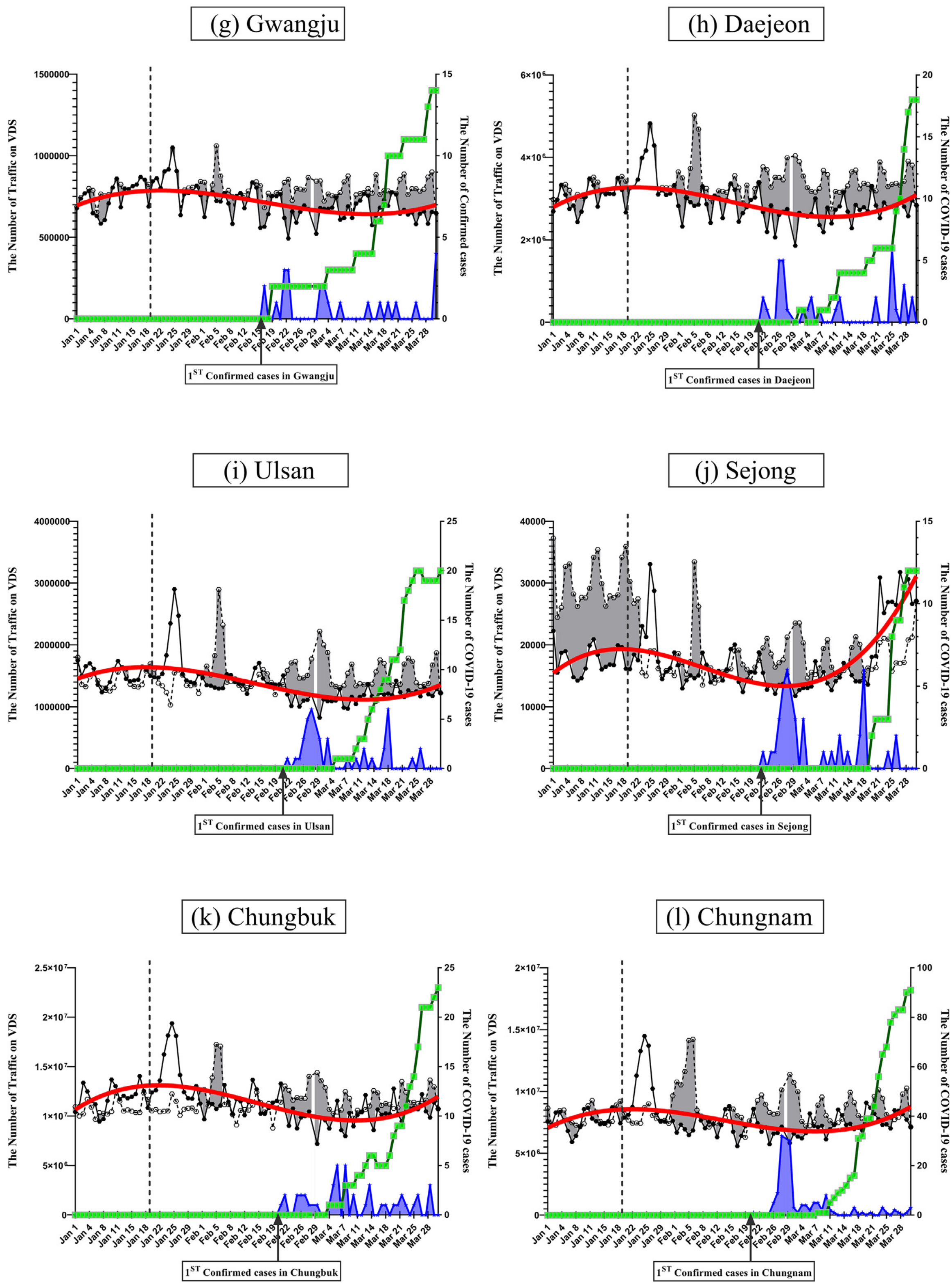

Figure 4. (Continued)

increasing trend from the end of February. In Gyeonggi, traffic increased in January, showed a slight decrease after the first COVID-19 case, and then switched to an increasing trend again from March 7. In Sejong, the traffic suddenly increased in March. In Daegu, the traffic decreased significantly compared with other regions in February, and shifted to an increasing trend in March; however, overall traffic was still low.

