Analysis of the Rate of Confirmed COVID-19 Cases in Seoul and Factors Affecting It Using Big Data Analysis

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Introduction

Coronavirus disease (COVID-19) is caused by infection with severe acute respiratory syndrome coronavirus 2 and presents with mild to severe symptoms. The transmission mode is by droplet infection when coughing, talking, or breathing.¹ Large-scale infectious diseases such as COVID-19 occur sporadically, and little is known about the factors of the major transmission routes, for effective infection control. In addition, it is necessary to analyze real-time data early and establish a specific infection prevention strategy to reduce the infection rate effectively. Previously, studies related to factors such as climate, treatment strategies, obesity, and respiratory diseases have been conducted.²⁻⁴ Domestic research on COVID-19 mainly focused on data analysis of climate factors, the economy, education, tourism, and news reports.⁵⁻⁸ Particularly, Lim et al⁹ analyzed the correlation between the spread of COVID-19 and meteorological factors, such as temperature, humidity, rainfall, and air pollution for each period in Seoul in 2020. In addition, Al-Rousan et al¹⁰ performed a comparative analysis of the recovery rate and mortality rate by sex, province, and cause of infection regarding the spread of COVID-19 in Korea. Data were collected daily for analysis on COVID-19 in the Seoul region of South Korea. This study aimed to help lower the COVID-19 infection rate effectively by analyzing the infection factors and focusing on areas where infections had mainly occurred.

Methods

For this study, we used data from a public data portal on COVID-19 infection in Seoul, which was provided by the government (https://www.data.go.kr/). The data collection period was from January 2020 to November 23, 2021. Correlation analysis, data refinement, and frequency analysis were used to analyze the possible factors affecting coronavirus infections. All informed consent was obtained from the patients. Ethical approval for this study was obtained from KyungHee Cyber University of Ethics committee (KHCU-Ethics-2022-1).

Data Refinement

In the case of large text, data consisting of natural languages, keywords corresponding to synonyms, or various related keywords can be grouped together. When analyzing big data for data aggregation, statistical processing and summing of data may not be possible if the analysis is performed without unifying the data keywords. Data on contact history for COVID-19 confirmed cases are currently provided; however, the classification is not precise. Therefore, before performing big data analysis, it is necessary to reclassify the data using a data refining operation that converts the big data into a data format that can be easily processed. In this study, keywords were extracted by removing commonalities from the data on the contact history of 36,253 confirmed patients and reclassifying them into higher categories.

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Visualization of Heatmap Through R Statistics Language

This research was analyzed and processed using the R statistical programming language (R Core Team, Vienna, Austria). Graph visualization and table organization of the COVID-19 infection rate by district in Seoul were conducted using R programming.

Results

Figure 1 shows the number of confirmed COVID-19 cases per month in Seoul, South Korea, between 2020 and 2021.

In Figure 2, a heatmap shows summarized contact history of confirmed patients for each period. According to the color-coding, beige (see color figure in online version) defines closer to zero patients while red-brown (see color figure in online version) defines a higher number of patients (≥400 people) in contact history. The number of confirmed cases in contact history was higher mainly in hospital, markets, workplace, nursing facilities, and other cities. Cases of spread in a detention center occurred between December 2020 to January 2021. Infections at work and contacts related to visits to other cities and provinces previously showed relatively many confirmed cases; however, the number has recently decreased.

Other common factors in the spread of COVID-19 infection are listed in Table 1.

As shown in Table 2, infections from other cities, workplace, and nursing facilities were the commonest. In nursing facilities, the number of confirmed cases seemed to increase, as many elderly people who were less mobile came into close contact with caregivers. In addition, there were many confirmed cases while holding religious events such as worship services. Furthermore, there were confirmed cases in indoor sports facilities. In general, people were concentrated in indoor spaces, and conditions for the spread of droplet infection were created considering physical activities such as conversation, singing, and exercise. It seems that restrictions on outdoor activities due to increased COVID-19 infection increased infection through indoor sports.

Discussion

In this study, big data analysis was conducted on public data released by the Seoul Metropolitan Government to examine the leading causes of high contact history among confirmed COVID-19 patients in each district. The big data, which was accumulated and provided daily, was not organized by a data analyst, but a medical examination official. Therefore, data refinement was necessary for the big data analysis, as it was pre-processed data that had not undergone unification.

