



# Online citizen petitions related to COVID-19 in South Korean cities: a big data analysis

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## Abstract

What do citizens demand of their governing bodies to cope with the spread of emerging infectious diseases after recognizing the growing danger? What are the similarities and differences in political participation via online citizen petitions regarding COVID-19 across cities with different degrees of pandemic experience? This study aims to answer these questions by examining citizen petitions regarding the COVID-19 pandemic in urban areas of South Korea. The pattern of citizens' requests is a part of integrative socio-ecological and political systems with spatial and temporal dimensions. We compare the pattern of online citizen petitions in four Korean cities, namely Seoul, Busan, Daegu, and Incheon, some of which were epicenters of the COVID-19 outbreak. By applying relevant big data analysis techniques such as text mining, topic modeling, and network analysis, we compare the characteristics of citizen petitions on COVID-19 in the four cities, particularly whether (and how) they want financial or welfare support or COVID-19 prevention. We find that cities that experience a rapid spread are likely to have more petitions for prevention than for support. By comparison, cities without such experience are likely to have more petitions for support. This study contributes by tracing citizen and local government interactions in response to emerging infectious diseases by empirically analyzing the related big data on petitions. Policy implications suggest that urban authorities should listen to analyze and respond to the urgent needs of citizens.

**JEL Classification** H75

## 1 Introduction

Densely populated urban areas are among the most vulnerable to emerging infectious diseases (EIDs). The spread of EIDs, including SARS, Ebola, and the current COVID-19 virus, and their health challenges are deeply associated with urbanization

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and the increasing movement of people within and across cities (Ahmed et al. 2019; Degeling et al. 2015). Urban settings with a massive influx of residents and their frequent interactions can quickly make cities incubators for new EID epidemics. Simultaneously, cities with economic, political, and technological power concentrations can plan and implement quick actions to address EIDs (Neiderud 2015).

Scholars and practitioners of public health, urban studies, political science, and public policy have a keen interest in examining the causes, processes, and consequences of the spread of COVID-19 in urban areas. Based on a keyword search using “coronavirus” and “city,” Sharifi and Khavarian-Garmsir (2020) found four major themes in 167 academic articles: (1) the impact of the COVID-19 pandemic on environmental quality (e.g., water and air pollution), (2) socio-economic impacts (e.g., inequality and the urban economy), (3) management and governance (e.g., the coordination of sectors and smart city initiatives), and (4) transportation and urban design (e.g., the transmission risks of transport modes and urban form). These are all subjects related to the urban landscape, especially that of citizens’ political participation. However, prior studies have not examined what or how citizens request governmental authorities to respond to the COVID-19 outbreak.

The aim of this study is twofold: to examine (1) what requests citizens make to local authorities to cope with the spread of infectious diseases and (2) how such citizen requests vary across cities that have different experiences regarding EID outbreak. To this end, we conceptualize the “citizen request landscape” as a part of integrative socio-ecological and political systems with several spatial and temporal dimensions. Citizen petitions—as a form of political participation—vary across urban settings and over time. The citizen request landscape is not conventional or physical. However, it has political and cultural qualities that people value and often induces other types of landscape changes. Citizens are one of the most critical components of the urban landscape. Thus, acknowledging and reflecting citizens’ needs should be a primary component in urban planning and EID policymaking. By analyzing the big data of online citizen petitions to local governments in South Korea’s four major cities (Seoul, Busan, Daegu, and Incheon), this study explains the landscape of people responding to EID outbreaks.

## 2 Literature review

### 2.1 EIDs and cities

Regarding the relationship between urban settings and EIDs, existing studies have examined the infrastructure landscape and EID outbreaks (Honey-Rosés et al. 2020; Spencer et al. 2020), globally interconnected cities and infectious disease transmission (Alirol et al. 2011), inequality in urban demography and infrastructure and EID pandemics (Wilkinson 2020), and EID management and governance (Sharifi and Khavarian-Garmsir 2020). However, little is known about citizens’ needs and their interactions with local authorities regarding EID outbreaks. Who requests that local authorities deal with EIDs? What are

the similarities and differences between local petitions with or without an EID pandemic? Answering citizens' requests regarding EID outbreaks, spread, and various policies can improve our understanding of EIDs and urban governance, thus providing timely policy suggestions for superior strategies and institutional design.

In the design of public health policies and responses, understanding people's needs and requests is fundamental for providing timely and effective strategies. Instead of implementing invasive approaches such as quarantine and lockdown using police and military forces, community-based initiatives, particularly in resource-constrained urban settings, are feasible and effective for responding to public health crises and for bolstering the public health infrastructure (Fallah et al. 2016). Community information on EIDs and the response of public health and local government authorities can help citizens protect themselves and prevent infectious disease epidemics (Neiderud 2015).

During the COVID-19 pandemic, most people were unable to contact one another or their local authorities in person. Therefore, contactless and online interactions became increasingly prominent. In the urban context, smart cities using data-driven responses to COVID-19 are spotlighted as solutions. Newly collected data alongside existing data such as traffic and pedestrian volume and flow can provide insights for tailored EID policy and urban governance (James et al. 2020). Furthermore, smart technologies, including active surveillance systems to identify the infected, have been used in countries such as China and South Korea. Other countries, mostly western democracies, prefer to protect privacy and not use personal information and data to detect the infected (Kummitta 2020). Despite the controversy over data and technology use, COVID-19 may function as a lubricant (Kunzmann 2020) or accelerator. The digitization of business, education, and public health management are the new normal for smart city development.

