

How Did the COVID-19 Pandemic Affect Mobility, Land Use, and Destination Selection? Lesson from Seoul, Korea

Lee, Jiwon* · Gim, Tae-Hyoung Tommy** · Park, Yunmi*** · Chung, Hyung-Chul**** · Handayani, Wiwandari***** · Lee, Hee-Chung***** · Yoon, Dong Keun***** · Pai, Jen Te*****

Abstract

The COVID-19 pandemic has brought about significant social changes through government prevention and control measures, changes in people's risk perceptions, and lifestyle changes. In response, urban inhabitants changed their behaviors significantly, including their preferences for transportation modes and urban spaces in response to government quarantine policies and concerns over the potential risk of infection in urban spaces. These changes may have long-lasting effects on urban spaces beyond the COVID-19 pandemic or they may evolve and develop new forms. Therefore, this study aims to explore the potential for urban spaces to adapt to the present and future pandemics by examining changes in urban residents' preferences in travel modes and urban space use due to the COVID-19 pandemic. This study found that overall preferences for travel modes and urban spaces significantly differ between the pre-pandemic, pandemic, and post-pandemic periods. During the pandemic, preferences for travel modes and urban spaces has decreased, except for privately owned vehicles and green spaces, which are perceived to be safe from transmission, show more favorable than others. Post-pandemic preferences for travel modes and urban spaces are less favorable than pre-pandemic with urban spaces being five times less favorable than transportation. Although green spaces and medical facilities that were positively perceived during the pandemic are expected to return to the pre-pandemic preference level, other factors of urban spaces are facing a new-normal. The findings suggest that the COVID-19 pandemic has had a significant impact on urban residents' preferences for travel modes and urban space use. Understanding these changes is crucial for developing strategies to adapt to present and future pandemics and improve urban resilience.

Keywords : COVID-19, Travel Mode Choice, Urban Spaces, Risk Perception, Pandemic

*Ph.D. Candidate, Graduate School of Environmental Studies, Seoul National University (First Author: aimeru2@snu.ac.kr)

**Associate Professor, Graduate School of Environmental Studies, Interdisciplinary Major in Regional Studies and Spatial Analytics, Interdisciplinary Program in Landscape Architecture and Environmental Planning Institute, Seoul National University (Corresponding Author: taehyoung.gim@snu.ac.kr)

***Assistant Professor, Department of Civil & Environmental Engineering and Institute of Construction and Environmental Engineering, Seoul National University

****Associate Professor, Department of Urban Planning and Design, Xi'an Jiaotong-Liverpool University

*****Professor, Department of Urban and Regional Planning, Diponegoro University

*****Professor, Department of Urban Planning and Design, University of Seoul

*****Professor, Department of Urban Planning and Engineering, Yonsei University

*****Professor, Department of Land Economics, National Chengchi University

Received: June 8, 2023 / Revised: August 27, 2023 / Accepted: August 27, 2023

1. Introduction

As dense urban structures have been recognized as susceptible to the rapid spread of infectious diseases, densely populated urban areas where frequent human interaction occurs have emerged as hotspots for the transmission of COVID-19. The pandemic has led to social changes through government prevention and control measures, shifts in people's risk perceptions, and alterations in lifestyle. In particular, urban inhabitants have significantly changed their behavior by adjusting their preferences for transportation modes and urban spaces in response to government quarantine policies and potential risk of infection in urban spaces (Geana, 2020; Kim et al., 2021; Ugolini et al., 2020).

In the early stages of the pandemic, COVID-19 was rapidly transmitted through transportation hubs such as Wuhan (China), Seoul (South Korea), and Milan (Italy), leading to mass infection cases in densely populated and frequently visited urban areas. As a result, government COVID-19 response policies aimed at controlling people's movements and use of urban spaces were implemented to combat the virus. For example, the South Korean government gradually enforced controls on the use of urban spaces and facilities and used encouraged citizens to avoid crowded areas by utilizing social distancing policies.

Along with government COVID-19 control measures, urban residents' risk perception of popular urban spaces and modes of transportation increased, leading to cancellations of trips and visits, and changes in destinations and transportation

modes (Cahyanto et al., 2016; Kim et al., 2021). In 2020, public transportation use in Seoul metropolitan areas decreased by 26.8%. Long-distance wide-area traffic decreased by 12.1% compared to the pre-pandemic period (as of 2019) (Ministry of Land, Infrastructure and Transport, 2022). Physical interaction-based industries such as sales services, tourism, and the restaurant business suffered a significant drop in sales compared to the pre-pandemic period (Seoul Institute, 2020). Consequently, physical sales services were replaced with contactless services like online shopping and food delivery. The perceived risk in public spaces increased, leading to decreased use of public transportation and increased car ownership (Kim et al., 2021). Fatigue from the prolonged pandemic and government regulations and social restrictions led to increased participation in outdoor activities (for example, camping, hiking, and jogging), highlighting the importance of green spaces in cities.

The pandemic has brought about changes in preferences for travel modes, travel destinations and urban space usage that may persist even after the COVID-19 pandemic ends (Pawar et al., 2020; Shakibaei et al., 2021), or may evolve into new forms. While vaccination efforts have become widespread and borders have reopened, the virus has continued to mutate, resulting in a rising number of confirmed cases. In the summer of 2022, South Korea experienced its seventh wave of COVID-19, as experts had predicted (Yonhap, 2022). This resurgence occurred in alignment with predictions by experts (Seo, 2022). Additionally, with the lifting of the mask-

wearing measure in early 2023, the epidemic rebounded. Currently, as of August 31, COVID-19 is scheduled to be reclassified as a Level 4 infectious disease according to KCDA's (2023) classification. However, alarming signs of resurgence are evident, given the infection reproduction index surpassing 1. Experts have argued that cycles of disease infection may become shorter due to climate change. Therefore, it is crucial to identify and respond to changes in perceptions of urban spaces caused by the pandemic to increase our resilience to future pandemics and their impacts on our cities and communities.