Conclusion

This study provided primary processing, categorization, and reclassification of data to enable future organization of big cumulative data, even when the data are not correctly coded or
Figure 2. Heatmap of COVID-19 infected patient numbers for each period (January 2020 to November 23, 2021).

Table 1. COVID-19 Contact History Keyword and Reclassified Keyword.

| Contact history keyword                                                                 | Reclassified names                                                                 |
|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Related to PC room in Yongsan District; PC room related to Gangbuk-gu; PC room related to Seongdong-gu; Eunpyeong-gu family related; Metropolitan acquaintance gatherings related to Nowon-gu family; Seongbuk-gu family; kindergarten related; Songpa-gu family; children's home related; Gangnam-gu family related; Gangbuk-gu family; children's home related; Dongdaemun-gu family; children's home related; Guangjin-gu family gathering; Dongdung-gu family reunion; Dong-gu family related; Songpa-gu family related; Seongbuk-gu family gathering-related; Metropolitan family gathering-related; Gangdong-gu family related; Kangseo family related; Nowon-gu family related; Seongbuk-gu family related; Yeongdeungpo-gu family related; Guro-gu family related; Guro-gu family related; Dobong-gu family related; II; Yeongdeungpo-gu family related; Goyang city couple related; Kwanak-gu family related; Gwanak-gu family gathering; Gangbuk-gu family related; Seongdong-gu family related; Dobong-gu family related; Zhonglang-gu family related; Seocho-gu family related; Eunpyeong-gu family related; Metropolitan acquaintances; Family Reunion Related. Other, One family of Chinese compatriots in Gwanak District, related to Pagoda Urban District, related to Dobong-gu Chengliang; Zhonggu Chenggu 00 related; Guanak-gu Evada related; Eunpyeong-gu Haircock related; Operation District Dr. Q related; Yongin Brothers; Liquid Soul; ha ha; Flink; Dongdaemun-related; EZHL, Jongno-gu outbreak; Close Contact with COVID-19 Patient. Persons with disabilities related to living facilities; apartment-related; apartment, Guro-ku apartment-related; apartment, Guro-ku apartment-related; Seongdong-gu apartment management office. Gyeonggi Namyangju Construction Site 2 Related; Gyeonggi Goyang City Construction Site Related; Related to the construction site in Gyeonggi Province, related to the construction site in other cities, related to the construction site, related to the construction site in Yongsan District, related to the construction company in Seocho-gu, construction site in Dobong-gu. Gangseo-gu elderly facility. Goshiwon related; Goshiwon related in Gwanak District; Goshitel related; Goshiwon related in Zhonglang District; Goshiwon related in Guangjin District. Regarding public institutions, related to public institutions in Zhonglang District; related to Nowon-gu office; Yangcheon police station in Yangcheon District; related to Jangno-gu office; Seoul Local Revenue Agency; Yeongdeungpo-gu National Assembly entrance and exit reporter; Jongno-gu Hyehwa police station; National Defense Security Support Command. | Internet cafe; Family. Infection route under investigation; Residence; Construction; Elderly facility; Goshiwon; Public institution. |
Table 1. (continued)