Changes in traffic and COVID-19 trends

In Figure 4, the first COVID-19 patient in South Korea is indicated by a vertical dotted line on January 19. The daily new confirmed cases are displayed as a blue line, and the cumulative number released from isolation is displayed as green squares, corresponding to the right-hand *y*-axis.

Table 1
Average traffic per day in 2019 and 2020, and COVID-19 trend per day in 2020.

Date	Traffic average per day		Gap[a] (%)[b]	Daily new confirmed cases (*N*)	Released from isolation
	2019	2020			
Jan – 1st week	145 797 502	135 994 670	−9 802 832 (−6.7%)	0	0
Jan – 2nd week	149 049 737	148 389 105	−660 632 (−0.4%)	0	0
Jan – 3rd week	150 897 726	146 908 915	−3 988 811 (−2.6%)	1	0
Jan – 4th week	149 778 529	185 314 734	+25 844 728 (+17.3%)	10	0
Jan – 5th week	147 251 673	150 482 955	+3 231 282 (+2.2%)	7	0
Feb – 1st week	182 825 475	140 144 295	−42 681 180 (−23.3%)	6	2
Feb – 2nd week	162 747 801	165 831 722	+3 083 921 (+1.9%)	4	7
Feb – 3rd week	151 192 280	142 631 273	−8 561 006 (−5.7%)	176	18
Feb – 4th week	170 090 529	125 730 973	−44 359 556 (−26.1%)	2133	27
Mar – 1st week	164 855 643	123 492 052	−41 363 591 (−25.1%)	4430	117
Mar – 2nd week	154 628 156	132 054 132	−22 574 024 (−14.6%)	1319	713
Mar – 3rd week	158 348 967	136 602 840	−21 746 126 (−13.7%)	713	2611
Mar – 4th week	162 656 743	139 886 152	−22 770 591 (−14.0%)	679	4811
Mar – 5th week[c]	176 503 164	137 714 570	−38 788 594 (−22.0%)	308	5567
Average	159 044 566	143 655 563	−201 776 965 (−9.7%)		

Data: Public data portal, Korea Expressway Corporation point traffic data (date of access: April 1, 2020) (http://data.ex.co.kr/portal/fdwn/view?type=VDS&num=37&requestfrom=dataset#); Korea Centers for Disease Control and Prevention (KCDC), South Korea COVID-19 press release (KCDC, 2020).
[a] Gap = average traffic per day (2020) − average traffic per day (2019).
[b] %: (average traffic per day (2020) ÷ average traffic per day (2019)) × 100.
[c] March 29, 2020 to March 31, 2020 (3 days).

Following the first COVID-19 patient in South Korea, the traffic trend curve (displayed as a red line) decreased continuously until the first week of March, while the frequency of daily new confirmed COVID-19 cases increased during the same period. Thereafter, the national traffic trend curve shifted to an increasing trend from March 7, while the daily new confirmed COVID-19 cases shifted to a decreasing trend, and the cumulative number released from isolation began to show an increasing trend. Thus, as the COVID-19 situation in South Korea began to improve after March 7, the rate of increase in the traffic trend curve continued to grow.

When the regional traffic trend curves and COVID-19 trends were analyzed in Seoul, Incheon, and Gyeonggi, the number of new confirmed cases and the traffic trends in March both increased compared with February. Other regions showed a decrease in the number of new confirmed cases compared with February, while the traffic trends increased (Figure 4).

