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The Choice of Urban Spaces in the COVID-19 Era

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Abstract: The spread of infectious diseases is a spatial process, including Coronavirus disease 2019 (COVID-19). Cluster infections of COVID-19 have arisen globally in various urban spaces, implying that tracking the spread necessitates a spatial approach to understanding the dynamics of the disease. In this study, we employ an online survey in the Seoul metropolitan area in South Korea to examine changes in the use of urban spaces and factors that affect individual's choice in using urban spaces in the COVID-19 era. We classify various urban spaces into three activity types according to the previous studies: spaces for mandatory activities, maintenance activities, and discretionary activities. The results show that every type of urban space is visited less than before the COVID-19 outbreak. Factors involved in the use of spaces for mandatory activities include the preference for offline consumption, gender, and risk perception of COVID-19. In the case of non-mandatory activity spaces, factors that commonly influence the use of the spaces are compliance with social distancing regulations, preference for offline consumption, refraining from outdoor activities, risk perception of COVID-19, and perceived safety in the city concerning COVID-19. The present study is significant as it identified not only different factors affecting the choice of mandatory and non-mandatory activity spaces but also distinctive variables determining the choice of urban spaces for maintenance activity and discretionary activity. From the analysis, this study draws policy implications to effectively prevent and control infectious disease in the context of urban spaces.

1. INTRODUCTION

The spread of infectious diseases such as Coronavirus disease 2019 (COVID-19) is a spatial process (Cordes & Castro, 2020). Two diseases posing a risk to human life in the twenty-first century, severe acute respiratory syndrome and Middle East respiratory syndrome coronavirus, have also spread locally and spatially (Kuebart & Stabler, 2020; Qian et al., 2009), presenting different challenges depending on the region (Gardner, Chughtai, & MacIntyre, 2016; Meng et al., 2005). The incidence rates, confirmation rates, and death tolls showed heterogeneous distribution by region (Al-Ahmadi, Alahmadi, & Al-Zahrani, 2019; JHU CSSE, 2020). The distribution and spread of these infectious diseases are predominately caused by people moving across regions and borders via various means of transportation (Arthur et al., 2017; Charu et al., 2017).

More than half of the world's population are living in cities, and they function as a central place of economic growth and innovation. They are also believed to be vulnerable to natural and human-made disasters due to a high population density and a concentration of various activities (Sharifi & Khavarian-Garmsir, 2020). In the context of COVID-19, this vulnerability has been shown to be accurate, with approximately 90% of the world's confirmed cases of COVID-19 concentrated in urban areas (UN, 2020).

A city with a large population is a place where numerous social, political, and economic exchanges and movements take place, leading, in turn, to frequent contact between people. An increased amount of shared airspace between people in a densely populated area can heighten the possibility of getting exposed to infectious diseases or viruses (Alirol et al., 2011). Previous studies have shown that high population density and urbanization increase the likelihood of contact between people, resulting in the proliferation of infectious diseases in cities (Hamidi, Sabouri, & Ewing, 2020; Mu, Yeh, & Zhang, 2020).

Cluster infections of COVID-19 have occurred in various urban spaces, including workplaces, restaurants, bars, religious facilities, health-care facilities, shopping centers, and sports clubs (ECDC, 2020; Kim, 2020; Liu et al., 2020; Salama, 2020). Accordingly, many countries worldwide have temporarily suspended or restricted the operation of multi-use facilities and community facilities in urban areas and imposed strict social distancing measures (Hsiang et al., 2020; IMF, 2020; KDCA, 2020a; MHCLG, 2020).

Thus, it is needed to take a spatial approach to grasp the dynamics of COVID-19 (Poom et al., 2020; Smith & Mennis, 2020). Previous studies have already examined the spread of the virus in urban spaces (Cai et al., 2020; Chang et al., 2021; Jang, Han, & Rhee, 2020; Kim, 2020; Liu et al., 2020; Salama, 2020; Wei et al., 2020, 2021); however, studies that have sought to cover multiple urban spaces in a city and identify factors influencing the level of the visit to different urban spaces during the COVID-19 crisis have so far been insufficient. Thus, this paper explores changes in the use of urban spaces and investigates factors that affect the use of these spaces in the COVID-19 era. The result of the study would be applicable to cities or regions where COVID-19 mitigates and repeatedly spreads the same as the Seoul metropolitan area, which is the study area in this study. From this analysis, this study draws policy implications for preventing and controlling infectious diseases in urban areas in the context of urban spaces.