| Contact history keyword                                                                 | Reclassified names                  |
|-----------------------------------------------------------------------------------------|-------------------------------------|
| Related to elementary school and Jongno-gu performance venue, related to performance in Yongsan District, related to performance practice, performance practice room, performance venue related to Guan gin-gu industry workshop | Performance                          |
| Related to manufacturing factory, related to manufacturing plant in Gangbuk-gu, related to plastic factory in other cities, related to Zhonggu manufacturing plant 2, related to Zhonggu manufacturing factory, related to Dobong-gu garment industry workshop | Factory                              |
| Southern Prison Related, Eastern Detention Center Related                               | Prison                              |
| Savings Finance Consulting                                                              | Financial counseling                |
| Financial Company, Gangnam Station Samdong Financial Company                            | Financial company                  |
| Regarding university dormitories, related to university dormitories in Mapo-gu           | Dormitory                           |
| Related to the singing practice hall, related to the singing practice hall in Seongdong-gu, related to the singing practice field in Yongsan District, related to the singing practice field in Zhonglang District, related to the singing practice hall in Gangbuk-gu | Karaoke                             |
| Health Experience Facility in Gwanak District, Songpa-gu Proverbs Medical Machine, Gang dong-gu Happiness Day Care Center | Senior facilities                  |
| Hospital in Songpa-gu, Hospital in Zhonglang-gu, Hospital in Jongno-gu, Hospital in Songdong-gu, Hospital in Seongbuk-gu, Hospital in Gangnam-gu, Hospital in Uijeongbu, Seoul Hospital in Seongdong-gu, Hospital in Eunpyeong-gu | Large hospital                     |
| Related to Seoul City Dance Practice Room, Dance Practice Room in Mapo-gu, Dance School in Seoul City, Gangseo-gu Dance Teaching Related Hospital, Gangseo-gu Dance Teaching Related Facilities | Dance practice room                |
| Massage Shop Related                                                                    | Massage parlor                      |
| Zonglangu Mart, Mart-related                                                            | Mart                                |
| Regarding the Dobong-gu, Nowon-gu acquaintance meeting, related to the Kangseo District acquaintance meeting, related to the Bupyeong-gu foreign acquaintance meeting, related to the Bupyeong-gu foreign acquaintance meeting, related to the metropolitan acquaintance meeting in Zhonglang-gu, related to the university student meeting, related to the acquaintance meeting in Gangbuk-gu, related to the Guan gin-gu acquaintance meeting restaurant, related to the acquaintance meeting in Northeast Region, related to the acquaintance meeting in Yongsan District, related to the acquaintance meeting in Seodaemun-gu, related to the acquaintance meeting in Guro-gu, related to the acquaintance meeting in Seongbuk-gu, related to the acquaintance meeting in Gangbuk-gu, related to the acquaintance meeting in Gangbuk-gu, related to the other city basketball club, related to the Seocho-gu acquaintance meeting, Regarding metropolitan travel/Gangnam-gu acquaintance meeting, acquaintance travel meeting/Seocho-gu workplace, Regarding the Gangnam-gu acquaintance meeting, related to the Zhonggu acquaintance meeting, related to the Guan gin-gu acquaintance meeting, related to the Gangdong-gu acquaintance meeting, related to the small acquaintance meeting, related to the app small group meeting, the Metropolitan Mountain Society, the Choi Bya related to the Dong-gu meeting, the Chuncheon briquette service meeting, the Yongsan District National Army Welfare Corps, the acquaintance-family propagation, the Dong-gu Mojo Cafe, the metropolitan acquaintance meeting, the birthday party meeting, the Gangnam-seo Cho acquaintance meeting, the metropolitan acquaintance meeting II, the Yeongdeungpo-gu small meeting, the cafe related, the Kwanak-gu acquaintance meeting, the programmers’ acquaintance meeting, the construction briefing meeting, the September Songpa-gu acquaintance meeting, the Seodaemun acquaintance meeting, the Yeongdeungpo acquaintance meeting, the extreme mountain related, Regarding the Darae auction, Dongdaemun-gu sk table tennis club, Dongdaemun-gu study cafe, Military Human Rights Center, Jongno-gu acquaintance meeting, Songpa-gu acquaintance meeting, Gangnam-gu station sam-dong meeting | Congregation                        |
| Cultural facilities                                                                    |                                    |
| Logistics                                                                               |                                    |
| Regarding US military bases in Yongsan District                                         |                                    |
| Regarding visiting teachers in Eunpyeong-gu                                             |                                    |
| Visiting Nursing Facilities, Visiting Care Facilities                                    |                                    |