Scatter plots were created to show regional daily traffic in 2020 against the daily new confirmed COVID-19 cases (Figure 5), and single regression analyses were performed (Table 2). In Incheon, there was a positive but insignificant linear relationship (β = 43 146; p = 0.056) with an increasing number of new confirmed cases associated with increased traffic. Meanwhile, all the other regions showed negative linear relationships, with traffic decreasing as the numbers of new confirmed cases increased (Figure 5). The regions showing significant linear relationships were the national region (β = −52 176, $p < 0.001$), Busan (β = −17 895, $p < 0.001$), Daegu (β = −1778.5, $p < 0.001$), Gwangju (β = −39 368, p = 0.005), Ulsan (β = −77 689, p = 0.003), Chungbuk (β = −637 223, p = 0.002), Gyeongbuk (β = −49 467, $p < 0.001$), and Gyeongnam (β = −230 313, p = 0.006) (Table 2).

Types of relationship between regional traffic and COVID-19

In Table 3 the analyses in Table 2, Figure 4, and Figure 5 have been classified into types for each region, based on whether the trends in traffic and COVID-19 were increasing or decreasing. Incheon was categorized as a region requiring strong control (Type 1), with increasing trends for both COVID-19 spread and traffic. Gyeonggi and Seoul were categorized as regions in the early stages of focused control or requiring control (Type 2), with increasing traffic but a relatively stable trend for new confirmed COVID-19 cases. The other regions were categorized as stable (Type 3), with increasing traffic but decreasing trends for COVID-19 spread.

Discussion

This study analyzed the relationship between traffic trends and the spread of COVID-19 after the first COVID-19 patient was confirmed in South Korea. This was carried out at both national and regional levels.

Since the first confirmed patient in South Korea on January 19, the mass media (e.g. TV news, newspapers, the Internet) and other studies have shown a decrease in peoples' engagement in outdoor activities as a result of self-isolation, working from home, voluntarily staying indoors, delaying the commencement of schools and universities, and the delivery of educational messages for COVID-19 prevention (e.g. via the Internet, broadcast media, and written articles) (Chinazzi et al., 2020; Magal and Webb, 2020). Similarly, our study showed that, following the COVID-19 outbreak in South Korea, nationwide traffic decreased by 9.7% compared with 2019, indicating a decrease in citizens' outdoor activities. In particular, after the KCDC raised the infectious disease alert level to 'orange' on January 27, a large decrease was observed in nationwide traffic. After the alert level was raised to 'red' on February 22, traffic in the fourth week of February was down by 26.1% compared with 2019 (Figure 4).

To counteract the rapid increase in confirmed COVID-19 patients, the South Korean government implemented policies such as advising the restriction of outdoor activities, implementing a work-from-home system in public organizations, encouraging private organizations to employ work-from-home systems, advising educational institutions (kindergartens, after-school academies, etc.) to close, and delaying the commencement of elementary/middle/high schools and universities. The effectiveness of these policies was evidenced by the decrease in nationwide traffic. In particular, the data show that although the Korean government did not forcefully prohibit public excursions, citizens voluntarily adhered to the government's guidelines and restricted outdoor activities. Various studies and media opinions have suggested that these results are due to a high level of existing public health education, good information accessibility due to the rapid Internet environment, and effective delivery of educational messages. It would be valuable for future research to identify the