This paper presents a theoretical background of epidemics and the choice of urban spaces and categorizes urban spaces by activity type according to distinctions made in previous studies. Subsequently, the paper presents descriptive statistics on the changes in urban space visits, collected from a primary source. Employing factor analysis and ordered logit models as a methodology, this study identifies the factors that influence urban space visits by the type of space.

2. THEORETICAL BACKGROUND

In this section, existing studies are reviewed to examine the influence of infectious diseases on the use of urban spaces. The section first discusses changes in urban space visits since COVID-19 and identifies the urban spaces that are expected to have notable differences in visits. Second, urban spaces and their characteristics which make them vulnerable to the spread of

infectious diseases, are investigated to distinguish urban spaces with high transmission potential. Third, the section examines the relationship between risk perception of infectious disease and personal preventive actions in the urban environment to shed light on the reasons for behavioral changes in the context of the use of urban spaces. Fourth, the link between the perceived safety in the city and the use of urban spaces was examined as neighborhood safety perceptions were known to be involved with people's physical activity. Finally, studies that classify urban spaces according to the type of activity are presented to analyze factors and variables influencing the use of urban spaces by type.

Figure 1 describes a conceptual framework of the literature review.

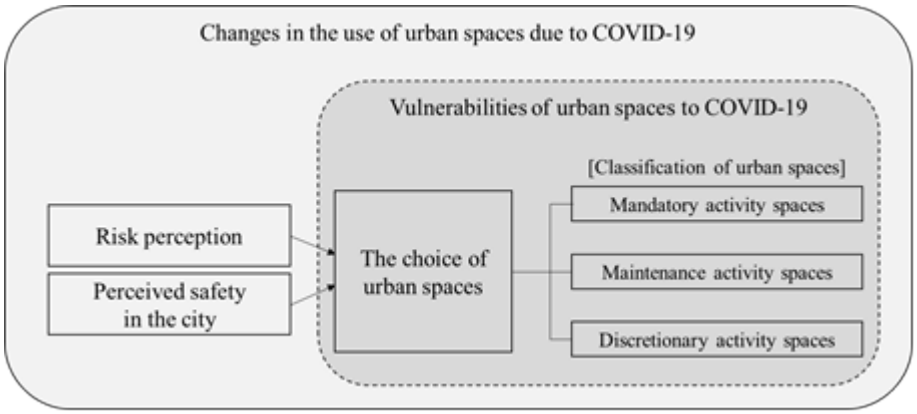

Figure 1. The conceptual framework of the literature review

2.1 Changes in the Use of Urban Spaces due to COVID-19

Few studies exist that document changes in how often individuals have visited multiple urban spaces and facilities during the COVID-19 pandemic. Nonetheless, it is possible to indirectly trace these changes using household or personal consumption and expenditure data. Examining this data suggests that individuals have changed the number of goods and services that they previously consumed before the pandemic (Baker et al., 2020). Alexander and Karger (2020) identified a sharp drop in transportation spending in the United States, while spending on food delivery services increased. Another study analyzed daily transaction data in China, finding that spending in restaurants, nightlife activities, and travel and tourism has decreased considerably since the beginning of the pandemic, with a striking impact on overall spending levels (Chen, Qian, & Wen, 2021).

To sum up, the studies above indicate that many people have refrained from activities such as traveling and using public transportation to restrain the COVID-19 spread. As a result, they have begun to more frequently use food delivery services rather than eating out. These changes in consumer behavior mean that it is logical to assume that there have been concurrent changes in the use of urban spaces associated with activities regarding travel, public transportation, nightlife, and food and drink services.