In addition to detecting confirmed and suspected cases, collecting and analyzing citizens' requests and needs should be the primary aims of smart and sustainable cities. Smart cities are not the agglomeration of fancy technologies. Information and communication technologies (ICTs) in smart cities enhance quality of life and sustainability (Lee 2017). Therefore, assessing the citizen request landscape should be the fundamental component of smart cities and their responses to EIDs. The citizen request landscape is a political and socio-economic system that varies over time and across space. It is not conventional (e.g., urban density and forms) or physical (e.g., housing, building, and infrastructure). Instead, it is political, responsive, and virtual (in cases of online requests).

Citizens' requests are political because they are related to the authoritative allocation of people's values. The citizen request landscape is responsive (in some cases, imitative) because it reflects internal needs and external events and shocks with temporal and spatial variations. It is also virtual, especially in the form of formal and informal online participation. Online participation is ubiquitous because it does not restrain participation time or space compared with formal election and voting. The citizen request landscape can change urban

planning and policy through governments' instant response or political decisions. The next section discusses online citizen petitions and EIDs.

## 2.2 EIDs and online citizen petitions

The COVID-19 pandemic is a natural and human-made disaster, even though many of these pathogens spread through humans. Like other disasters, EIDs occur in a political space. Although these pandemics (mostly beyond our control) may trigger a disaster, the level of national and local government preparedness and response largely determines the extent of the suffering incurred by the affected population (Cohen and Werker 2008; Davis and Seitz 1982; Platt 1999). EIDs constitute exogenous shocks to which governance systems must respond. Within days and weeks of any major impact (i.e., spread), this epidemiological disaster starts becoming political. The event's politicization then only increases, as the affected community, or often an entire society, moves from emergency response through the spread control, patient hospitalization, vaccine production, and economic recovery phases. Some scholars have begun to note the substantial impact of EIDs on the affected region's politics (Honey-Rosés et al. 2020; Kunzmann 2020).

In this context, the rapid rise of EIDs should have increased mass political participation by citizens to demand assistance for affected localities. The conventional definition of political participation encompasses those legal activities carried out by private citizens to directly influence the selection of state personnel and policymaking and implementation (Verba et al. 1978). In democracies, political participation involves selecting governmental leaders and influencing agenda setting, policymaking, and policy implementation through a legally protected election. In non-democracies, however, political participation is rather influencing policymaking and policy implementation through alternative institutions (Cai 2004; Huntington and Nelson 1976; Shi 1997; Verba et al. 1978).<sup>1</sup> Whether its political regime is democratic or authoritarian, affected citizens are more likely to contact, demand, and sometimes resist governing institutions. Petitioning belongs to the category of institutionalized non-electoral participation.

However, there has been little clear evidence to support this intuitive reasoning until now. It is hard to know whether affected citizens participate more in the political process to demand that governing bodies and political parties address EID-related damage. Aside from elections, there is no systematic test to demonstrate the correlation between the degree of EIDs and level and content of non-electoral political participation. In this context, our approach uses petition activism as citizen political participation (Paik 2012) to demand the ruling political entities or governments respond to minimize the catastrophic damage to human lives and redistribute public resources to recover their quality of life across society.

Petitioning is a type of political participation (Huntington and Nelson 1976; Juhgherr and Jürgens, 2010; Schlozman et al. 2010) that has existed since the birth of

<sup>1</sup> There are four categories of political participation using two criteria in political science—institutionalization and election and violence—which create four modes (Bennett and Bennett 1986; Bratton 1999).

complex political entities in human history. It includes people's political participatory activities such as sending letters, paying visits, and filing to designated government institutions to address their economic, social, and political needs along with a broad spectrum of policy suggestions.

Combined with rapidly advancing ICTs, a new breed of petition—the online petition—has emerged and spread globally (Gibson and Cantijoch 2013; Horstink 2017; Karpf 2016; Schlozman et al. 2010; Zúñiga et al. 2010). The online petition's growing presence is felt in most countries to the extent that most governmental websites at all levels are equipped with an online petition section<sup>2</sup> and private organizations such as change.org are essential to delivering the collected citizen demands to governing authorities.<sup>3</sup> As done by the Parliament of Australia, many countries have encouraged their citizens to use online petitioning systems instead of offline counterparts because of the impact of COVID-19.

We expect a positive correlation between EID spread and degree and content of citizens' political participation, which differs from the government's controlling governance and response to the pandemic without affected citizens' and societal entities' specific demands. Surprisingly, reliable evidence to support this correlation is lacking in the literature (Kim 2021). EIDs might not have caused substantial active political participation by affected citizens, or this causal relation might have received insufficient attention from relevant fields. However, we observe this phenomenon for COVID-19. It is new for citizens to more actively demand that national and local governments take action on the political issues caused by the unprecedentedly pervasive and enduring COVID-19 pandemic. However, it has not been addressed what citizens ask for to cope with the pandemic. Petition types, frequency, and patterns have not been explored.

This study expects that the petition contents and pattern could vary in response to pandemic experience. Particularly local citizen petitions between cities with and without COVID-19 pandemic experiences are likely to differ. Citizen petitions to local governments that have experienced the pandemic are likely to deal with the elimination of the root causes of COVID-19. In contrast, citizen petitions to local governments that have not experienced the pandemic are likely to deal with managing the local economy and preventing COVID-19. In addition, the location of the city could matter. Citizens in cities where have international access through airport might ask COVID-19 prevention. Airport connection along with population size is one of the drivers for initial global expansion of COVID-19. Coelho et al. (2020) found that the rate of daily increase of COVID-19 mostly was driven by importance in global air transport network, controlling socio-economic and climate factors. This implies that cities with more global airport connections are likely to face petition on pandemic prevention. On the other hand, cities without major importation of people are likely to have more support petitions (Nakamura and Managi 2020).

<sup>2</sup> See [https://www.aph.gov.au/petition\\_sign?id=EN1823](https://www.aph.gov.au/petition_sign?id=EN1823).