This study explores the potential for urban spaces to adapt to the present and future pandemics by examining changes in urban residents' preferences for travel modes and urban space use resulting from the COVID-19 pandemic. The study uses ANOVA to identify changes in urban residents' urban space usage preferences over time, and whether these preferences returned to their pre-pandemic state (back-to-pandemic) or took on a 'new-normal' in the post-pandemic period.

2. Literature Review

In the initial stage of the COVID-19 pandemic, the virus spread rapidly from transportation hubs where human resources and logistics are concentrated. In cities with large numbers of residents share urban spaces and transportation modes, they are particularly vulnerable to infectious diseases. Nevertheless, despite being

potential hotspots for pandemics with cities becoming 'breeding grounds' for infectious diseases, they have demonstrated great resilience in overcoming pandemics.

In comparison with previous pandemics, one of the distinguishing features of COVID-19 is its rapid global spread. The virus is transmitted through respiratory droplets, and thus urban spaces that are characterized by "Closed, Crowded, Close-contact (3Cs)" are particularly vulnerable to transmission (WHO, 2020). Multiple cases of mass infection were reported in enclosed indoor spaces such as sports facilities, restaurants, cafés, and clubs. Dining places and marketplaces where it is challenging to wear personal protective gear and practice social distancing, were especially hard hit (Yip et al., 2021). For example, several mass infection cases were reported in 2020 in restaurants and cafes, such as the one that occurred on August 12th in a cafe in the Seoul metropolitan area, where 50 cases were confirmed. The Korean Disease Control and Prevention Agency (KDCA) attested that mass infection is attributed to the unique characteristics such as enclosed spaces with poor ventilation where people remove their masks to eat and drink (WHO, 2021). Similarly, a mass infection transmitted by air conditioners in a restaurant was reported in China. These incidents highlight the vulnerability of densely populated areas with poor ventilation where individuals come into close contact with others for extended periods to the rapid spread of infection (Lu et al., 2021).

Perceptions of risk of infection in urban spaces affected people's travel behavior and destination

selection. Public transportation use decreased by 93 percent in the early pandemic period compared to the pre-pandemic period (Aloi et al., 2020). This was primarily due to concerns about poor ventilation and the inability to maintain social distancing on public transportation. As a result, many individuals increasingly began to prefer traveling in their own private vehicles. In addition, recommendations to work from home and stay-at-home policies further reduced travel frequency. Activities such as retail shopping, dining out, and commuting by public transport were replaced by contactless services and private travel to avoid physical interaction (Shamshiripour et al., 2020; Kim et al., 2021). Moreover, individuals sought out green areas such as parks and mountains to relieve stress and fatigue due to the prolonged pandemic and avoid risk of infection in urban settings.

The COVID-19 pandemic has thus brought about significant changes to urban residents' preferences for urban space use and transportation mode choice. The increased use of private cars and proliferation of contactless services are expected to persist in the post-pandemic period. Previous studies have compared pre-pandemic and pandemic periods, and occasionally predicted changes in the post-pandemic period on the basis of current patterns. However, it is also important to examine changes in preference in urban space use and transportation mode from the perspective of actual users to better prepare for the urban changes in the post-pandemic period. This study takes this approach to investigate changes in preferences for urban spaces and travel modes

in pre-pandemic, pandemic, and post-pandemic periods, and confirming differences between these periods through quantitative analysis. This study aims to provide a more comprehensive understanding of how urban residents' preferences have evolved over time and how they are likely to shape the urban spaces in the future.

3. Research Design

3.1 Research Questions

This study focuses on urban space and travel mode choice during the COVID-19 pandemic. Specifically, the study seeks to answer whether people's perceptions of urban space and transportation will return to pre-pandemic patterns ('normal') in the post-pandemic period or adopt 'new-normal' patterns based on changes in people's behaviors and risk perception during the pandemic. To achieve this aim, this study asks the following research questions to suggest directions and guidance for urban planning in preparation for the ongoing pandemic and future pandemics.

- Question 1: How have urban space and travel mode preferences changed over the pre-pandemic, pandemic, and post-pandemic periods,
- Question 2: Will urban space and travel mode preferences return to pre-pandemic patterns in the post-pandemic period?
 - Question 2.1: (YES) If so, what characteristics do urban space and travel mode preferences that return to pre-pandemic patterns show?
 - Question 2.2: (NO) If urban space and travel mode

preferences take on ‘new-normal’ characteristics in the post-pandemic period, do they share the similar characteristics with those during the pandemic?

3.2 Study Area and Data

To examine changes in people’s preferences for urban space and transportation mode, this study uses the Seoul metropolitan area as the study area. Seoul has a high population density and extensive connectivity, making it highly vulnerable to the transmission of infectious diseases. As of 30 November 2022, since the beginning of the outbreak, confirmed COVID-19 cases in this area accounted for 46.57 percent of total cases in South Korea (KDCA, 2022).

In response to the COVID-19 outbreak, South Korea implemented a social distancing policy rather than imposing mandatory mobility restrictions such as lockdowns or border closures. Social distancing policies included measure to regulate the use of urban spaces. However, these policies were not so strict as to prohibit residents from using them according to their preferences as they were implemented only to limiting opening hours and occupancy of urban spaces. For this reason, it was judged that measuring changes in urban residents’ preferences was suitable for this study’s purpose.

This study performed an online survey to investigate destination and mobility selection preferences by period. The survey was carried out by a professional survey agency (<http://www.entrustsurvey.com/>) and the questionnaire was

verified by seven experts in related fields from seven domestic and foreign universities. The survey was conducted from October 8 to October 26, 2021, involved a total of 300 participants, comprising 149 males and 151 females. The data was gathered from residents of the Seoul metropolitan areas through a voluntary response sampling technique. Additionally, a quota sampling approach was adopted, stratified by gender and age. The participants were distributed across age groups as follows: 60 participants in their 20s (20%), 105 participants in their 30s (35%), 105 participants in their 40s (35%), and 30 participants in their 50s and older (10%). The survey items included 14 urban spaces and 8 travel modes as shown in Table 1. The selection of urban spaces was guided by the Special Act on Safety Management of Multi-use businesses which designates “business facilities used by an unspecified number of people.” as targets for safety management. One of the most noteworthy findings of the descriptive statistics is that while the preference level for urban spaces and public transportation modes has not yet fully recovered to pre-pandemic levels, there was a significant drop in preference during the pandemic period, followed by a rebound in the post-pandemic period. However, the preference for using private cars has increased more than ever across all periods.