2.2 Vulnerabilities of Urban Spaces to COVID-19

The transmission of COVID-19 can occur not only via person-to-person contact but also through airborne transmission (CDC, 2020). Several studies

have observed that the transmission risk of infectious diseases is heightened in crowded and poorly ventilated indoor spaces (Distasio & Trump, 1990; Li et al., 2005; Morawska et al., 2020). A study conducted by Sun and Zhai (2020) identified enclosed spaces such as public transportation, large and open-plan offices, shops, and restaurants as places with a high risk of infection. Sadique et al. (2007) surveyed five European countries, as well as Guangdong in China, Hong Kong, and Singapore, to explore people's precautionary actions for a hypothetical influenza pandemic. Respondents reported beliefs that, in order, public transportation, hospitals, shops, workplaces, and schools were the riskiest places, selecting home as the least dangerous place.

2.3 Effect of Risk Perception of Infectious Disease on Personal Preventive Actions

Risk perception of infectious disease is believed to be linked with preventive health behaviors such as washing hands, wearing face masks, and avoiding crowded places (Katz et al., 2012; Leppin & Aro, 2009; Wang, Wei, & Shi, 2018; Zhang et al., 2020). Surveying 819 university students in the Mid-Atlantic region of the United States, Katz et al. (2012) found that the higher the perceived risk of H1N1 (novel swine-origin influenza A), the more preventive health behavior there was among students. Wang et al. (2018) tested this hypothesis using a health model and protective action decision model during the H7N9 (avian influenza A) outbreak. The authors indicated that risk perception affects individuals' willingness to follow government-recommended protective actions.

Furthermore, Leppin and Aro (2009) argued that perceived risk is associated with protective behaviors in the context of infectious respiratory diseases such as COVID-19. The choice of urban spaces during the COVID-19 era could, therefore, be related to perceived levels of risk since risk perception influences an individual's behaviors (e.g., washing hands, wearing face masks, and avoiding crowded places and public gatherings) (Leppin & Aro, 2009; Yıldırım, Geçer, & Akgül, 2021).

From this, it can be presumed that those kinds of behavioral changes caused by risk perception affect the visits to urban spaces. It is necessary to investigate the link between risk perception and behavioral changes in that not only does risk perception influence visiting behavior, but also behavior patterns can affect the spread of infectious diseases (Abdelrahman, 2020). As a factor affecting urban space visits, the perceived risk of infectious disease differs depending on the characteristics of urban space (Sadique et al., 2007). Thus, exploring the association between perceived risk and visiting behavior would be of great value in terms of empirically analyzing how strong and significant risk perception affects the use of urban spaces by their type.

2.4 Perceived Neighborhood Safety

Although not many studies have yet addressed the link between the perceived safety in the city and the use of urban spaces of citizens, the perceived safety in a city or neighborhood can be considered to affect the physical behavior of people. By analyzing cross-sectional survey data, Lenhart et al. (2017) revealed that adolescents having lower neighborhood safety perceptions were less likely to do physical activity. Crime and

COVID-19 may share a similarity in that they are external threats that individuals cannot control. Safety perception in crime studies indicates that perceived safety in the neighborhood towards crime is associated with physical activities yet having an inconsistent result depending on the characteristics of respondents (Evenson et al., 2012).

As such, if citizens feel that the environment in the city or region they live in is safe from external threats, it can cause behavioral changes in their urban space visiting.

2.5 Mandatory and Non-Mandatory Activity Spaces

This study focuses on various urban spaces and identifies the factors affecting the level of visits to these spaces. The study classifies urban spaces depending on the activity type. According to Anggraini (2009); Anggraini, Sugiarto, and Pramanda (2017); Vovsha, Petersen, and Donnelly (2004), activities can be grouped into three categories: mandatory activity, maintenance activity, and discretionary activity. Going to work or school is included in mandatory activities. Maintenance activities refer to pursuits such as shopping, banking, seeing a doctor, raising children, eating, and hygiene maintenance. Lastly, discretionary activities refer to leisure and entertainment activities, social activities, sports, dining out, taking up hobbies, and volunteering (Chen & Mokhtarian, 2006). As proposed in prior studies, maintenance activities and discretionary activities are treated as non-mandatory activities (Anggraini, 2009; Bradley & Vovsha, 2005; Yagi & Mohammadian, 2010).