| Regarding Yeongdeungpo-gu Visiting Vendors, Regarding Visiting Injections in Busan City, Daejeon Multi-level Related Journalist-related, Yananewsclass |                                    |
| Hospital Related, Hospital Related in Seongdong-gu, Oriental Hospital Related, Hospital in Yangcheon-gu Related, Hospital in Gangbuk-gu Related, Hospital in Yongsan District, Associated with Postpartum Cookery in Mapo-gu, Related to Medical Institution, Related to Medical Institution in Gangbuk-gu, Related to Medical Institution in Zhonglang-gu, Relevant to Nowon-gu Medical Institution/Seongdong-gu Workplace, Gwanak-gu Beauty Industry/Zhonggu Medical Institution, Songpa-gu Family/ Medical Institution Related, Postpartum Cookery Staff, Related to Medical Institution 2, Related to Medical Institution in Gwanak District, Hospital 2 related, Dongdaemun-gu Wisdom Hospital related, Hospital 1 related, Medical institution in Yeongdeungpo, Medical institution, Hospital related, Hospital related in Zhonglang-gu, Hospital, Hospital in Guan gin-gu, Nowon-gu medical institution related, Seongdong-gu hospital, Related to medical institution in Seongdong-gu, Related to Gwanak-gu Hospital outbreak, Dobong-gu Hospital, Kwangjin-gu Hospital, Hospital out hospital, Songpa-gu hospital, Seoul Daehyo Hospital in Kangseo District, Kim Hye-jeun Hospital in Kwanak-gu, Kangseo Hospital related, Hospital in Guro-gu, Regarding dialysis patients in Gwanak-gu |                                    |
| Contact history keyword                                                                 | Reclassified names                  |
| Performance                                                                             | Performance                          |
| Factory                                                                                 | Factory                              |
| Prison                                                                                  | Prison                              |
| Financial counseling                                                                   | Financial counseling                |
| Financial company                                                                      | Financial company                  |
| Dormitory                                                                               | Dormitory                           |
| Karaoke                                                                                 | Karaoke                             |
| Senior facilities                                                                       | Senior facilities                  |
| Large hospital                                                                          | Large hospital                     |
| Dance practice room                                                                     | Dance practice room                |
| Massage parlor                                                                          | Massage parlor                      |
| Mart                                                                                    | Mart                                |
| Congregation                                                                           | Congregation                        |
| Cultural facilities                                                                    |                                    |
| Logistics                                                                               |                                    |
| Regarding US military bases in Yongsan District                                         |                                    |
| Regarding visiting teachers in Eunpyeong-gu                                             |                                    |
| Visiting Nursing Facilities, Visiting Care Facilities                                    |                                    |
| Regarding Yeongdeungpo-gu Visiting Vendors, Regarding Visiting Injections in Busan City, Daejeon Multi-level Related Journalist-related, Yananewsclass |                                    |
| Hospital Related, Hospital Related in Seongdong-gu, Oriental Hospital Related, Hospital in Yangcheon-gu Related, Hospital in Gangbuk-gu Related, Hospital in Yongsan District, Associated with Postpartum Cookery in Mapo-gu, Related to Medical Institution, Related to Medical Institution in Gangbuk-gu, Related to Medical Institution in Zhonglang-gu, Relevant to Nowon-gu Medical Institution/Seongdong-gu Workplace, Gwanak-gu Beauty Industry/Zhonggu Medical Institution, Songpa-gu Family/ Medical Institution Related, Postpartum Cookery Staff, Related to Medical Institution 2, Related to Medical Institution in Gwanak District, Hospital 2 related, Dongdaemun-gu Wisdom Hospital related, Hospital 1 related, Medical institution in Yeongdeungpo, Medical institution, Hospital related, Hospital related in Zhonglang-gu, Hospital, Hospital in Guan gin-gu, Nowon-gu medical institution related, Seongdong-gu hospital, Related to medical institution in Seongdong-gu, Related to Gwanak-gu Hospital outbreak, Dobong-gu Hospital, Kwangjin-gu Hospital, Hospital out hospital, Songpa-gu hospital, Seoul Daehyo Hospital in Kangseo District, Kim Hye-jeun Hospital in Kwanak-gu, Kangseo Hospital related, Hospital in Guro-gu, Regarding dialysis patients in Gwanak-gu |                                    |
Table 1. (continued)