3.3 Methodology

We performed by the following process. First, the survey was conducted to examine travel mode and urban space choices in the pre-pandemic,

Table 1. Descriptive Statistics of the Input Variables

Questionnaire
 Before the outbreak of COVID-19 (pre-pandemic), during the pandemic (pandemic), and after the pandemic ends (post-pandemic), what is your preference for using those transportation and urban space items below? (-5: Never (negatively) ~ +5: Always)

Items	Pre-pandemic			Pandemic			Post-pandemic		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Transportation modes									
Walking	-5	5	2.31	-5	5	1.48	-5	5	2.54
Privately Owned Vehicles	-5	5	1.39	-5	5	1.71	-5	5	1.81
City Bus	-5	5	1.54	-5	5	-1.20	-5	5	1.07
Intercity Bus	-5	5	1.32	-5	5	-1.33	-5	5	0.91
Subway	-5	5	1.95	-5	5	-1.28	-5	5	1.29
Railroad	-5	5	1.46	-5	5	-0.99	-5	5	1.07
Taxis	-5	5	0.59	-5	5	-0.90	-5	5	0.38
Micro Mobility Vehicles	-5	5	1.33	-5	5	0.48	-5	5	1.25
Urban Spaces									
Business Facilities	-5	5	1.46	-5	5	-1.52	-5	5	0.91
Education Facilities	-5	5	1.98	-5	5	-1.73	-5	5	1.23
Medical Facilities	-5	5	1.97	-5	5	-0.38	-5	5	1.60
Shopping Centers	-5	5	1.98	-5	4	-2.25	-5	5	1.20
Restaurants and Cafés	-5	5	2.08	-5	4	-2.09	-5	5	1.15
Clubs and Bars	-5	5	0.51	-5	5	-3.59	-5	5	-0.47
Cultural Facilities	-5	5	2.24	-5	5	-1.67	-5	5	1.39
Indoor Sports Facilities	-5	5	1.93	-5	5	-2.32	-5	5	0.99
Outdoor Sports Facilities	-5	5	1.85	-5	4	-1.44	-5	5	1.29
Sauna and Public Bath	-5	5	1.44	-5	4	-3.20	-5	5	0.21
Religious Facilities	-5	5	0.49	-5	5	-3.24	-5	5	-0.72
Green Spaces	-5	5	2.67	-5	5	0.62	-5	5	2.53

pandemic, and post-pandemic periods and to measure changes compared to the pre-pandemic period. To measure accurate changes in preference, the rate of change in travel mode and urban space (as destination) preference between the pandemic and the post-pandemic periods compared to the pre-pandemic period was calculated using [Equation 1].

$$\frac{t_2 - t_1}{t_2} \tag{1}$$

where t1 = preference for travel mode and urban space in pre-pandemic, t2 = preference for travel mode and urban space in the pandemic or post-pandemic period

Second, many experts have predicted that we will not be able to return to pre-pandemic patterns

and therefore face the prospect of a ‘new-normal’. To investigate the impact of the pandemic on urban space and transportation mode preferences, this study attempted to confirm whether the use of urban spaces returned to pre-pandemic patterns in the post-pandemic period. The study used the one-way analysis of variance (ANOVA) to compare the preference changes over time. The one-way ANOVA compares the means among groups and identifies whether any groups (means) significantly differ. If a result of the one-way ANOVA rejects the null hypothesis, the alternative hypothesis (HA) implies that two or more groups’ means are statistically different.

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \dots = \mu_k \quad (2)$$

where μ = group mean and k = number of groups

4. Changes in Preferences for Travel Modes and Urban Spaces by Period

4.1 Changes in Preferences for Travel Modes

The pandemic has had a significant impact on people’s transportation preferences, with an overall negative shift of 1.30 times compared to the pre-pandemic period (see Fig. 1). This shift was particularly pronounced for city buses (-1.78), intercity buses (-2.01), and subways (-1.66), which are commonly used by commuters and residents. Conversely, privately owned vehicles were the only mode of transportation that saw an increase in preference, with 0.24 times rise. Micro mobility vehicles and walking had relatively stable preference levels compared to the pre-pandemic period. Notably, the preference for taxis, which are non-shared rides, had the greatest change in

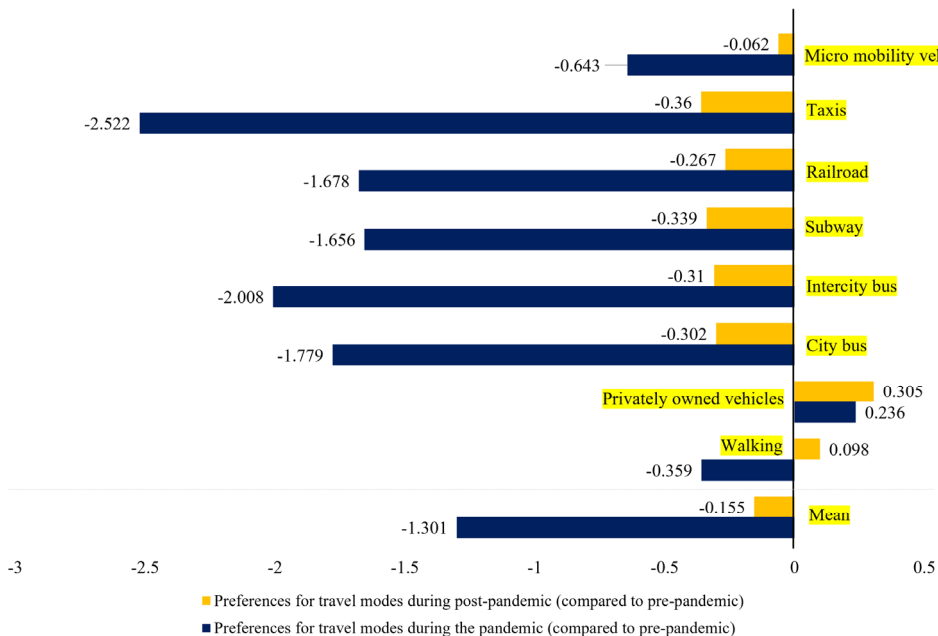


Fig. 1. Changes in Preferences for Travel Mode Choices

preference among all travel modes, with a negative shift of 2.52 times compared to the pre-pandemic period.