3. ANALYSIS

In the previous section, this paper investigated the relationship between COVID-19 and the individual's use of urban spaces. Since the pandemic, there has been a significant decline in consumption within the retail and hospitality sectors (Alexander & Karger, 2020; Baker et al., 2020; Chen et al., 2021). Part of the reason for this is that these activities are conducted in spaces where there exists a high probability of infection and perception of transmission risk (e.g., shops, restaurants, hospitals, workplaces, schools, and public transportation) (Sadique et al., 2007; Sun & Zhai, 2020). Moreover, the previous section established that the risk perception of diseases affects individual preventive health behaviors, including not visiting crowded spaces (Katz et al., 2012; Leppin and Aro, 2009; Wang et al., 2018; Zhang et al., 2020), and reviewed the link between safety perception and behavioral changes (Lenhart et al., 2017). Finally, according to the prior studies, the study classified urban spaces into three different types.

Building on this foundation, then, this study will now test the following hypotheses:

- Hypothesis 1: Changes in visits to urban spaces differ according to the type of space (urban spaces for mandatory, maintenance, and discretionary activity).
- Hypothesis 2: Factors that affect the visits to urban spaces vary depending on the type of space (urban spaces for mandatory, maintenance, and discretionary activity).

The urban spaces and facilities included in this study are classified based on the proposed activity type. Work facilities (e.g., workplaces and schools)

are spaces where mandatory activities are performed. Medical facilities (e.g., hospitals and pharmacies), shopping centers (e.g., shopping complexes, department stores, and markets), financial facilities, public bathhouses, saunas, and dry saunas, and public service facilities (e.g., public offices, public health centers, and public libraries), are classified as spaces where maintenance activities are carried out. In contrast, eateries (restaurants and cafés), nightlife facilities (e.g., pubs, clubs, amusement arcades, and karaoke rooms), cultural facilities (e.g., art museums, concert halls, and movie theaters), indoor sports facilities (e.g., gyms, swimming pools, and bowling alleys), outdoor sports facilities (e.g., football pitches and tennis courts), religious facilities, open spaces (e.g., parks and playing fields), and natural environments (e.g., mountains, seas, and rivers) are categorized as spaces where discretionary activities are performed.

3.1 Study Area and Method

The surveyed area of the study is the Seoul metropolitan area in South Korea, which includes Seoul, Gyeonggi Province, and Incheon. With a rush in the number of confirmed cases starting in August 2020, COVID-19 began to proliferate in the area. The daily average number of new cases in the Seoul metropolitan area increased eight times from 30.4 (August 2–August 15) to 239.1 (August 16–August 29) (KDCA, 2020b). However, the trend of spread showed an overall decline throughout September 2020 (MCST, 2020). The unit of analysis of this study were individuals over the age of 19 living in the Seoul metropolitan area. A survey was outsourced to a professional survey company in South Korea and proceeded on a first-come, first-served basis. The primary data utilized were derived from structured questionnaires collected between September 23, 2020, and October 7, 2020, through an online survey. Quota random sampling according to age and gender was employed, with a total of 537 respondents. Among all respondents, women accounted for 50.7%, and men accounted for 49.3%. People in their 20s constituted 20.3% of all respondents; 34.3% were in their 30s, 34.6% were in their 40s, and 10.8% were in their 50s and above.

The questionnaire consists of five main sections to identify the impact of COVID-19 on urban resident's perception and behavior changes. The five sections include knowledge about COVID-19, health, changes in the perception and the use of built-environments/urban spaces, economic activity and consumption, and demographic characteristics. For the analysis, this study utilized perception- and behavior-related questions that could affect the choice of urban spaces from all sections, except for the health section.

Then, exploratory factor analysis and ordered logit model were performed. Factor analysis is commonly used in survey research (Rummel, 1988) and leads to survey questions that have a potential relationship combined into a lower number of factors (Fricker Jr., Kulzy, & Appleget, 2012). A factor score result is generated through factor analysis, which can be used as a new variable to analyze the research topic of interest (DiStefano, Zhu, & Mîndrilã, 2009). Following that, an ordered logit model was performed using the factor score, the risk perception of COVID-19, the perceived safety in the city, and demographic variables since the dependent variable, which is the level of visits to each urban space, is ordinal.

4. RESULTS

4.1 Descriptive Statistics

Figure 2 summarizes responses to the question, "How often do you currently visit the urban spaces below compared to before the COVID-19 outbreak?" using an 11-point Likert-type rating scale (where -5 = a significant decrease in the level of visits; 0 = same as before the COVID-19 outbreak; +5 = a significant increase in the level of visits). The questions are later used as a response variable in the ordered logit model.