| Contact history keyword                                                                 | Reclassified names            |
|----------------------------------------------------------------------------------------|-------------------------------|
| Welfare Facilities Related, Welfare Sites Related, Elderly Care Facilities in Seongdong | Insurance                     |
| District, Children’s Centers Related, Disabled facilities in Gangbuk-gu Related,     | Welfare facilities           |
| Local Children’s Centers, Children’s Facilities in Yongsan District, Children’s      |                               |
| Facilities Related, Child Welfare Facilities Related, Social Welfare Facilities       |                               |
| Related, Education Institutes Related, Elderly Welfare Facilities in Zhonglang District, |                               |
| Facilities for the Disabled, Elderly Welfare Facilities in Mapo District, Education   |                               |
| Facilities for the Disabled in Seocho-gu                                             |                               |
| Dongjakggu Real Estate Companies                                                        | Real estate companies         |
| Gangnam Seungguang Building, Daewoo Diovie Plus, Yeongdeungpo-gu LG Twin Tower,       | Building                      |
| Gangnam-gu Shindo Venture Tower, Seoul City Hall                                        |                               |
| Sauna related, Sauna related in Mapo-gu, Sauna related in Zhonglang-gu, Cartoon room  | Sauna                         |
| sauna related, Sauna related in Gwanak-gu, Sauna related in Guangjin-gu, Sauna related |                               |
| in Yongsan District, Sauna related in Gangbuk-gu, Sauna related in Seongdong-gu,      |                               |
| Sauna related in Seongdong-gu, Related to modern public sauna, Seocho-gu sauna II      |                               |
| related, Operation District sauna related, Songpa-gu sauna related, Seocho-gu sauna    |                               |
| related, Gangseo sauna related, Gangnam-gu lucky sauna related                         |                               |
| Shopping mall related, Zhongguo shopping mall related                                    | Downtown                      |
| Accommodation related to Sokcho City, accommodation related                            | Lodging                       |
| Market related, Gyeonggi Guri-shi wholesale market related, Other cites livestock       | Market                        |
| products trial market related, market, Seongdong-gu market related, Songpa-gu market   |                               |
| related                                                                                  |                               |
| Seoul Seminary                                                                          | Seminary                      |
| Weewha Entertainment                                                                    | Entertainment                 |
| Metropolitan Acquaintance Family Travel Meeting, Metropolitan Family Tour, Jeju Trip,   | Travel meetings               |
| Songpa-gu Acquaintance Gangwon Travel Meeting                                          |                               |
| Building Relations                                                                      | Office                         |
| Nursing Hospital Related, Nursing Hospital in Gangbuk-gu Related, Nursing Hospital,   | Nursing hospital              |
| Dongdaemun-gu Ace Hope Care Center, Gwanak-gu Sanatorium                               | Nursing services              |
| Regarding Nowon-gu Jagayoyang Service                                                  | Nursing facilities            |
| Regarding nursing facilities, Hospitals and nursing facilities, Regarding elderly care  |                               |
| facilities Related, Related to nursing facilities, Regarding elderly care facilities in |                               |
| Zhonglang-gu, Regarding elderly care facilities in Gwanan District, Regarding elderly  |                               |
| care facilities in Gangbuk-gu, Regarding elderly care facilities in Mapo-gu, Nursing   |                               |
| facilities in Gwanan District, Nursing facilities in Zhonglang-gu, Related to         |                               |
| correctional facilities, Residential facilities/nursing facilities in Seongdong District,|                               |
| Nursing facilities 2 related to nursing facilities in Yangcheon District, Nursing     |                               |
| facilities in Guangjin-gu, Nursing facilities in Gangbuk-gu, Related to nursing        |                               |
| facilities in Yangcheon District, Related to nursing facilities in Yangcheon District,|                               |
| Related to nursing facilities in Seocho-gu, Related to children’s home in Gangbuk-gu, |                               |
| Related to Children’s Home in Guangjin-gu, Related to Children’s Home in Mapo-gu,     |                               |
| Related to Children’s Home in Zhonglang-gu, Family Children’s Home in Guangjin-gu,    |                               |
| Related to Children’s Home in Seocho-gu, Children’s Home in Gwanak-gu, Children’s     |                               |
| Home in Gangdong-gu                                                                      |                               |
| Itaewon Club Related                                                                    | Party                         |
| Slaughter and meat processing related                                                   | Meat processing               |
| Regarding banks in Zhonggu                                                              | Bank                          |
| Restaurant related in Guangjin-gu, Restaurant related in Yongsan District, Restaurant  | Restaurant                    |
| related in Gangbuk-gu, Restaurant related in Gwanak-gu, Nowon-gu restaurant Gyeonggi     |                               |
| do related to work, Mapo-gu restaurant related, Indoor sports facilities/restaurant in|                               |
| Gangbuk-gu, Guro-gu family restaurant sauna related, Gangnam-gu family related          |                               |
| restaurant related to Yongsan-gu, Geumcheon-gu workplace/Youngeungpo-gu restaurant     |                               |
| related, Guangjin-gu restaurant/Nowon-gu children’s home, Public institutions in       |                               |
| Mapo-gu related to Eunpyeong-gu restaurants, restaurants related, restaurants / beauty |                               |
| industry in Mapo-gu, Yonggan-gu restaurants related, Gangnam-gu restaurants II related,|                               |
| restaurants in Yongsan District, etc., Songpa-gu common noodles related, Restaurant/ |                               |
| Educational Facilities Related, Gwanan District Restaurant Related                     |                               |
| Related to music practice room, related to music practice room in Seocho-gu, Guangjin-   | Music practice room           |
| gu high school, related to music club in Yongsan-gu, related to music teaching center,|                               |
| performance band related, University in Seongbuk-gu band club, Jongno-gu recording     |                               |
| studio related                                                                          |                               |
| Regarding the music school, related to the music school in Zhonglang District, Seoul    | Academy of music              |
| Music Teaching Related                                                                  |                               |
| Gangnam Mobile Communications Worker                                                   | Mobile carriers               |
| Station related                                                                        | Subway                        |
| Regarding the Bounty Parent Company, Funeral Home, Funeral Home                         | Funeral                       |