<sup>3</sup> Change.org experienced an unprecedented number of people participating in contactless online political activities (~ 57 million signatures just on virus-related petitions in March and April 2020).

### 3 Methods

#### 3.1 Data

We chose four South Korean cities, Seoul, Busan, Incheon, and Daegu, for comparative case studies. These are the four largest cities (in terms of population) in South Korea. Seoul and Daegu have experienced rapid and widespread COVID-19 outbreaks in different periods in contrast to Busan and Incheon. Seoul has a larger population and population density than the other cities. The population density of Daegu and Incheon is similar ( $2750 \text{ people/km}^2$ ). The gross regional domestic product of Busan and Incheon is similar. In terms of confirmed COVID-19 cases, Daegu has the highest number (7181 people) and cases per 100,000 (294). More detailed information of each city is reported in Table 1.

This paper tries to preliminarily analyze the urban political mechanisms that revolves around the COVID-19 pandemic with the ordinary citizens' online petition behaviors. In this context, the selected four cities are geographically well distributed and represent the South Korea's major urban environments with the following significant variations. In this context, this small-n framework largely covers one dimension of the South Korea's COVID-19 pandemic politics in the early stage, even though we do not try to generalize the pattern yet. To be sure, this is a preliminary study, which pave a way to the follow-up studies on more cities with more data in the large-n framework.

The Korean cities have had varying experiences of COVID-19 outbreaks. Daegu became an epicenter of the EID spread due to the group infection of the religious sect of Shincheonji in February and March 2020. The peak of confirmed cases in Daegu was soaring by 741 people per day on February 29, 2020. Figure 1 illustrates the number of confirmed cases per day in the major cities in South Korea.

To analyze citizens' requests regarding COVID-19, we collected 44,242 relevant online petitions from Seoul, Busan, Daegu, and Incheon from January 1, 2019, to September 23, 2020. The online petitions were from the "Sae-Ol electric petitions window" system, a part of South Korea's regional administration information system. We collected the petition data by developing a website crawler that could be applied to all Sae-Ol systems using the Python programming language. We have collected completed publicly open petitions as well as any remaining private, not replied to, and deleted petitions.

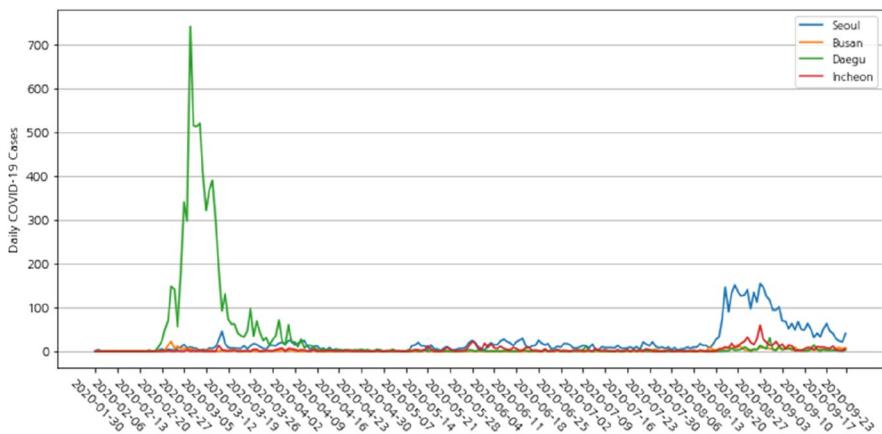
Petitions are text data written by citizens in Korean. To analyze such text data, we first preprocessed them. First, we corrected spacing issues using PyKoSpac-ing, a Python package for automatic Korean word spacing. We then extracted nouns and gerunds from the data using the MeCab Korean morphology dictionary. Because our research aimed to capture the responses of citizens to COVID-19, we added custom words to the dictionary, such as "우한폐렴 (Wuhan pneumonia)," "질병관리청 (Korea Disease Control and Prevention Agency)," and "신천지 (Shincheonji)". From all the nouns, stop-words and one-syllable nouns were removed. The last step was to remove too common and too rare words. Those

**Table 1** Population, population density, and confirmed COVID-19 cases

	Population (2020)	Population density (person/ km <sup>2</sup> , 2020)	GRDP* (billion KRW, 2018)	Confirmed COVID-19 cases (by October 2020)	Confirmed COVID-19 cases per 100,000 (by October 2020)
Seoul	9,589,159	16,425	423,742	6145	62.7
Busan	3,397,598	4484	89,980	594	17.3
Incheon	2,942,233	2748	88,735	1056	35.5
Daegu	2,242,171	2794	56,714	7181	294.6
South Korea	51,838,900	515	1,902,528	26,925	51.7

Source: Korean Statistics Office (2018, 2020)

\*GRDP Gross regional domestic product



**Fig. 1** Number of confirmed COVID-19 cases by city

words provide little information about each document and degrade model performance. The 40 most used words and 24,480 words used in the bottom 10 petitions were removed.

### 3.2 Analyses

#### 3.2.1 Topic modeling

We identified the topics of the petitions about COVID-19 using the latent Dirichlet allocation (LDA) topic modeling method by applying it to the petition data. Topic modeling is a text analysis technique that is used to find conceptual topics in a set of documents (i.e., petitions in this case). LDA, the most common method for topic modeling, was introduced by Blei et al. (2002). The LDA analysis was conducted using the LDAModel class in the “tomotopy” Python package. We chose 40 as the number of topics in the petition data because it had the lowest perplexity score. A lower perplexity score implies that the LDA model explains better the dataset. Because LDA returns a probability distribution of topics for each document (i.e., petition), we determined the topic with the highest probability as the document’s main topic.