In the post-pandemic period, there was 0.16 times decrease in overall transportation preferences compared to the pre-pandemic period. Walking (0.10) and privately owned vehicles (0.31) remained highly preferred compared to the pre-pandemic period. However, city bus (-0.30), intercity bus (-0.31), and subway (-0.34) are less preferred than they were before and during the pandemic. While taxis (-0.27) showed the largest preference changes during the pandemic compared to the pre-pandemic period, they were the least preferred mode of transportation in the post-pandemic period.

4.2 Changes in Preferences for Urban Spaces as Destinations

During the pandemic, average preferences for

urban spaces decreased by 2.88 times compared to the pre-pandemic (see Fig. 2). Urban spaces were negatively perceived compared to transportation by almost 2 times. Among urban places, clubs and bars (-7.98) and religious facilities (-7.61) were seven times less preferable than pre-pandemic. In contrast, the change in preference for green space was insignificant with a minor decrease of 0.76 times compared to the pre-pandemic. Restaurants and cafés (-2.01) were twice as unfavorable as they were in the pre-pandemic period.

In the post-pandemic period, preferences for using urban spaces are lower by 0.69 times than pre-pandemic. However, the negative preferences seen during the pandemic, have mostly recovered to the pre-pandemic levels, although they were still five times more negatively perceived than transportation preferences during the same period. Clubs and bars (-1.91) and religious

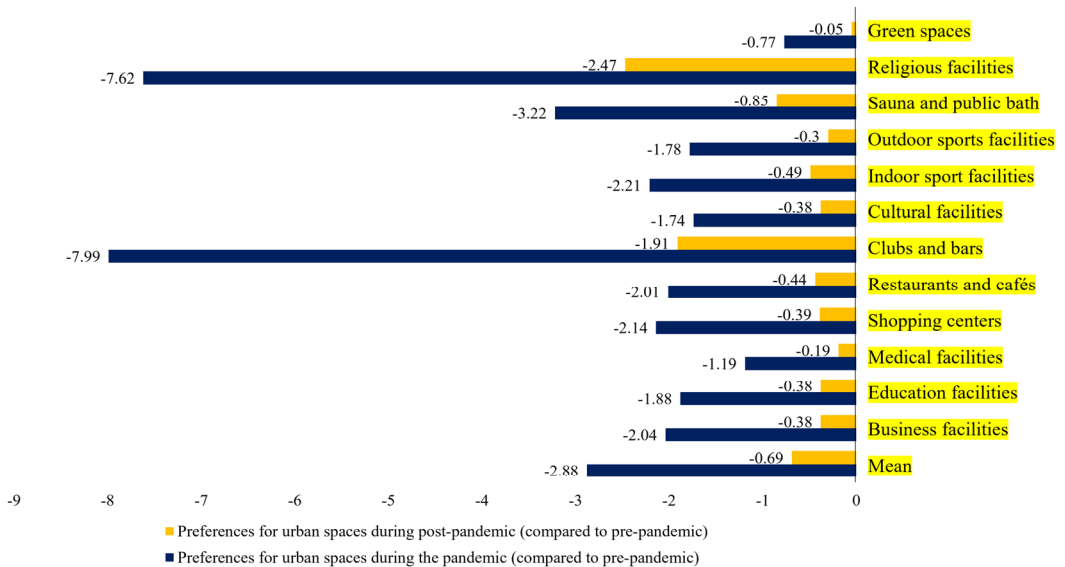


Fig. 2. Changes in Preferences for Urban Spaces

facilities (-2.47) were more positively perceived than they were during the pandemic, but they remained twice as low as pre-pandemic. In contrast, the preferences for restaurants and cafés (-0.44) increased with the change rate of preferences in the post-pandemic that was five times greater than in the pandemic. Green space preferences recovered to pre-pandemic levels, with only minor changes during the pandemic. While medical facilities were negatively impacted during the pandemic (-1.19), they were expected to be used more frequently during the post-pandemic, with a preference level comparable to the pre-pandemic (-0.19).

5. Back-to-Normal verse New-Normal

The aim of this study was to investigate whether there were significant differences in preferences for travel modes and urban spaces across the pre-pandemic, pandemic, and post-pandemic periods using ANOVA. Table 2 shows the analysis results of preferences for travel modes and urban space choices by period. The study defines 'back-to-normal' as the point where preferences for travel modes and urban spaces during the post-pandemic are expected to be the same as pre-pandemic, in contrast, the term 'new-normal' is used to describe a situation where the preferences for travel modes and urban spaces in each period are significantly different or have changed from pre-pandemic.

5.1 Preferences for Travel Mode Choice

Overall, there were significant differences in

transportation preferences across the three periods. However, some transportation mode preferences are expected to return to pre-pandemic level in the post-pandemic period. For instance, the preference for walking decreased significantly during the pandemic compared to pre-pandemic and post-pandemic. The preference for walking in post-pandemic (0.53) appeared to return to pre-pandemic levels. Similarly, the preference for taxis decreased during the pandemic compared to pre-pandemic and post-pandemic. However, in the post-pandemic period, people are expected to use taxis more than during the pandemic and pre-pandemic period. Preferences for personal mobility during the pandemic showed significant differences compared to pre-and post-pandemic. However, post-pandemic preferences are expected to regress to pre-pandemic levels.