(continued)
| Contact history keyword | Reclassified names |
|-------------------------|--------------------|
| Religious facilities in Guangjin District, Religious facilities Related, Religious facilities in Mapo District, Churches in Goyang City, Gyeonggi Goyang, Funeral Homes in Yangcheon District, Religious Welfare Facilities Related, Religious facilities in Gangbuk-gu Related, Religious facilities in Gwanak District, Religious facilities, Religious facilities/Tasido Gatherings Related, Churches Related, Companies in Yongsan District/Churches in Yangcheon District, Religious facilities in Seongdong District, Workplace Religious Facilities in Seongdong District, Mission Education Facilities, Regarding medical institutions/religious facilities, related to Daejeon IM Mission Church, related to Changzhou BTJ Nations Center, religious facilities in Mapo District, related to religious facilities in Zhonglang District, related to churches in Gangbuk-gu, related to churches in Gangseo District, religious facilities in Seongbuk District, religious facilities in Seocho-gu, church related, Gangbuk-gu Saesong Church, Regarding the Pure Gospel Church in Yeoido, in relation to the Hongdae New Church in Mapo-gu, in connection with the prayer place of the Dong-gu Church, in the Church/Education Institute, in Gwanak-gu Big Faith Restoration Methodist Church, in Dongdaemun-gu Bible Meeting, in North Seoul in Gangbuk-gu, in connection with the Dream Church in Songpa-gu, in connection with the Search Cathedral in Eunpyeong-gu, in the Nowon-gu Lightson Church, in connection with the Love First Church in Seongbuk-gu, in connection with the Nowon-gu Prayer Meeting, in Yeongdeungpo-gu Power Church, in Yangin-shi Uri First Church, in Bethel Presbyterian Church in Seongbuk District, in the Remembrance Church, in Goyang City Rock Church, in Eunpyeong-gu Bible Study Meeting, in the Mission Small Meeting, in Songpa-gu Church, in Kwanak-gu Wangsun Church, in Daejeon Dreaming Church, in Wangsun Church, in Kwanak-gu, Metropolitan Planting Church Meeting, Jesus Discipleship Church Korean University Student Mission Church, Anyang Pastor Related, Gangnam-gu Dongin Church, Original Language Bible Study Society, All Minh Central Church, Seongnam Grace River Church, Shin Chun-ji, Prestige Church | Religion |
| Regarding residential facilities in Guangjin District, related to shared housing | Dwelling |
| Regarding Yeongdeungpo-gu Securities Company, a securities company based in Yeongdeungpo | Securities companies |
| History-related, Gangnam-gu Station Sam Station, Shindorim History, Seoul City Hall Station Facility, Improvement Corporation Security Personnel Related | Subway |
| Workplace related in Seongdong-gu, related to Mapo workplace, related to company in Su-won, related to shared office, related to broadcasters in the metropolitan area, related to workplace in Gangbuk-gu, related to Nowon-gu workplace/acquaintance meeting, work-related, Seodaemun-gu family work related, building-related, game developer company in Seongnam-shi, Seoul, related to work, family/workplace in Zhonglang-gu, workplace, Gwanak-gu work/Incheon collective life, work-related to Dongdaemun-gu family/Seongdong-gu workplace, Workplace in Gwanak-gu, related to workplace 2, related to the workplace of acquaintances in Gwanak-gu, related to Yangcheon-gu family workplace, Yongson-gu Workplace/Acquaintance Related, Workplace 3 Related, Workplace 4 Related, Workplace 1 Related, Taxi Company Related, Public Enterprise Related, Gangnam-gu Private Guard Team, Mapo-gu Building Related, Seocho-gu Building Related, Dongdaemun-gu Korea Industrial Workforce Corporation, Gangnam-gu Hae-Nam Tax Accounting, Gangnam-gu Samsung Fire, Seocho-gu LG Uplus, Gangnam-gu D-Wai Development, Gangnam-gu K Health Industry, Gangdong-gu BF Mobile Related, Yeongdeungpo-gu Iljeonggol Seoul Po Kyo Station, Dong-gu Promotion Global, KT Seat Branch, Kangseo Company, Lotteria Workers Meeting, Hyundai Compound in Yeongdeungpo, IFC Mall Orchestra, Loan Asset Development Related, Gold Train, Gangnam-gu Office, Gwanak-gu Office, Gangnam-gu Office, Office, Richway, DaeNature Korea, Geumcheon-gu Pottery Company, Bucheon Daewoong Pharma, Samsung Fire, ESCOM Global, Samsung Mulsan Corporation, Workplace Related to Yongsan District, Workplace Related to Mapo-gu, Workplace Related to Gunjin-gu, Workplace Related to Yeongdeungpo-gu, Workplace Related to Seocho-gu, Workplace related in Gwanbuk-gu, Workplace in Gwanak-gu, Yongsan-gu workplace related, Clothing companies based in Yongsan District, Gyeonggi Bucheon-shi semiconductor company 2 related, company / Nowon-gu family related, company related, Mapo-gu home shopping company related, Yeongdeungpo-gu company related | Workplace |
| Congregation Related, Religious facilities Related, Religious facilities in Yangsang-gu, Religious facilities Related, Religious facilities in Gwanak District, related to indoor sports facilities in Gangbuk-gu, related to indoor sports facilities in Seongdong-gu, related to indoor sports facilities in Yangheun-gu, related to indoor sports facilities in Yangcheon-gu, related to indoor sports facilities in Zhonglang-gu, related to ice hockey classes in the metropolitan area, related to indoor sports facilities in Eunpyeong, Regarding acquaintances of the Geumcheon-gu workplace game, related to sports facilities, Related to sports facilities, Regarding Songga-gu Sports Facilities, Zhonglang-gu Indoor Sports Facilities II, Related, Dongdaemun-gu Sports Facilities Related, Nowon-gu Sports Facilities Related, Alumni Athletic Gatherings Related, Mnet Gymnasium Acquaintances, Seongdong-gu Sports Facilities Related, Zhonglang-gu Sports Facilities Related, Gangnam-gu Gymnasium-Related Sports, Metropolitan Graduate School of Fine Arts/Ice Hockey Related, Kwanak-gu Sammosfores K, Yongin-shi Alumni Golf Meeting, Gwanak-gu Fitness Related, Kwanak-gu Sammosfores, Seongdong-gu Deoksuge Baseball Department, Dobong-gu Athletic Facility, Sports Facilities in Zhonglang-gu, Yangcheon-gu Athletic Facility, Seongbuk-gu Gymnastics Entrance Examination Related, Related to indoor sports facilities in Mapo-gu, Indoor sports facilities, Indoor sports facilities, Indoor sports facilities in Zhonglang-gu | Congregation |
| Telemarketing-related, Call Center 4-related, Call Center Related, Gangnam-gu Call Center II. related, Call Center, Call Center II. related, Call Center I. related, Gangnam-gu Call Center Related, Mapo-gu Fubon Life Call Center | Call center |
| Other city Confirmed Contact, Other city, Other city Athletic Facility, Other city Historical Forum World Missionary Conference, Other city Youth Athletic Conference, Other city Confirmed Person Contact, Jeju Acquaintance Meeting, Jeju Guesthouse Related | Other city |
Table 1. (continued)