#### 3.2.2 Network analysis

We conducted network analyses to examine which words were used together, especially with the word “COVID-19,” in the petitions related to COVID-19 in each city. Accordingly, we constructed a network composed of nouns and gerunds used in the petitions about COVID-19 for each city. During the preprocessing stage, stop-words that did not have a significant meaning in this study (e.g., pronouns) were also removed.

We constructed a separate network for each city using the nouns and gerunds, which resulted in four networks for the four cities examined in this study. A node of a network is a noun or gerund used in the petitions of the city. A tie between two nodes (i.e., two words) was defined to exist when the two words were used in the same petition. The number of petitions in which a pair of two words were used together was the weight of the tie between the two words. The number of nodes in the Seoul network was 3785, that of Busan was 3338, that of Daegu was 2024, and that of Incheon was 2796. Furthermore, the correlation coefficient between different networks was calculated using the QAP (quadratic assignment procedure) method.

## 4 Results and discussion

### 4.1 Topic modeling results

Through topic modeling, we identify 40 topics in the online petitions.<sup>4</sup> There are two COVID-19-related topics, one related to “prevention” and the other related to “support.” The keywords for the “prevention” topic consist of “confirmed case,” “mask,” “self-isolation,” “isolation,” “test,” “route,” and “public health center.” In South Korea, public health centers are at the forefront of testing and treating COVID-19 cases. On the other hand, the keywords for the “support” topic include “emergency disaster relief fund,” “application,” “welfare,” and “provision.”

A close look at the petitions data reveals that the petitions related to the “prevention” topic include petitions (1) asking about disclosing the travel routes of individuals who tested positive for COVID-19, (2) asking about mask mandate, (3) asking about enforcing social distancing policies, (4) demanding punishment of individuals who have violated self-isolation rules, (5) demanding closure of public places where a large number people gather, and (6) asking distribution of masks for individuals who meet certain conditions. Prevention petitions also include measures for pandemic prevention from foreign travelers. Conversely, the petitions related to the “support” topic were mainly about either the emergency disaster relief fund or the disaster basic income. Via such petitions, people tended to ask about (1) the requirements, (2) who can apply for such fund (or income), (3) how to apply, (4) when the fund (or income) will be provided, (5) where the fund (or income) can be used, and some petitions contained citizens’ complaints or dissatisfaction with respect to the unfair eligibility of such assistance.

Figure 2 presents the number of petitions of each topic in the four cities. COVID-19-related topics have varying features. In Seoul, prevention-related topic (topic ID 33) was ranked second, whereas support-related topic (topic ID 10) was ranked relatively low, which indicates that there were more petitions about “prevention” than about “support” in Seoul. In contrast, support-related topic was ranked second (more than 600 petitions) and the rank of prevention topic was relatively low (the number of petitions were fewer than 200) in

<sup>4</sup> The full list of keywords for each topic is reported in Appendix 1.

**Fig. 2** Frequency of the 40 topics in cities. Topic ID 10 is about “support,” and topic ID 33 is about “prevention”. \*The green bar indicates the “prevention” topic and yellow bar indicates the “support” topic (color figure online)

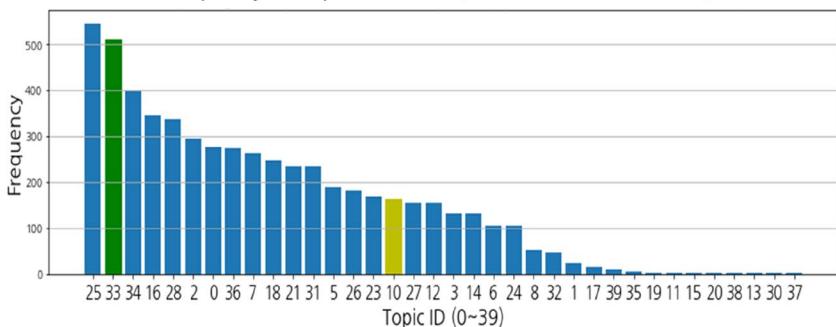
Busan. In Daegu, support-related petitions outnumbered prevention-related petitions. This result might reflect the speed of the COVID-19 outbreak and spread. Within two weeks, Daegu experienced the first rapid spread, and there might have been insufficient time to file a complaint on prevention. Instead, the national and Daegu city governments quickly announced a COVID-19 disaster relief fund to restore the region.

Figure 3 compares the percentages of “prevention” and “support” petitions on COVID-19 in each city. Seoul and Incheon show a similar pattern of more petitions on prevention (9 and 7%, respectively). Busan and Daegu present a higher proportion of support-related petitions than prevention-related ones. Busan, with a lower degree of COVID-19 spread, has a relatively high proportion of support-related petitions.

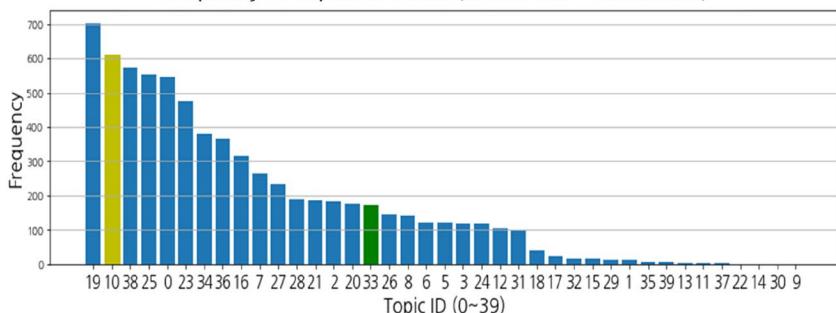
As we discussed in the theory part, this pattern may reflect the location of cities as international airport connection. Seoul and Incheon are international access hubs in Korea. The Gimpo international airport in Seoul and the Incheon international airport are major airports for international passengers to/from China and Japan; in Table 2, one of the most frequent words in network analysis for Incheon and Seoul is ‘visit.’ In the initial stage of the global pandemic, petitions for the prevention measure to control visit from foreign countries could increase. Prevention petitions asked ‘temporal quarantine facility construction for travelers from abroad’, and ‘strict management for self-isolated travelers from abroad’. While the relationship between international travel hub and petition type should be rigorously investigated, in the initial stage of foreign inflow pandemic, citizens in global air travel hubs could raise voices through prevention petitions.