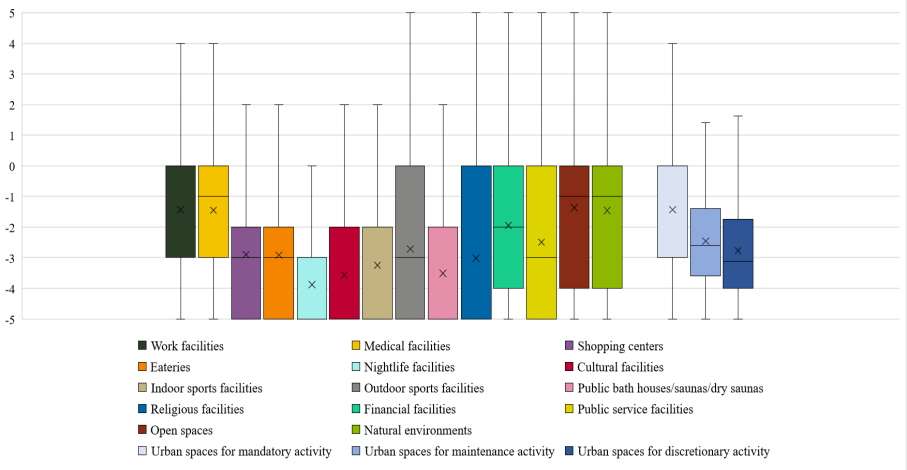

Figure 2. Changes in urban space visits compared to before the COVID-19 outbreak

In *Figure 2, 0* on the Y-axis indicates that the level of visits is the same as before the COVID-19 outbreak.

Figure 2 demonstrates the change in the use of urban spaces that was indirectly explained by consumption and expenditure data in prior studies (Alexander & Karger, 2020; Baker et al., 2020; Chen et al., 2021). While the number of urban space visits decreased for all types of activity spaces during the COVID-19 crisis, work facilities, as spaces for mandatory activity, medical facilities, as spaces for maintenance activity, and open spaces and natural environments appear to show a relatively small decrease in visits. In contrast, the level of visits to the spaces that are expected to have 3C settings (closed spaces, crowded places, and close-contact settings) (PAHO, 2020), such as shopping centers, eateries, nightlife facilities, cultural facilities, indoor sports facilities, public bathhouses, saunas, and dry saunas, dropped significantly. Among the three types of urban spaces, the level of visits decreased the most in the spaces for discretionary activity.

Table 1 presents descriptive statistics of behavior-related questions from the changes in the perception and the use of the built-environments/urban spaces section and the economic activity and consumption section. The following items were loaded in the factor analysis.

Table 1. Descriptive statistics of survey items used in the factor analysis

Questions	Measurement	Mean	SD
Postponed or canceled trips to the out-of-city area	1=Never; 5=Very frequently	4.195	1.020
Postponed or not attended school/work/local events	1=Never; 5=Very frequently	3.940	1.190
Postponed or canceled personal/social activities	1=Never; 5=Very frequently	3.931	1.082

Refrained from going out for eating out and leisure and spent time at home	1=Never; 5=Very frequently	3.951	1.101
Worked or studied at home	1=Never; 5=Very frequently	2.849	1.504
Worn face mask when attending any kind of event	1=Never; 5=Very frequently	3.929	1.422
Stayed at home and kept social distancing rules except for working, emergency situation, and going to school	1=Never; 5=Very frequently	4.132	1.051
Not attended gatherings of more than 10 people (e.g., social gatherings, watching sports games, watching movies, religious events, etc.)	1=Never; 5=Very frequently	3.916	1.359
Took public transportation (bus, railway, subway, taxi, etc.)	1=Never; 5=Very frequently	2.966	1.336
Your visits to your family or friends' home	1=Never; 5=Very frequently	1.960	0.922
Your family or friends' visits to your home	1=Never; 5=Very frequently	1.767	0.932
What was your preferred mode of consumption over the past month? – supermarkets, department stores, shopping complexes	1=More strongly not preferable; 6: same as before the COVID-19 outbreak; 11: More strongly preferable	4.310	2.665
What was your preferred mode of consumption over the past month? – local grocery stores	1=More strongly not preferable; 6=Same as before the COVID-19 outbreak; 11=More strongly preferable	4.998	2.485
What was your preferred mode of consumption over the past month? – local markets	1=More strongly not preferable; 6=Same as before the COVID-19 outbreak; 11=More strongly preferable	4.119	2.453
What was your preferred mode of consumption over the past month? – online shopping	1=More strongly not preferable; 6=Same as before the COVID-19 outbreak; 11=More strongly preferable	9.206	1.942
What was your preferred mode of consumption over the past month? – real-time online delivery service	1=More strongly not preferable; 6=Same as before the COVID-19 outbreak; 11=More strongly preferable	8.391	2.369