On the other hand, there were significant differences in preference for the subway across different periods. Particularly, the preference for the subway during the pandemic was much lower than pre-and post-pandemic. It is expected that the preference for the subway will decrease after the pandemic ends, but it will still be more preferred than during the pandemic. Similarly, the preference for railroads varied significantly across different periods. In the post-pandemic period, there is expected to be an increase in people's preference for private cars compared to the pre-pandemic period, indicating a new-normal.

5.2 Preferences for Urban Spaces

There were significant differences in preferences

Table 2. The ANOVA Results

Items	Period (i)	Period (j)	Differences of Means (i-j)	Standard Error	P-value
Walking	Pre-pandemic	Pandemic	0.321 ***	0.083	0.000
		Post-pandemic	-0.088	0.077	0.583
	Pandemic	Pre-pandemic	-0.321 ***	0.083	0.000
		Post-pandemic	-0.409 ***	0.081	0.000
	Post-pandemic	Pre-pandemic	0.088	0.077	0.583
		Pandemic	0.409 ***	0.081	0.000
Privately Owned Vehicles	Pre-pandemic	Pandemic	-0.135	0.083	0.287
		Post-pandemic	-0.174 *	0.077	0.072
	Pandemic	Pre-pandemic	0.135	0.083	0.287
		Post-pandemic	-0.040	0.084	0.951
	Post-pandemic	Pre-pandemic	0.174 *	0.077	0.072
		Pandemic	0.040	0.084	0.951
City Bus	Pre-pandemic	Pandemic	1.084 ***	0.071	0.000
		Post-pandemic	0.184 **	0.074	0.038
	Pandemic	Pre-pandemic	-1.084 ***	0.071	0.000
		Post-pandemic	-0.900 ***	0.071	0.000
	Post-pandemic	Pre-pandemic	-0.184 **	0.074	0.038
		Pandemic	0.900 ***	0.071	0.000
Intercity Bus	Pre-pandemic	Pandemic	1.088 ***	0.071	0.000
		Post-pandemic	0.168 *	0.073	0.065
	Pandemic	Pre-pandemic	-1.088 ***	0.071	0.000
		Post-pandemic	-0.920 ***	0.071	0.000
	Post-pandemic	Pre-pandemic	-0.168 *	0.073	0.065
		Pandemic	0.920 ***	0.071	0.000
Subway	Pre-pandemic	Pandemic	1.142 ***	0.071	0.000
		Post-pandemic	0.234 **	0.071	0.003
	Pandemic	Pre-pandemic	-1.142 ***	0.071	0.000
		Post-pandemic	-0.908 ***	0.072	0.000
	Post-pandemic	Pre-pandemic	-0.234 **	0.071	0.003
		Pandemic	0.908 ***	0.072	0.000
Railroad	Pre-pandemic	Pandemic	1.030 ***	0.072	0.000
		Post-pandemic	0.164 *	0.074	0.080
	Pandemic	Pre-pandemic	-1.030 ***	0.072	0.000
		Post-pandemic	-0.866 ***	0.073	0.000
	Post-pandemic	Pre-pandemic	-0.164 *	0.074	0.080
		Pandemic	0.866 ***	0.073	0.000

Table 2. The ANOVA Results (Continued)

Items	Period (i)	Period (j)	Differences of Means (i-j)	Standard Error	P-value
Taxis	Pre-pandemic	Pandemic	0.621 ***	0.079	0.000
		Post-pandemic	0.089	0.078	0.589
	Pandemic	Pre-pandemic	-0.621 ***	0.079	0.000
		Post-pandemic	-0.533 ***	0.079	0.000
	Post-pandemic	Pre-pandemic	-0.089	0.078	0.589
		Pandemic	0.533 ***	0.079	0.000
Micro Mobility Vehicles	Pre-pandemic	Pandemic	0.351 ***	0.081	0.000
		Post-pandemic	0.034	0.080	0.963
	Pandemic	Pre-pandemic	-0.351 ***	0.081	0.000
		Post-pandemic	-0.317 ***	0.082	0.000
	Post-pandemic	Pre-pandemic	-0.034	0.080	0.963
		Pandemic	0.317 ***	0.082	0.000
Business Facilities	Pre-pandemic	Pandemic	1.067 ***	0.072	0.000
		Post-pandemic	0.198 **	0.076	0.027
	Pandemic	Pre-pandemic	-1.067 ***	0.072	0.000
		Post-pandemic	-0.868 ***	0.069	0.000
	Post-pandemic	Pre-pandemic	-0.198 **	0.076	0.027
		Pandemic	0.868 ***	0.069	0.000
Education Facilities	Pre-pandemic	Pandemic	1.310 ***	0.067	0.000
		Post-pandemic	0.264 **	0.070	0.001
	Pandemic	Pre-pandemic	-1.310 ***	0.067	0.000
		Post-pandemic	-1.047 ***	0.066	0.000
	Post-pandemic	Pre-pandemic	-0.264 **	0.070	0.001
		Pandemic	1.047 ***	0.066	0.000
Medical Facilities	Pre-pandemic	Pandemic	0.863 ***	0.077	0.000
		Post-pandemic	0.136	0.072	0.170
	Pandemic	Pre-pandemic	-0.863 ***	0.077	0.000
		Post-pandemic	-0.727 ***	0.078	0.000
	Post-pandemic	Pre-pandemic	-0.136	0.072	0.170
		Pandemic	0.727 ***	0.078	0.000
Shopping Centers	Pre-pandemic	Pandemic	1.424 ***	0.064	0.000
		Post-pandemic	0.258 ***	0.067	0.000
	Pandemic	Pre-pandemic	-1.424 ***	0.064	0.000
		Post-pandemic	-1.165 ***	0.061	0.000
	Post-pandemic	Pre-pandemic	-0.258 ***	0.067	0.000
		Pandemic	1.165 ***	0.061	0.000