Figure 4 presents the change in confirmed COVID-19 cases (blue) as well as the numbers of “support” petitions (yellow) and “prevention” petitions (green) from January to September in 2020. The citizen request landscape through online petitions shows both common and different features across the four cities. First, EID prevention petitions by citizens are likely to increase when confirmed cases rise in both their own cities’ jurisdiction and in other cities. The rapid increase and spread from Daegu in late February made citizens there as well as in Incheon and Seoul sign more online petitions on EID prevention (e.g., subjects such as face mask distribution and information disclosure on infected people’s movements). Citizens in cities without high COVID-19 cases also tend to raise concerns through online petitions. Second, petitions on support are likely to come after those on prevention. Owing to the negative economic impacts of COVID-19, petitions to demand “support,” such as the quick provision of emergency disaster relief funds, tend to increase. Aside from the national relief fund distribution, the amount and distribution speed vary at the local level depending on each local government’s disposable resources. As the quarantine authority mitigates the diffusion of COVID-19 in a city, its citizens’ petitions may change course to

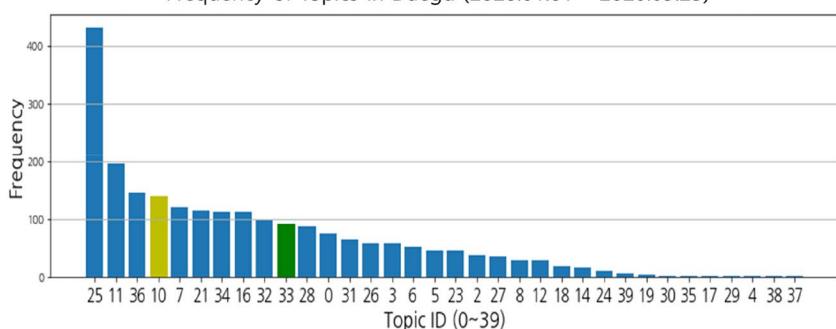
Frequency of Topics in Seoul (2020.01.01 – 2020.09.23)



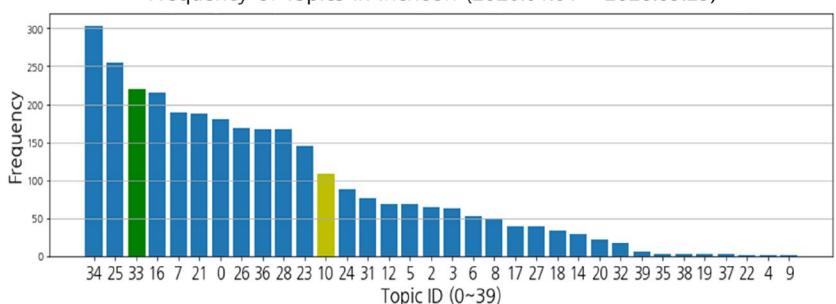
Frequency of Topics in Busan (2020.01.01 – 2020.09.23)

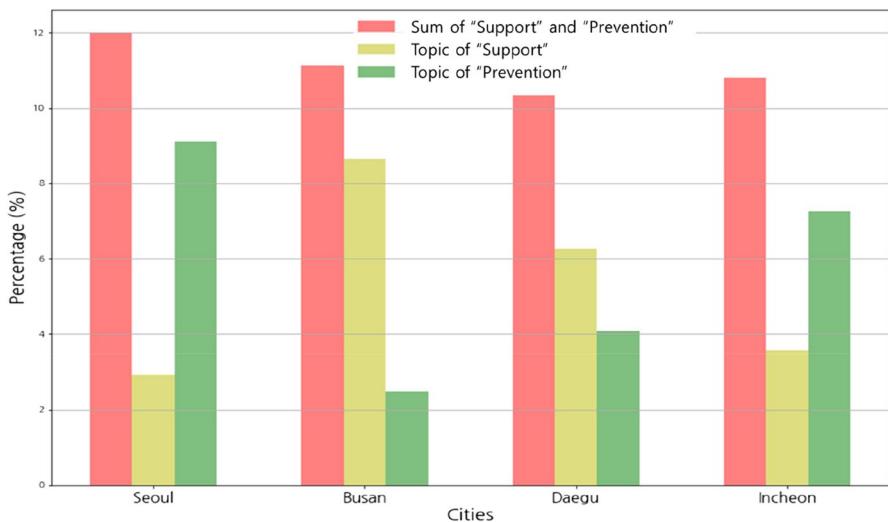


Frequency of Topics in Daegu (2020.01.01 – 2020.09.23)



Frequency of Topics in Incheon (2020.01.01 – 2020.09.23)