Exploratory factor analysis was then employed using SAS University Edition; the chosen factor rotation method was varimax rotation. The minimum criteria for factor loading were set as greater than 0.3. The value of Cronbach's α was set at 0.6 since the number is considered to be an acceptable level of reliability (van Griethuijsen et al., 2015; Taber, 2018). The factors with a Cronbach's α value lower than 0.6 were deleted. Furthermore, the survey questions that directly or indirectly asked about the use of urban spaces (concerning visits to, for example, shopping centers, nightlife facilities such as bars and clubs, and indoor and outdoor sports facilities) were excluded from the analysis. As a result of factor analysis, three common dimensions were extracted: compliance with social distancing, preference for offline or face-to-face consumption, and refraining from outdoor activities (see *Table 2*).

Table 2. Exploratory factor analysis

Items	Factor Loadings*		
	Compliance with social distancing (Factor 1)	Preference for offline consumption (Factor 2)	Refraining from outdoor activities (Factor 3)
Stayed at home and kept social distancing rules except for working, emergency situation, and going to school	0.779	0.018	0.201
Refrained from going out for eating out and leisure and spent time at home	0.763	-0.002	0.156
Not attended gatherings of more than 10 people (e.g., social gatherings, watching sports games, watching movies, religious events, etc.)	0.634	-0.027	0.116
Worn face mask when attending any kind of event	0.514	-0.052	-0.038
Worked or studied at home	0.302	-0.020	-0.054
Preferred mode of consumption over the past month – local markets	-0.011	0.794	-0.062
Preferred mode of consumption over the past month – local grocery stores	-0.004	0.772	-0.013
Preferred mode of consumption over the past month – supermarkets, department stores, shopping complexes	-0.013	0.543	-0.107
Took public transportation (bus, railway, subway, taxi, etc.)	-0.118	-0.127	0.113
Preferred mode of consumption over the past month – real-time online delivery service	0.210	-0.231	0.076
Preferred mode of consumption over the past month – online shopping	0.207	-0.242	0.196
Your family or friends' visits to your home	-0.039	-0.025	0.825
Your visits to your family or friends' home	-0.075	-0.017	0.746
Postponed or canceled trips to the out-of-city area	0.066	-0.116	0.340
Postponed or canceled personal/social activities	0.219	-0.045	0.251
Postponed or not attended school/work/local events	0.135	-0.079	0.227
Eigenvalues	5.277	3.871	3.263
Variance explained(%)	42.5	31.1	26.2
Cronbach's α	0.710	0.743	0.628

*cutoff at 0.3

4.2 Ordered Logit Models

Table 3 shows the result of the ordered logit model and indicates the variables that influence urban space use by its activity type during the pandemic. While the parallelism assumption was not satisfied in performing the ordered logit model, violation of the assumption is not critical, given that it is frequently violated (Long & Freese, 2006). Moreover, a generalized ordered logit model was not applied as an alternative considering that the sample size is not sufficient enough. With the exception of the space for mandatory activity, which consisted of only one type of space (work facilities), the values of Cronbach's α of space for maintenance activities (Model 2) and space for discretionary activities (Model 3) was 0.774 and 0.838, respectively. These values are relatively high in terms of reliability

(Taber, 2018). As stated in section 4.1, the response variable was set as the level of urban space visits compared to before the COVID-19 outbreak using an 11-point Likert-type rating scale.