Table 2. The ANOVA Results (Continued)

Items	Period (i)	Period (j)	Differences of Means (i-j)	Standard Error	P-value	
Restaurants and Cafés	Pre-pandemic	Pandemic	1.391 ***	0.063	0.000	
		Post-pandemic	0.308 ***	0.069	0.000	
	Pandemic	Pre-pandemic	-1.391 ***	0.063	0.000	
		Post-pandemic	-1.083 ***	0.064	0.000	
	Post-pandemic	Pre-pandemic	-0.308 ***	0.069	0.000	
		Pandemic	1.083 ***	0.064	0.000	
	Clubs and Bars	Pre-pandemic	Pandemic	1.343 ***	0.064	0.000
			Post-pandemic	0.321 ***	0.073	0.000
Pandemic		Pre-pandemic	-1.343 ***	0.064	0.000	
		Post-pandemic	-1.022 ***	0.064	0.000	
Post-pandemic		Pre-pandemic	-0.321 ***	0.073	0.000	
		Pandemic	1.022 ***	0.064	0.000	
Cultural Facilities		Pre-pandemic	Pandemic	1.357 ***	0.065	0.000
			Post-pandemic	0.297 ***	0.069	0.000
	Pandemic	Pre-pandemic	-1.357 ***	0.065	0.000	
		Post-pandemic	-1.060 ***	0.065	0.000	
	Post-pandemic	Pre-pandemic	-0.297 ***	0.069	0.000	
		Pandemic	1.060 ***	0.065	0.000	
	Indoor Sports Facilities	Pre-pandemic	Pandemic	1.434 ***	0.063	0.000
			Post-pandemic	0.317 ***	0.067	0.000
Pandemic		Pre-pandemic	-1.434 ***	0.063	0.000	
		Post-pandemic	-1.117 ***	0.064	0.000	
Post-pandemic		Pre-pandemic	-0.317 ***	0.067	0.000	
		Pandemic	1.117 ***	0.064	0.000	
Outdoor Sports Facilities		Pre-pandemic	Pandemic	1.222 ***	0.068	0.000
			Post-pandemic	0.206 *	0.072	0.013
	Pandemic	Pre-pandemic	-1.222 ***	0.068	0.000	
		Post-pandemic	-1.016 ***	0.067	0.000	
	Post-pandemic	Pre-pandemic	-0.206 *	0.072	0.013	
		Pandemic	1.016 ***	0.067	0.000	
	Sauna and Public Bath	Pre-pandemic	Pandemic	1.518 ***	0.060	0.000
			Post-pandemic	0.404 ***	0.067	0.000
Pandemic		Pre-pandemic	-1.518 ***	0.060	0.000	
		Post-pandemic	-1.114 ***	0.061	0.000	
Post-pandemic		Pre-pandemic	-0.404 ***	0.067	0.000	
		Pandemic	1.114 ***	0.061	0.000	

Table 2. The ANOVA Results (Continued)

Items	Period (i)	Period (j)	Differences of Means (i-j)	Standard Error	P-value
Religious Facilities	Pre-pandemic	Pandemic	1.213 ***	0.065	0.000
		Post-pandemic	0.393 ***	0.077	0.000
	Pandemic	Pre-pandemic	-1.213 ***	0.065	0.000
		Post-pandemic	-0.820 ***	0.070	0.000
	Post-pandemic	Pre-pandemic	-0.393 ***	0.077	0.000
		Pandemic	0.820 ***	0.070	0.000
Green Spaces	Pre-pandemic	Pandemic	0.742 ***	0.079	0.000
		Post-pandemic	0.048	0.074	0.885
	Pandemic	Pre-pandemic	-0.742 ***	0.079	0.000
		Post-pandemic	-0.694 ***	0.077	0.000
	Post-pandemic	Pre-pandemic	-0.048	0.074	0.885
		Pandemic	0.694 ***	0.077	0.000

*: p-value < 0.01, **: p-value < 0.05, ***: p<0.001

for urban spaces across different periods, with the exceptions of medical facilities and green spaces. In other words, the preference of each urban space was expected to show “new-normal” characteristics in the post-pandemic period. Specifically, business facilities, educational facilities, shopping centers, cultural facilities, sauna and public baths, clubs and bars, restaurants and cafés, and indoor/outdoor sports facilities failed to recover their pre-pandemic preference levels. The preferences for these urban spaces significantly varied across different periods. The pre-pandemic period showed a higher preference rate than the values of the other periods. During the pandemic, overall preference for urban spaces decreased, and while it was expected to increase post-pandemic compared to during the pandemic, it was expected to be still lower than pre-pandemic levels.

On the other hand, for medical facilities and

green spaces, the preference for using urban spaces was expected to return to the previous level post-pandemic. During the pandemic, medical facilities differed from pre-pandemic by -0.86; post-pandemic, they were expected to increase by 0.73 compared to pre-pandemic. Similarly, the preference for green spaces were expected to increase by 0.69 in post-pandemic period, indicating back-to-normal (pre-pandemic).

6. Discussion and Conclusion

This study is meaningful in identifying changes in preferences for travel modes and urban space choices to enhance the resilience of cities to future pandemic and their impact on communities and urban structures. We have confirmed the changes in preferences for the past, present, and future. The findings of this study demonstrate that preferences for urban spaces and travel

modes have changed in pandemic, compared to pre-pandemic period.

Firstly, this study examined the changes in preference for travel mode and urban space in the pandemic and post-pandemic period, compared to pre-pandemic period. Preferences for those urban spaces differed significantly across different periods, with the pre-pandemic period having a higher preference rate than the other periods. Moreover, we found that the difference in preference for urban space was larger than for travel mode. Transportation is a way/method to reach a destination, and there are various travel options compared to urban spaces. In contrast, people visit urban spaces for specific purposes, such as leisure, work, shopping, or socializing; their visiting time may be longer than travel mode. Additionally, preferences for urban spaces have declined, possibly due to their vulnerability to COVID-19 infection, including multiple mass infection cases were reported in these areas. Particularly, the Korean Centers for Disease Control and Prevention have publicly disclosed the locations and places visited by confirmed patients, which may have had a negative impact by creating a stigma effect on urban spaces.