**Fig. 3** Comparison of topic percentages of petitions in each city

**Table 2** Top 20 words in the network of a city based on degree

City	Top twenty words and their degrees
Seoul	'Corona': 3061, 'confirmed case': 2054, 'need': 2024, 'inhabitants of a gu': 1957, 'mask': 1880, 'Seoul': 1798, 'outbreak': 1701, 'infection': 1692, 'visit': 1667, 'possibility': 1605, 'health center': 1592, 'content': 1575, 'reason': 1560, 'relevant': 1557, 'management': 1555, 'government': 1469, 'prevention': 1455, 'distance': 1454, 'living': 1412, 'center': 1410
Busan	'Corona': 2453, 'Busan': 2089, 'mask': 1999, 'inhabitants of a gu': 1821, 'support': 1710, 'pay': 1530, 'confirmed case': 1337, 'center': 1304, 'residence': 1300, 'need': 1295, 'disaster': 1278, 'application': 1276, 'Coronavirus relief fund': 1253, 'living': 1252, 'chief of a gu': 1214, 'support fund': 1200, 'understanding': 1199, 'welfare': 1182, 'period': 1172, 'reason': 1167
Daegu	'Corona': 1386, 'Daegu': 1369, 'mask': 1098, 'center': 891, 'support': 842, 'confirmed case': 838, 'residence': 742, 'civil servant': 714, 'health': 651, 'inhabitant of a gu': 648, 'part': 638, 'government': 631, 'institution': 628, 'employee': 610, 'welfare': 590, 'pay': 587, 'need': 582, 'family': 576, 'distribution': 573, 'phone': 572
Incheon	'Corona': 2050, 'Incheon': 1486, 'confirmed case': 1310, 'case': 1292, 'mask': 1259, 'enhancement': 1207, 'support': 1202, 'content': 1149, 'possibility': 1140, 'reason': 1106, 'prevention': 1104, 'living': 1093, 'phone': 1050, 'government': 1047, 'enforcement': 1035, 'spread': 1007, 'pay': 980, 'application': 973, 'visit': 964, 'outbreak': 953

financial and welfare support. Beyond the main argument, we find that each city presents other features. During late February and March, Daegu experienced a hike in confirmed cases as well as an increase in both “support” and “prevention” petitions. Both fell dramatically after April. Busan presented a large number of “support” petitions from March to April compared with the relatively low number of “prevention” petitions, even in the peak of confirmed cases in August.

Incheon, with no serious epidemic, interestingly, shows a large number of “prevention” requests. Prevention-related petitions rose with the peak of confirmed cases related to the large demonstration in August. Seoul shows a similar pattern of confirmed cases and support/prevention petitions to Incheon.

## 4.2 Network analysis results

### 4.2.1 Top 20 words in each network based on degree

A node’s degree in a network refers to the number of other nodes adjacent to that node. From the word network of each city, we first extracted the 20 nodes (i.e., words) with the largest degrees. Table 2 reports the results.

“COVID-19” has the largest degree in each city’s network. In the network of Seoul, “confirmed case”, has the second-largest degree. For Busan, the name of the city has the second-largest degree in the network, followed by “face mask.” In Daegu, similar to Busan, the name of the city has the second-largest degree and “face mask” has the third-largest degree. In the network of Incheon, the name of the city has the second-largest degree, followed by “confirmed person.”

The results in Table 2 also show similar patterns to those found in the topic modeling analysis. In Busan and Daegu, with more petitions about “support,” “support”-related words such as “support” itself and “pay” were more frequently used with other words in petitions. In contrast, in Seoul and Incheon, words related to prevention tended to have a greater degree, including “prevention” itself, “health center,” “distance,” and “enforcement.”

### 4.2.2 QAP (quadratic assignment procedure) analysis

To compare the correlations among the word networks of each city, we performed a QAP analysis. A QAP analysis can be used to calculate the correlation coefficient between two networks and also provides the statistical significance of the coefficient. We constructed a separate network for each city using a set of the same words related to COVID-19, including “COVID-19,” “confirmed case,” “infection,” “route,” “test,” “screening station,” “text message,” “outbreak,” “isolation,” “mask,” “pay,” “support”, “support fund,” “application,” “disaster,” and “distribution.” Table 3 reports the results of the QAP analysis.

The results in Table 3 indicate that the network of Seoul is more highly correlated with the network of Incheon ( $r=0.54$ ) and statistically significant at the 0.5 level, whereas the network of Busan is more highly correlated with that of Daegu ( $r=0.42$ ,  $p<0.001$ ). This indicates that the usage patterns of the selected words are more similar in Seoul and Incheon as well as in Busan and Daegu. The results are in the similar line of the topic modeling results. According to the topic modeling results, in Seoul and Incheon, there were more petitions about prevention than about

**Fig. 4** COVID-19 topic complaints and daily cases of COVID-19 infections ▶

support, whereas Busan and Daegu had more support-related petitions than prevention-related ones.

## 5 Conclusions

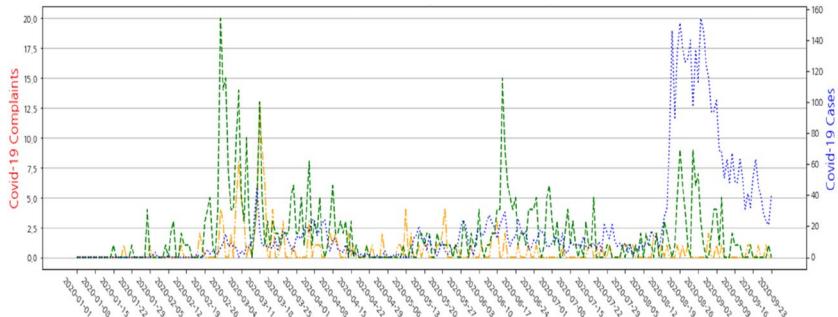
This study answered the following two questions. First, what do citizens demand of their governing bodies to cope with the spread of EIDs after they recognize the growing danger? Second, what are the similarities and differences in citizens' political participation to demand—via petitions—COVID-19-related actions in cities with different degrees of pandemic experience? In particular, we examined how the COVID-19 pandemic was managed in urban areas of South Korea by conceptualizing the citizen request landscape as a part of integrative socio-ecological and political systems that possess several spatial and temporal dimensions. Although the citizen request landscape is neither conventional nor physical from the mainstream perspective, it has political and economic features that change the conventional landscape dimensions in urban studies.