Table 3. Ordered logit models

	Model 1. Urban spaces for mandatory activity			Model 2. Urban spaces for maintenance activity			Model 3. Urban spaces for discretionary activity		
Variable	Odds ratio		Std. Error	Odds ratio		Std. Error	Odds ratio		Std. Error
Factor 1: Compliance with social distancing	0.977		0.088	0.836	*	0.086	0.817	*	0.086
Factor 2: Preference for offline consumption	1.198	*	0.091	1.567	***	0.090	1.493	*	0.090
Factor 3: Refraining from outdoor activities	1.098		0.090	0.787	**	0.088	0.712	***	0.088
Gender (reference = male)	0.639	**	0.162	0.740		0.157	0.798		0.157
Age	1.010		0.009	0.990		0.009	0.978	*	0.009
Marriage (reference = married)	1.207		0.194	1.655	**	0.189	1.381		0.189
Education (reference = middle school)									
High school	1.485		1.290	1.617		1.282	0.693		1.280
College/university	2.133		1.285	1.241		1.277	0.534		1.275
Graduate school	2.257		1.324	2.200		1.314	0.678		1.311
Household income	1.000		0.000	1.000		0.000	1.000		0.000
Risk perception of COVID-19	0.869	*	0.057	0.840	**	0.054	0.793	***	0.055
Perceived safety in the city towards COVID-19	1.023		0.095	1.406	***	0.093	1.416	**	0.093

*p<0.05, **p<0.01, ***p<0.001

An odds ratio of greater than one means an increased occurrence of the event of using the urban space as one unit of increase in the independent variable (positive relationship). That of less than one refers to a decreased occurrence of the event of using the urban space as one unit of increase in the independent variable (negative relationship).

Variables that affect the use of space for mandatory activities include the preference for offline consumption, gender, and risk perception of COVID-19. Preference for offline consumer activities, such as visiting supermarkets, department stores, local grocery stores, and local markets, is found to affect the increase in using space for mandatory activities. Also, the results show that women visited work facilities less often than men during the study period, and the higher the risk perception of COVID-19, the lower the use of work facilities. It can be assumed that the level of visits to work facilities by women decreased because women abide by social distancing rules more than men (Abdelrahman, 2020; Liao et al., 2010). The perceived risk shows a statistically significant influence on the decline in urban space visits in all

models. Presumably, the perceived risk of the virus caused people to avoid crowded places as part of preventive health behavior (Leppin & Aro, 2009; Yıldırım et al., 2021).

In the case of Models 2 and 3, which refer to non-mandatory activity places, variables that commonly influence the use of the spaces are as follows: compliance with social distancing regulations (factor 1), preference for offline consumption (factor 2), refraining from outdoor activities (factor 3), risk perception of COVID-19, and perceived safety in the city concerning COVID-19. Compliance with social distancing measures (factor 1) affected the decline in visiting the non-mandatory activity spaces in the city, thereby facilitating the outcome these measures initially targeted. Although factor 1 did not correlate with the use of mandatory activity spaces such as work facilities, it is presumed that an individual's will or intention not to visit the space may not be accurately reflected due to the regulations and work guidelines of companies or organizations for which people worked. The preference for face-to-face or offline consumption, which inevitably leads to contact with other people, is a factor that increases the level of visits to spaces for maintenance activities and discretionary activities. People refraining from going out and undertaking outdoor activities turn out to visit the spaces less often. Furthermore, the more that people perceived the severity of COVID-19, the less likely they were to visit non-mandatory activity places. Lastly, the more people that understand their city to be safe from COVID-19, the more likely they are to visit these non-mandatory activity spaces, as shown in Models 2 and 3 in *Table 3*.

In Model 2, the marital status appears to affect the use of medical facilities, shopping centers, financial facilities, and many other spaces for maintenance activity. Compared to married people, unmarried people used spaces for maintenance activities more often. Given that married people tend to engage in more preventive health behaviors (Kim & Cho, 2020), it seems that married people tend to protect their personal health by visiting those spaces less often.