| Contact history keyword                                                                 | Reclassified names                                                                 |
|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Gangnam-gu Telecom Sales Business                                                        | Telecommunications sales Sales                                                   |
| Regarding business facilities, related to sales facilities, Zhonggu Unification Shopping District, Gangnam-gu sales office, Gangnam-gu coffee shop | Sales                                                                                |
| Relevant to Middle School in Guangjin District, High School Related, Elementary School Related, Kindergarten Related, Middle School Related, Middle School Related to Mapo District, Alternative School Related, Elementary School in Gangbuk-gu Related, High School in Gangbuk-gu Related, Alternative School in Hongcheon County, Gangwon Hongcheon County, High School Related to Yongsan District, High School Related to Gangjin District, Related to Zhonglang Family High School, Educational Facilities in Zhonglang District, Operation District Family Jeonju School Related, Regarding a middle school in Yongsan-gu, related to a primary school in Seongdong-gu, related to a college student in Seongdong-gu, related to a group of acquaintances of college students/a university, related to educational facilities, related to a university, related to a university in Gwanak-gu, related to a high school/private tutoring, related to an educational institution, related to a high school in Guro-gu, related to Dongdaemun-gu High School, Mapo-gu Seoul High School, University in Seodaemun-gu related |
| Regarding the school, related to the school in Yangcheon-gu, related to the school in Goyang-shi, Gyeonggi-goyang-shi, related to the school in Mapo-gu, related to the high school, related to the Mapo-gu beauty salon Seodaemun school, related to the school in Seongdong-gu, related to the personal and diplomatic workshop, related to the Yeongdeungpo-gu family school, related to the Geumcheon-gu/school, related to the school in Guangjin-gu, related to the Gangnam-gu cultural teaching center, related to the Gangnam-gu language school I, related to the Yeongdeungpo-gu school, related to the Gangnam-gu acting school, related to the Yongnam-gu Appointment Short-term notice, related to the language school in Gangnam-gu II, Young Lanbrandt Academy of Fine Arts | Academy                                                                            |