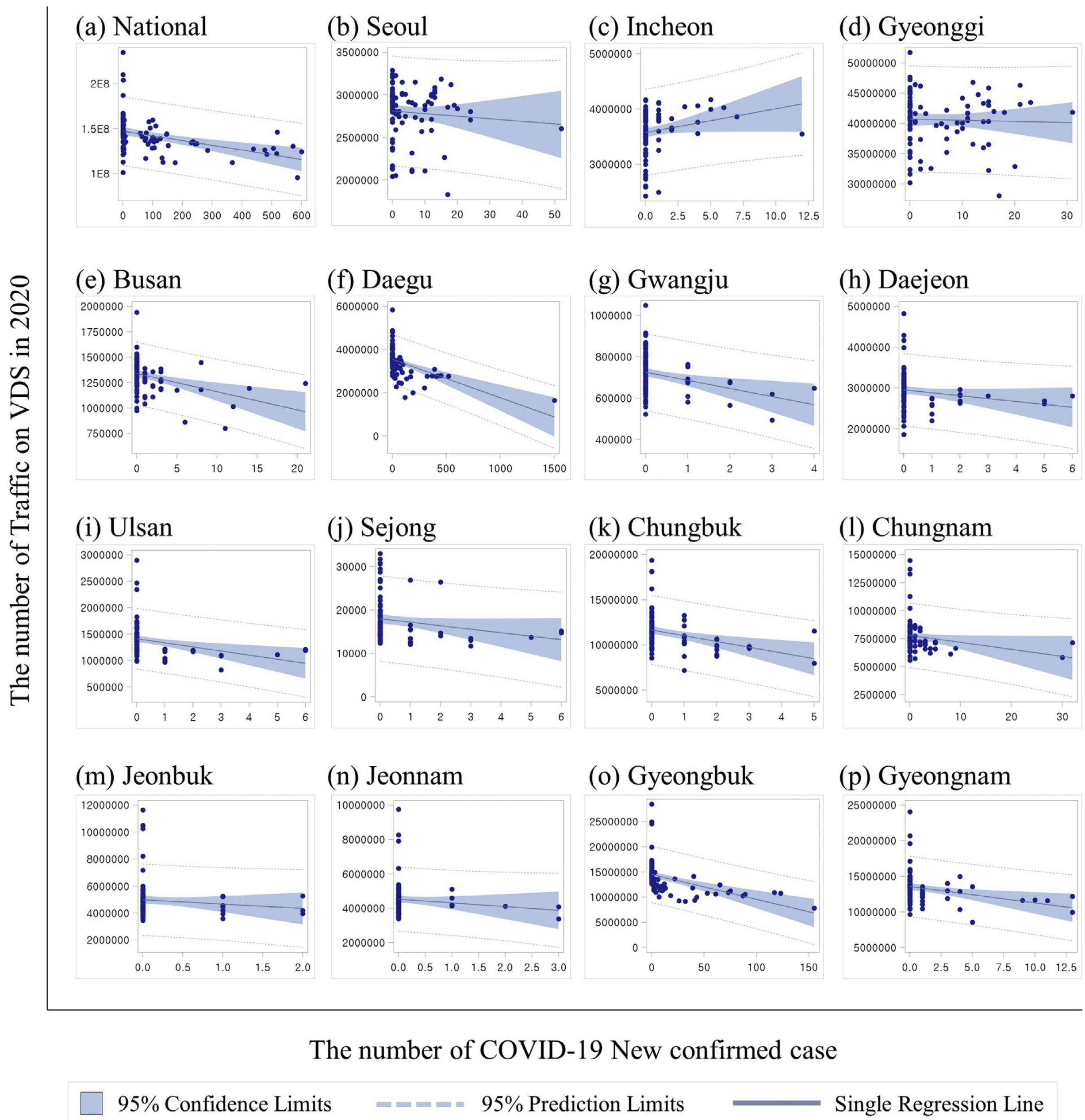

Figure 5. Scatter plots and single regression lines by region.

most effective measures among the South Korean government's COVID-19 policies.

Although the nationwide traffic in South Korea showed a continuously decreasing trend after the initial COVID-19 outbreak, it shifted to an increasing trend after March 7. This was the day after the numbers of daily new confirmed COVID-19 cases in South Korea shifted to a decreasing trend on March 6, when the Korean press and media had begun reporting decreasing trends in COVID-19 (The Briefing, 2020). Moreover, immediately after the WHO Director-General, Tedros Adhanom Ghebreyesus, at a foreign media briefing on March 5, reported that 'the numbers of new confirmed COVID-19 patients in South Korea are decreasing, and there are encouraging signs', corresponding news articles were published on March 6 in Korean Standard Time – the day before the nationwide traffic shifted to an increasing trend (The Associated Press, 2020). In the cases of Daegu, Cheongdo, and Gyeongsan city, the KCDC recommended that citizens in these areas undergo self-isolation for prevention from 23 February to 8 March, which contributed to the subsequent increase in traffic.