Secondly, we discovered that only green spaces and medical facilities, which were preferred among urban spaces during the pandemic, returned to pre-pandemic levels in the post-pandemic period. Medical facilities constitute essential infrastructure for people's daily lives. In the early stages of the pandemic, they were less favored due to concerns about COVID-19 transmission. However, the situation appears to have returned to the

pre-pandemic levels in the post-pandemic period as the functional aspect (i.e., treatment) of medical facilities has been emphasized. Particularly, the increased emphasis on preventive measures against the spread of COVID-19 in medical facilities has increased the preference for such facilities (Tsai, 2021).

Furthermore, while green spaces were not initially considered an essential amenities like medical facilities during the pandemic, they served as the only alternative when mobility and accessibility to other destinations were restricted due to various anti-COVID measures. Specifically, green spaces became more preferred because they have a lower risk of infection than other urban spaces. They also provide opportunities for recreation and exercise, which became increasingly important for maintaining physical and mental health during the pandemic (Lopez et al., 2021; Van den Berg et al., 2010). Under the restricted circumstances created by social distancing policies and other anti-COVID-19 measures, green spaces were perceived as essential areas that support a healthier lifestyle by promoting physical exercise and social interaction. These findings highlighted the importance of green spaces as a vital component of community planning, especially during the time of crisis, and suggested that green spaces should be prioritized in future urban planning and quarantine policies.

Thirdly, travel modes such as walking, micro-mobility vehicles, and taxis, which were highly preferred during the pandemic, are expected to return to normal. In particular, walking was found to be favored more greatly peri- and post-

pandemic than pre-pandemic. Harrington and Hadjiconstantinou (2022) showed that some car and public transport commuters switched their travel mode to cycling or walking for safety reasons. Notably, walking and micro-mobility promote physical activity and mental health (Marquart and Schicketanz, 2022), which may have contributed to their continued preference even post-pandemic.

Lastly, we confirmed that most travel modes and urban space preferences failed to fully recover as much as the pre-pandemic levels. In particular, preferences for the travel modes and urban spaces vulnerable to COVID-19 transmission (e.g., crowded areas, close contact, and closed place) showed a lower preference. Even though preference recovers to a certain level in post-pandemic, policy interventions are required to restore preferences that have changed during the pandemic. For example, it is anticipated that personal transportation preferences will continue even after the pandemic. Therefore, the government needs to support active transportation such as walking and cycling by investing in infrastructure such as bike lanes, pedestrian zones, and shared streets.

Changes in preferences for urban space and travel modes over time are likely to persist in the future. It is crucial to examine alterations in statistical indicators to ascertain whether these shifts have indeed manifested within urban areas. Such analyses will not only provide insights for forthcoming urban policies but also aid in evaluating the tangible influence of research findings and the efficacy of policies. For example,

privately owned vehicles were found to be facing a new normal in post-pandemic, and their preference is expected to increase further compared to the other periods. In addition, further studies should consider what factors directly or indirectly affect preferences to create a safe urban space and traffic conditions.

This study focused temporal shifts, with a specific emphasis on urban spatial preferences and transport mode choices. A limitation of this study lies in its inability to pinpoint detailed factors through an all-encompassing analysis of preferences across 14 urban spaces and transport modes. Consequently, forthcoming research should consider analyzing potential regional disparities in preferences, alongside demographic, social, and economic facets of the city, to yield more pertinent and applicable findings. Additionally, more profound insights can be derived by employing quantitative analysis techniques, such as difference-in-difference, to scrutinize disparities between different time periods, specifically assessing shifts attributed to the pandemic.

References

1. Aloi, A., B. Alonso, J. Benavente, R. Cordera, E. Echániz, F. González, C. Ladisa, R. Lezama-Romanelli, Á. López-Parra, V. Mazzei, L. Perrucci, D. Prieto-Quintana, A. Rodríguez and R. Sañudo (2020), "Effects of the COVID-19 Lockdown on Urban Mobility: Empirical Evidence from the City of Santander (Spain)", *Sustainability*, 12(9): 3870.
2. Cahyanto, I., M. Wiblishauser, L. Pennington-Gray and A. Schroeder (2016), "The Dynamics of Travel Avoidance: The Case of Ebola in the US", *Tourism Management Perspectives*, 20: 195~203.