We compared the landscape of online citizen petitions in four Korean cities namely, Seoul, Busan, Daegu, and Incheon, some of which were epicenters of the COVID-19 outbreak. Accordingly, we collected publicly available data on citizen petitions from these four cities. By applying relevant big data analysis techniques such as topic modeling and network analysis, we compared the characteristics of citizen petitions on COVID-19 in the four cities, particularly whether (and how) they want financial or welfare “support” or COVID-19 “prevention.” Cities in the capital area, Seoul and Incheon, are likely to have more petitions for prevention than for support. In contrast, cities located in local areas, Busan and Daegu, are likely to have relatively more petitions for support. We found some mixed results as well. We expected citizens with pandemic experience to be likely to request EID prevention. In contrast, those citizens without pandemic experience were expected to request support. However, Daegu, an epicenter of the EID outbreak and spread, asked for support, whereas Incheon, where there was no serious EID spread, demanded prevention more than support. The explanations of these findings should be answered in future research.

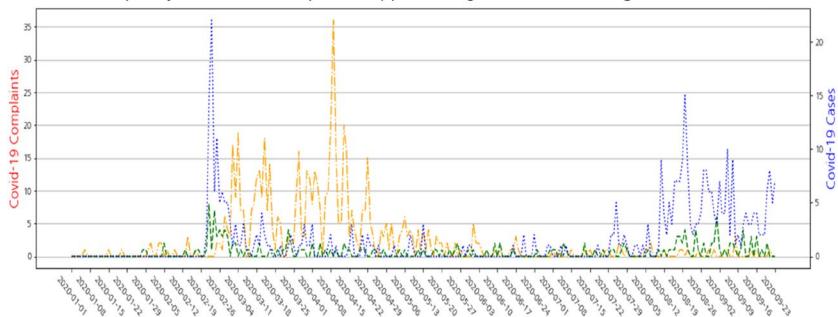
Thanks to the development of ICTs, it has become easier to collect and analyze data on citizens' needs. Text mining and analytic advancement also promote the examination of the citizen request landscape. To address people's needs, particularly during urgent situations, it is imperative to develop the theory, methods, and empirical analysis of the citizen request landscape.

This study contributes to the literature in three ways. First, we contribute to the theory of citizen and local government interaction in response to EIDs by conceptualizing the citizen request landscape. Second, we empirically use statistical data analysis tools for text data, including topic modeling and network analysis, with text mining to analyze the big data of more than 44,000 citizen

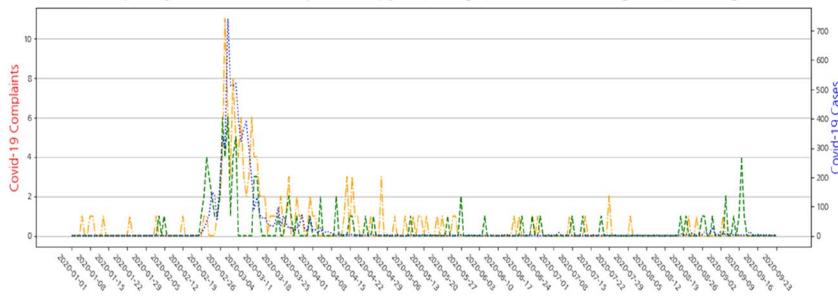
Frequency of COVID-19 Topics – Support(orange) and Prevention(green) in Seoul



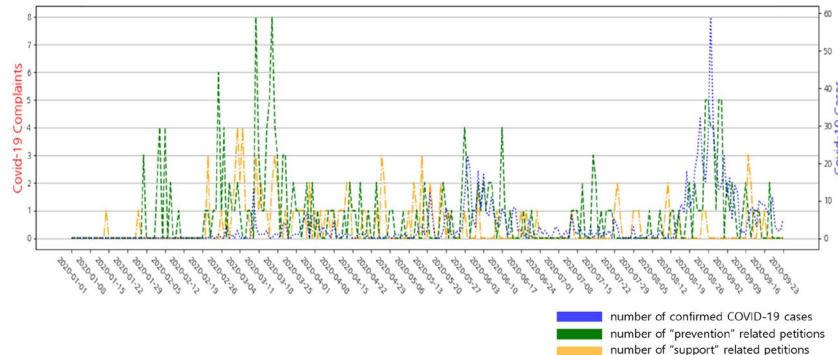
Frequency of COVID-19 Topics – Support(orange) and Prevention(green) in Busan



Frequency of COVID-19 Topics – Support(orange) and Prevention(green) in Daegu



Frequency of COVID-19 Topics – Support(orange) and Prevention(green) in Incheon



**Table 3** Quadratic assignment procedure of petition networks by each city

	Seoul network	Busan network	Daegu network	Incheon network
Seoul network	—			
Busan network	0.12 (0.248)	—		
Daegu network	0.19 (0.094)	0.42 (<0.001)	—	
Incheon network	0.54 (<0.001)	0.22 (0.059)	0.22 (0.044)	—

The values within parentheses are *p* values

petitions. Third, based upon our conceptualization and empirical data analysis, we discover a simple but critical policy implication for urban governance—that local authorities should respond to damaging EIDs swiftly with direct input from affected citizens, such as via online petitions and their prepared protocols. However, Seoul presents an interesting outlier for this proposition, likely due to the city's size and density. Cities with a higher density and larger population may request prevention instead of support, reducing the economic and social costs for tackling the EID spread. National strategies for combating EIDs should be coherent, yet local strategies should be able to respond to local disparities and a variety of requests. When local citizens request “support” (for masks, vaccines, or financial help), local and national authorities should provide specific support. If citizens ask for “prevention” through testing and route information disclosure, authorities should reflect citizens’ concerns as well as provide scientific prevention measures, particularly in the foreign travel hubs.