The shift to an increasing trend in nationwide traffic from March may have been caused by: (1) a change in COVID-19 prevention attitudes toward decreasing compliance; (2) a decrease in people working from home; (3) increased usage of personal vehicles; and (4) an increase in outdoor excursions due to seasonal changes. These are discussed below.

First, as the number of new daily confirmed COVID-19 patients decreased and the number of persons released from isolation increased, it is likely that the attitudes of the public shifted toward decreasing compliance. According to previous research, 2 months following the first COVID-19 case in South Korea, citizens became increasingly fatigued by the preventive measures, and their attitudes to prevention became less stringent (Remuzzi and

Table 2
The result of single linear regression between traffic in 2020 and newly confirmed COVID-19 cases.

	β	β *t*-value	*p*
(a) National	−52 176.0	−4.17	<0.001***
(b) Seoul	−3 025.6	−0.72	0.474
(c) Incheon	43 146.0	1.94	0.056
(d) Gyeonggi	−19 180.0	−0.30	0.766
(e) Busan	−17 895.0	−3.68	<0.001***
(f) Daegu	−1 778.5	−5.58	<0.001***
(g) Gwangju	−39 368.0	−2.9	0.005**
(h) Daejeon	−71 490.0	−1.66	0.100
(i) Ulsan	−77 689.0	−3.03	0.003**
(j) Sejong	−806.5	−1.84	0.069
(k) Chungbuk	−637 223.0	−3.23	0.002**
(l) Chungnam	−62 733.0	−1.96	0.053
(m) Jeonbuk	−322 490.0	−1.03	0.308
(n) Jeonnam	−217 346.0	−1.15	0.255
(o) Gyeongbuk	−49 467.0	−5.05	<0.001***
(p) Gyeongnam	−230 313.0	−2.81	0.006**

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 3
The level of relationship between traffic and COVID-19 in cities, 2020.

	Trend in 2020		Specific	City
Level	Traffic	COVID-19		
1	+	+	(Danger) Strong control required	Incheon
2		0	(Caution) Control required, or in the early stage of focused control	Gyeonggi, Seoul
3		−	(Stable) Under stable control	Daegu, Busan, Gwangju, Daejeon, Ulsan, Sejong, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, Gyeongnam

+ = increasing; 0 = same; − = decreasing.

Remuzzi, 2020). For instance, analysis of public data from Seoul showed that the number of Seoul Metro passengers in March increased by 3.3% compared with March 2 (Won, 2020).

Second, employees following work-from-home policies since February started commuting to work again once the spread of COVID-19 had decreased in March, and this led to increased traffic. Indeed, employees working from home reached their highest levels of movement in the first week of March, after which they showed a decreasing trend.

Third, citizens who had previously used public transport (the Metro, buses, taxis, etc.) showed increased use of their personal vehicles for outings to avoid public transport, which is susceptible to COVID-19 spread.

Fourth, South Korea is a country with four distinct seasons, and has a culture where people frequently go out in the springtime. The culture, sports, and tourism ministries in individual cities, provinces, and counties attempted to prevent outdoor activities by closing or reducing the operating hours of major tourism sites; however, the number of tourists visiting these sights increased as the weather got warmer.

When the regional COVID-19 and traffic trends were analyzed in this study, the traffic in Seoul, Gyeonggi, and Incheon showed smaller changes compared with the other regions. This is because the Korean citizens, including overseas students, started returning to the country as COVID-19 began rapidly spreading overseas, such as in Europe and the US (Cho, 2020). The number of Korean citizens returning from overseas and requiring control was estimated to be 210 000 individuals, making the risk of a resurgence of COVID-19 considerably high. Indeed, 23.8% of the confirmed cases in Seoul in the third week of March were individuals returning from abroad (Young-kyung et al., 2020). Thus, Seoul, Gyeonggi, and Incheon, which are closer to the airport and the residences of many citizens returning from abroad, showed increased COVID-19 and traffic trends compared with other regions. In particular, Incheon showed a positive linear relationship between traffic and new confirmed COVID-19 patients, prompting increasing concern about a secondary COVID-19 outbreak in this region compared with others.