Overseas influx Overseas

Table 2. Confirmed Reason of COVID-19 and Numbers of COVID-19 Patients.

| COVID-19 confirmed reason       | Numbers |
|---------------------------------|---------|
| Other city                      | 4720    |
| Workplace                       | 4203    |
| Religion                        | 3762    |
| Nursing facilities              | 2728    |
| Market                          | 2472    |
| Hospital                        | 2256    |
| Sports facilities               | 2298    |
| Overseas                        | 1981    |
| Restaurant                      | 1408    |
| School                          | 1329    |
| Prison                          | 1176    |
| Sauna                           | 1085    |
| Nursing hospital                | 830     |
| Academy                         | 822     |
| Welfare facilities              | 536     |
| Kindergarten                    | 456     |
| Dance practice room             | 357     |
| Family                          | 338     |
| Goshiwon                        | 314     |
| Karaoke                         | 240     |
| Insurance                       | 227     |
| Downtown                        | 218     |
| Public institution              | 202     |
| Internet cafe                   | 191     |
| Call center                     | 187     |
| Construction                    | 165     |
| Music practice room             | 158     |
| Party                           | 139     |
| Residence                       | 136     |
| Performance                     | 128     |
| Congregation                    | 126     |
| Logistics                       | 119     |

(continued)

Table 2. (continued)

| COVID-19 confirmed reason       | Numbers |
|---------------------------------|---------|
| Dwelling                        | 80      |
| Senior facilities               | 86      |
| Large hospital                  | 74      |
| Factory                         | 73      |
| Academy of music                | 69      |
| Travel meetings                 | 61      |
| Building                        | 60      |
| Subway                          | 48      |
| Funeral                         | 39      |
| Dormitory                       | 33      |
| Seminary                        | 32      |
| Sales                           | 31      |
| Military bases                  | 37      |
| Cultural facilities             | 27      |
| Office                          | 24      |
| Securities companies            | 20      |
| Visiting care                   | 16      |
| Mart                            | 13      |
| Telecommunications sales        | 13      |
| Door-to-door sales              | 13      |
| Massage parlor                  | 12      |
| Financial company               | 11      |
| Lodging                         | 11      |
| Meat processing                 | 11      |
| Broadcaster                     | 10      |
| Nursing services                | 9       |
| Financial counseling            | 8       |
| Visiting teachers               | 7       |
| Bank                            | 6       |
| Mobile carriers                 | 5       |
| Transport business              | 4       |
| Real estate companies           | 2       |
| Entertainment                   | 1       |

(continued)
refined. Massive data were currently under being analyzed, as the route of infection was not known. Therefore, further analysis is necessary as the data accumulate in real time.

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