3. Geana, M. V. (2020), "Kansans in the Middle of the Pandemic: Risk Perception, Knowledge, Compliance with Preventive Measures, and Primary Sources of Information about COVID-19", *Kansas Journal of Medicine*, 13: 160.
4. Harrington, D. M. and M. Hadjiconstantinou (2022), "Changes in Commuting Behaviours in Response to the COVID-19 Pandemic in the UK", *Journal of Transport & Health*, 24: 101313.
5. Kim, M. H., J. Lee and T. H. T. Gim (2021), "How Did Travel Mode Choices Change According to Coronavirus Disease 2019? Lessons from Seoul, South Korea", *International Journal of Urban Sciences*, 25(3): 437~454.
6. Lopez, B., C. Kennedy, C. Field and T. McPhearson (2021), "Who Benefits from Urban Green Spaces During Times of Crisis? Perception and Use of Urban Green Spaces in New York City during the COVID-19 Pandemic", *Urban forestry & Urban Greening*, 65: 127354.
7. Lu, H., P. Nie and L. Qian (2021), "Do Quarantine Experiences and Attitudes towards COVID-19 Affect the Distribution of Mental Health in China? A Quantile Regression Analysis", *Applied Research in Quality of Life*, 16(5): 1925~1942.
8. Marquart, H. and J. Schicketanz (2022), "Experiences of Safe and Healthy Walking and Cycling in Urban Areas: The Benefits of Mobile Methods for Citizen-adapted Urban Planning", *Transportation Research Procedia*, 60: 290~297.
9. Pawar, D. S., A. K. Yadav, N. Akolekar and N. R. Velaga (2020), "Impact of Physical Distancing Due to Novel Coronavirus (SARS-CoV-2) on Daily Travel for Work During Transition to Lockdown", *Transportation Research Interdisciplinary Perspectives*, 7: 100203.
10. Seo, J.-E. (2022, November 9), "Korea is Officially in Its Seventh Covid-19 Wave", Korea JoongAng Daily. <https://koreajoongangdaily.joins.com/2022/11/09/national/socialAffairs/Korea-Covid19-seventh-wave/20221109162810496.html>.
11. Seoul Institute (2020), "The Impact of the COVID-19 Pandemic on the Seoul Economy and Measures for Small Business Owners and the Tourism Industry", Policy Report, 297. (in Korean)
12. Shakibaei, S., G. C. De Jong, P. Alpkökin and T. H. Rashidi (2021), "Impact of the COVID-19 Pandemic on Travel Behavior in Istanbul: A Panel Data Analysis", *Sustainable Cities and Society*, 65: 102619.
13. Shamshiripour, A., E. Rahimi, R. Shabanpour and A. K. Mohammadian (2020), "How is COVID-19 Reshaping Activity-Travel Behavior? Evidence from a Comprehensive Survey in Chicago", *Transportation Research Interdisciplinary Perspectives*, 7: 100216.
14. Tsai, C. M. (2021), "Do Perceived Quality and Brand Image Still Affect Customer Satisfaction in Hospitals During the COVID-19 Pandemic?", *Journal of Business Administration*, 46(3): 1~17.
15. Ugolini, F., L. Massetti, P. Calaza-Martínez, P. Cariñanos, C. Dobbs, S. K. Ostoić, A. M. Marin, D. Pearlmutter, H. Saaroni, I. Šaulienė, M. Simoneti, A. Verlič, D. Vuletić and Sanesi, G. (2020), "Effects of the COVID-19 Pandemic on the Use and Perceptions of Urban Green Space: An International Exploratory Study", *Urban Forestry & Urban Greening*, 56: 126888.
16. Van den Berg, A. E., J. Maas, R. A. Verheij and P. P. Groenewegen (2010), "Green Space as a Buffer between Stressful Life Events and Health", *Social Science & Medicine*, 70(8): 1203-1210.
17. Yip, T. L., Y. Huang and C. Liang (2021), "Built Environment and the Metropolitan Pandemic: Analysis of the COVID-19 Spread in Hong Kong", *Building and Environment*, 188: 107471.
18. Yonhap (2022, November 26), "S.Korea's new COVID-19 Cases in 50,000 Range Amid Winter Resurgence Worries", The Korea Herald. <https://www.korea-herald.com/view.php?ud=20221126000045>.
19. KDCA (2023), "[8/23, Regular Briefing Press Release] COVID-19: One Step Closer to Normalcy", Accessed May 19, 2023. https://ncov.kdca.go.kr/tcmBoardView.do?brdId=3&brdGubun=31&dataGubun=&ncvContSeq=7266&contSeq=7266&board_id=312&gubun=BDJ.
20. KDCA (2022), "COVID-19 Domestic Outbreak Status",

- Accessed May 19, 2023. https://ncov.kdca.go.kr/bdBoardList_Real.do?brdId=1&brdGubun=11&ncvContSeq=&contSeq=&board_id=&gubun=
21. Ministry of Land, Infrastructure and Transport. (2022), "Midterm Results Released for 20s Metropolitan Transportation Survey... Public Transportation Usage Decreased by 26.8%", Accessed 21 May, 2023. <http://www.molit.go.kr/USR/NEWS>.
 22. WHO (2020), "Considerations for Implementing and Adjusting Public Health and Social Measures in the Context of COVID-19: Interim Guidance", Accessed 1 June, 2023. [WHO/2019-nCoV/Adjusting-PH_measures/2020](https://www.who.int/news-room/2020.06.01/adjusting-ph-measures-2020).
 23. WHO (2021), "Coronavirus disease (COVID-19): Ventilation and Air Conditioning", Accessed 3 June, 2023. <https://www.who.int/news-room>.

요약

COVID-19 팬데믹은 정부의 예방 및 통제 조치, 사람들의 위험 인식의 변화, 그리고 생활 방식의 변화를 통해 상당한 사회적 변화를 가져왔다. 특히, 정부의 방역정책과 도시공간의 잠재적 감염 위험에 대한 우려는 교통수단과 도시 공간에 대한 선호를 크게 변화시켰다. 이러한 변화는 COVID-19 팬데믹 이후에도 도시 공간에 지속적인 영향을 미치거나 새로운 형태로 변화할 수 있다. 따라서 본 연구는 코로나19 범유행에 따른 도시민의 이동수단 선호와 도시공간 이용 변화를 분석하여 도시공간이 현재와 미래의 감염병에 적응할 수 있는 회복탄력성과 잠재력을 탐색하고자 한다. 본고는 이동수단과 도시 공간에 대한 전반적인 선호도가 팬데믹 이전, 팬데믹 중, 팬데믹 종료에 따라 유의미하게 차이가 있다는 것을 확인하였다. 팬데믹 기간 동안 안전하다고 인식되는 개인 소유 차량과 녹지 공간을 제외하고는 전반적인 이동수단과 도시 공간에 대한 선호도가 감소하였다. 특히, 이동수단과 도시 공간에 대한 유행 중 선호도는 팬데믹 전에 비해 5배 가량 낮게 나타났다. 팬데믹 당시 긍정적으로 인식되었던 녹지 공간과 의료시설이 팬데믹 이전 선호도 수준으로 돌아올 것으로 예상되나, 다른 도시 공간 요소들은 뉴노멀을 맞이한 것으로 보인다. 본 결과는 코로나19 팬데믹이 도시민의 이동 수단과 도시 공간 선호에 큰 영향을 미쳤음을 시사한다.

주제어 : 코로나19, 이동수단 선택, 도시 공간, 위험인식, 팬데믹