This study had some limitations. First, it did not collect data on the total national traffic volume, instead relying on VDS data, although these are representative of the national trend. Moreover, the data collected included drive-through traffic, which would need to be excluded in future studies. Second, this study did not preclude the causal effects of regional influences, such as public policy, the media, education, etc. A future study should include a comparison of experiences in each city with those in other outbreak cities pursuing different policies (Pan, 2020).

Globally, COVID-19 is an ongoing pandemic. At present, the spread of COVID-19 is concentrated in Europe and the US, with WHO declaring Europe to be the second epicenter of COVID-19 (Johnson et al., 2020; Lin et al., 2020; Qasim et al., 2020). As of March 31, 2020, outside of Asia, the five countries with the highest numbers of confirmed COVID-19 cases were, in descending order, the US (163 479 cases), Italy (101 739 cases), Spain (87 956 cases), Germany (66 885 cases), and France (44 550 cases). All these countries allow Koreans to freely travel there and, consequently, South Korea is currently experiencing a persistent increase in the cases of infection re-entering the country from overseas regions such as Europe and the US. Preparing various physical and institutional measures, including social distancing, will be necessary to prepare for a secondary outbreak of COVID-19 in South Korea. In particular, increased traffic implies a rise in outdoor excursions, which elevates the risk of spread of COVID-19 due to increased social contact. The government needs to devise policies similar to social distancing to restrict citizens' excursions and other risks of contact.

Conclusion

This study analyzed nationwide traffic and the spread of COVID-19 in South Korea after the country's first confirmed case.

Nationwide traffic in the first 3 months of 2020 decreased by 9.7% compared with 2019. In particular, when the KCDC raised the infectious disease alert level to 'orange' there was an initial decrease in nationwide traffic, followed by a second decrease when the alert level was raised to 'red'. Over the same period, the number of COVID-19 patients and the rate of spread also increased.

Nevertheless, on March 6 WHO and the Korean media conveyed reports of a decrease in daily new confirmed COVID-19 patients in South Korea, and nationwide traffic increased from March 7. If vehicular traffic continued to increase at this rate, it would have reached 2019 levels in April.

Due to the spread of COVID-19 in the US and Europe, the number of Koreans and COVID-19 patients returning from overseas is increasing. In Seoul, Gyeonggi, and Incheon, unlike other regions, the trend for new confirmed patients increased in March. These regions showed relatively little change in traffic according to COVID-19 patient trends, with Incheon especially showing a significant positive linear relationship.

In South Korea, the number of new confirmed COVID-19 cases has been decreasing since March, while the traffic has been increasing. However, it will be necessary to use accurate data to further analyze circumstances in the event of a secondary outbreak of COVID-19 due to increased traffic and re-influx from the overseas, and to prepare policies and equipment to cope with such a scenario. In particular, the fact that traffic is increasing indicates greater contact between people, which in turn increases the risk of COVID-19 spread. Therefore, the government will need to devise suitable policies, such as total social distancing.

Ethics approval and consent to participate

Ethical approval and individual consent were not applicable.

Availability of data and materials

All data and materials used in this work were publicly available.

Consent for publication

Not applicable

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Authors' contributions

The first author, LHC, and the corresponding author, NEW, were responsible for the idea for this study, the methodology, the analysis, and the draft. PSH was responsible for the analysis, LGR for data cleaning, and KJE for the data results and discussion. Additionally, LJH processed the GIS location coordinates, and JY participated in debates and discussions. All the authors diligently participated in reviewing the paper.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements

First, we would like to express our gratitude to everyone working to overcome COVID-19 in South Korea and throughout the world. We would also like to thank our collaborators at Yonsei Global Health Center, who helped us with research on global COVID-19 trends and international healthcare, as well as collaborating researchers worldwide.

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