For Model 3, which covers urban spaces such as eateries, nightlife facilities, cultural facilities, and indoor and outdoor sports facilities, age appears to be a significant factor. The infection fatality rate of the coronavirus is associated with age: the risk is believed to increase as a person gets older (Levin et al., 2020). Persistent group infections have been reported in urban spaces for discretionary activities (e.g., eateries, nightlife facilities, and religious facilities) since the beginning of the COVID-19 pandemic (KDCA, 2020c). Thus, it is predicted that older people are likely to reduce their visits to spaces where discretionary activities take place.

5. DISCUSSION AND CONCLUSION

This study investigated differences in using urban spaces and identified the factors involved in urban residents' choices of urban spaces during the COVID-19 crisis. In addition, through classifying multiple urban spaces according to the activity type, this study also aimed to suggest policy implications for preventing and controlling infectious diseases in an urban context.

The study identified the preference for offline consumption and risk perception of COVID-19 as factors that commonly influence visits to all types of urban spaces. The greater people's preference for offline consumption, the more frequently they visited both mandatory and non-

mandatory activity spaces in the city. In comparison with online consumption, offline consumption involves physical contact with other people (Watanabe & Omori, 2020). In light of the increased risks associated with offline consumption, it is thus necessary to clarify whether those who prefer consumption in a face-to-face context accept the likelihood of becoming infected with the virus when shopping or prefer offline consumption due to a lack of accessibility in e-commerce. Another factor that affected the use of all types of urban spaces was the risk perception of COVID-19. It can be inferred that people reduced their use of spaces where the risk of infections existed or was thought to exist (Sadique et al., 2007; Sun & Zhai, 2020) as a preventive health strategy (Katz et al., 2012; Leppin & Aro, 2009; Wang et al., 2018; Zhang et al., 2020).

Factors that commonly influence the use of non-mandatory activity spaces were found to be compliance with social distancing, preference for offline consumption, refraining from outdoor activities, risk perception, and safety perception in the city with regards to the coronavirus.

This study has found differences in the variable that influence the choice of urban spaces, depending on maintenance activity and discretionary activity in the COVID-19 era. Marital status appears to affect the visits to spaces for maintenance activities, while age was discovered to affect visits to spaces for discretionary activities. Unlike studies that have analyzed an individual's activities and travel behaviors based on mandatory and non-mandatory activity (Anggraini et al., 2017; Oviedo & Guzman, 2020; Yaghoubi, Rassafi, & Mirzahossein, 2020), the present study identified not only different factors affecting the choice of mandatory and non-mandatory activity spaces but also distinctive variables determining the choice of urban spaces for maintenance activity and discretionary activity.

The results also emphasize the importance of risk management and risk communication. Risk perception of the disease is shown to reduce visits to all types of space, while the higher the safety perception in the city, the more people visit non-mandatory activity spaces, indicating a significant role of perception-related factors on people's visiting behavior. The study area is where COVID-19 is not fully controlled, and the government is still struggling to prevent the outburst of the virus. In this respect, risk communication plays a substantial role as it influences how people perceive, understand, and expect emergencies such as the pandemic (Moreno, Fuentes-Lara, & Navarro, 2020). Overwhelmed by too much information that contains false or misleading information, people have received scientifically unproven fake news regarding the coronavirus (Moscadelli et al., 2020). Those who are exposed to fake news may underestimate the government's efforts to curb the spread (Apuke & Omar, 2021) and even take risks that could lead to threats against public health (Pennycook et al., 2020). Therefore, based on scientific evidence, public health authorities should carry out risk management that suitably intervenes in the use of urban spaces by citizens. The interventions shall ultimately aim to mitigate infectious diseases and benefit public health.

The findings demonstrate that there is a need for policymakers and practitioners to consider these factors that are associated with urban space visits when designing response measures and policies. As demonstrated above, the factors influencing the choice of mandatory and non-mandatory activity spaces differ. Even among the non-mandatory activity spaces, the variables involved in people's visits vary depending on whether they are engaging in a maintenance activity or discretionary activity. Considering that visiting behavior may change depending on the level of lockdown or social

distancing, it is needed to pre-emptively or adaptively reflect the factors involved in the choice of urban spaces by their type. For example, when it comes to risk perception, visits to specific urban spaces with high transmission risk can be managed by effective risk communication strategies such as delivering in-time and accurate information or public campaigns through various communication channels. This approach could ultimately lead to a deeper understanding of the dynamics of infectious diseases in urban environments.

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