We acknowledge the limitations of this study. First, while it provides preliminary descriptive data on a type of variation—prevention or support in the COVID-19 situation—in the four cities’ citizen petitions to local governments, it does not find the primary causes of that variation from the perspective of conventional landscape studies. Although the different characteristics of the four cities reveal some speculative ideas, such as air travel hub, to create that variation, it is too early to tell and demands additional in-depth interdisciplinary research. Second, the data are limited to the four cities in South Korea, which means that generalization is not possible. Third, the most important deficiency is local governments’ responses to this line of citizens’ political participation via online petitions. Future research should identify whether they revised their pandemic response mechanisms and applied ensuing policies.

Accordingly, the following three types of variations should be incorporated in this line of study. First, variations in the urban landscape variables (size, density, transportation system, sanitation, school/church/civic structure, terrain, river/creek/sea, residential area type/composition, airport location, etc.) would be critical to analyze because they specify more concrete dynamics of online (and offline) petition politics. Second, variations in the degree of COVID-19 pandemic spread (or number of confirmed cases) by the specific urban landscape variables should be considered because the severity of pandemic creates more variations among urban citizens. Lastly, variations in local city governments’

responses to online citizen petitions are the other side of coin to complete the two-way interactions between citizens and local governments.

## Appendix 1. 40 Topics and keywords from LDA topic modeling

Topic ID	Keywords
0	Occurrence, photo, damage, safety, spot, paving, breakage, repair, condition, part
1	Gwangmyeong, Hangdong, Gangseo-gu, Gukje, stadium, Seoul, Samjung, Goduck, Gangseo, move-in
2	Application, phone, usage, guide, card, text message, possibility, content), registration, issuance
3	Traffic sign, crosswalk, left-turn, traffic light, intersection, traffic lane, direction, straight, pedestrian
4	Establishment, support, rural area, Siheung-si, office work, autonomy, organization, school year, integration, founding
5	Exercise, physical education, operation, center, usage, culture, space, member, closure, program
6	Parking lot, space, public, basement, spot, usage, fee, shopping mall, electricity
7	Phone, civil servant, staff, person in charge, words, responsibility, oneself, contact, work, conversation
8	Child, nursery, elementary, safety, student, kindergarten, commuting to school, protection zone, playground, school parent
9	Town, Kajwa, Il-san, metro line, Goyang-si, extension, Goyang, Deogi-dong, Paju, self-sufficiency
10	Support, mask, provision, welfare, application, center, subsidy, disability, Cronavirus relief fund, Corona
11	Buk-gu, Daegu, citizens, mayor, head, student, pain, ability, bank book, permission
12	Content, manufacture, agenda, disclosure, information, relevant, rule, representative, meeting, result
13	Uiwang-si, middle school, resident, integration, school district, survival, district, special, Baegun, household
14	Member of an association, association, contract, house, head of an association, 계약서 contract document, sample, Corona, general meeting, lotting-out
15	Begin construction, bridge, Walgot, going on foot, meeting, business, design, need, assembly, market
16	Tree, stroll, cat, animal, toilet, around, companion, removal, puppet, space
17	District, development, business, alternative, association, reorganization, Nunggok, enforcement, Goyang-si, event
18	Smoking, cigarette, area, nonsmoking, booth, building, Seocho-gu, street, Cheongbuk, Seocho
19	Chief of a gu, Dongnae, approval, emergency, Nangmin-dong, safety, Daesim, citizens, cancellation, Dongnae-gu
20	Songdo, Yurim, beach, Hillstate, approval, land, accident, hydrogen, household, tourist
21	Parking, penalty, report, banner, violation, motorbike, district, impose, prohibition, photo
22	Establishment, compositeness, office of education, Siheung-si, support, department, housing site, budget, pledge, service

Topic ID	Keywords
23	Smell, prevention, stink, Songdo, Seo-gu, Hillstate, mosquito, curtain, bug, color
24	Station, route, traffic, town bus, allocation of cars, driver, traffic, stop, interval, center
25	Site, building, window, damage, morning, dust, dawn, occurrence, construction site, start
26	Business, development, pushing ahead, opinion, environment, review, development, improvement, reason, budget
27	Sales, market, store, selling, merchant, street vendor, shopping mall, operation, sale, chairman
28	Collection, dump, without permission, cleaning, food, bag, discharge, application, waste, leaving alone
29	Culture, Siheung-si, Soosung, center, art, public hearing, pro, work of art, Hyosung, art
30	Factory, constructor, painting, ceremony, approval, move in, change, Prugio, application, renew
31	House, construction, lotting-out, permission, land, change, usage, approval, completion, building
32	Library, move in, household, Pyeongtaek, land, part, lotting-out, central, build, Pyeongtaek-si
33	Corona, confirmed case, mask, public health center, test, route, disclosure, isolation, wearing, prevention, self
34	Sidewalk, bicycle, sidewalk, streetlamp, block, photo, passage, maintenance, pedestrian, location
35	Prugio, Siheung station, painting, inducement, city, change, lotting-out, event, Goyang-si, move in
36	Lane, accident, entrance, section, parking, passage, traffic, direction, prevention, middle
37	Foundation, middle school, integration, Hakgu, Siheung-si, objection, education, land, commuting to school, Nongok
38	Busan, Jangan, election, keep, education, superintendent of education, Kijang, principal, governor, admission officer
39	Pyeongtaek, Anseong, incineration plant, Pyeongtaek-si, mayor, environment, approval, hospital, opposition, incineration

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