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Mobility Patterns of International Tourists: Implications for Responsible Urban Tourism

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ABSTRACT: Up until the height of the COVID-19 pandemic, the rapid growth of tourism in popular urban destinations around the globe saw the effects of chronic overcrowding and the breaching of acceptable limits of change imposed on local communities. Overtourism became prominent, intensifying amplified calls for planning and development regimes that emphasize responsible and sustainable tourism growth. In Japan, the term "tourism pollution" emerged as a response to untrammeled growth in cities like Kyoto, Tokyo and Osaka. Understanding the mobility of international tourists in urban contexts is raised here as one way to come to terms with urban overcrowding, particularly in hotspots where popular attractions predominate. In examining international tourist mobility, we argue that spatial and temporal behaviors can be constructive toward the responsible planning and development of urban tourism. Japan's second most populated city Osaka is the context for this research with GPS big data collected in partnership with one of the country's foremost navigation app developers. American, Chinese, and South Korean tourist mobility patterns were observed with the evidence pointing out that overcrowding evident at iconic attractions was largely influenced by public transport networks in the city. Evidently, there were distinct differences between the three groups of tourists highlighting that spatio-temporal behavior varied according to the tourist's country of origin. The findings from this research are instructive to urban tourism stakeholders including policy makers, destination marketing organizations (DMOs), and public transport providers and can help inform responsible and sustainable urban tourism planning and development.

KEYWORDS: urban tourism; overtourism; tourist mobilities; tourism planning; responsible tourism; tourism pollution

Introduction

Tourism is one of the pillar industries of Japan's economic development, contributing 10.3% of the country's total gross domestic product (GDP) in 2019; one in four new jobs in Japan have been created by travel and tourism over the last five years (World Travel & Tourism Council [WTTC], 2020). The Japanese government has actively promoted inbound tourism

since the launch of the "Visit Japan" campaign in 2003 and this has helped grow international visitation. The number of inbound tourists has exceeded the number of outbound tourists since 2015; in 2019, 31,882,049 international tourists visited Japan as compared to 5,211,725 in 2003 (Japan National Tourism Organization [JNTO], 2020a). Osaka, the country's second most populous city, is located in the southwest of the country. As it connects major Japanese tourist destinations, such as Kyoto, Nara, and Kobe, and has been a thriving business city for centuries, Osaka attracts millions of international tourists annually (Fig.1). Like many urban tourist destinations, Osaka is home to popular attractions, like Universal Studios Japan, the Umeda Sky Building, and Dotonbori Street, as well as historical sites, like Osaka Castle and Tsutenkaku Tower. In 2019, international tourists to Osaka Prefecture came from China (45.8% of the total), South Korea (13.1%), and the United States (4.0%), among others (Osaka Prefectural Government, 2020). Up until 2019, international tourist visitation to Osaka Prefecture had consistently expanded and reached 12,306 thousand in 2019—an 8% increase from the previous year (Osaka Prefectural Government, 2020).

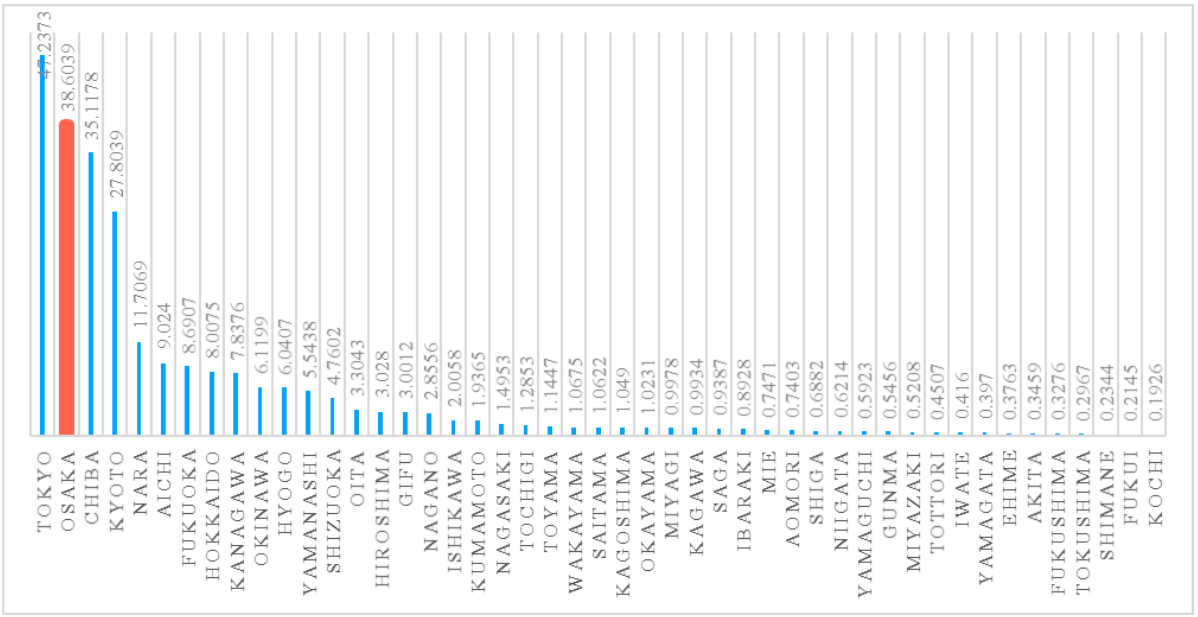


Figure 1: The international visit rate among all prefectures in Japan, 2019 (JTA, 2020)

The rapid growth of tourism in popular urban centers has led to a growing demand for the development of sustainable strategies (Bauder & Freytag, 2015). Many cities are experiencing the pressures of too much tourism (Blázquez-Salom, Blanco-Romero, Gual-Carbonell, & Murray, 2019)—faced with the dilemma of balancing residents' needs with tourist desires (Supak, Brothers, Bohnenstiehl, & Devine, 2015). Greater numbers of urban tourists alongside a dearth of effective management has led to overcrowding in popular cities, negatively shaping local residents' attitudes toward tourism development (Milano, Novelli, & Cheer, 2019; Seraphin, Sheeran, & Pilato, 2018), and hindering the chance of responsible and sustainable tourism growth.

Cities are characterized by density and diversity, and in turn, this attracts tourists interested in urban aesthetics (Ashworth & Page, 2011). According to Edwards and Griffin (2013), "cities perform a range of functions that play an important role in providing visitors with satisfying and fulfilling experiences of the city as a tourist destination," one of which is "facilitating feelings of being comfortable in an unfamiliar place" (p. 580). In fact, a series of surveys

showed that 73% of international tourists were first time visitors to Osaka in 2016 (Osaka Tourism Bureau, 2017). Accordingly, to optimize tourist satisfaction, understanding how to manage tourist flows and alleviate pressure points at the city level is vital (Ashworth & Page, 2011). This requires local government and tourism associations to understand overall tourist behavior and mobility patterns, and to work collaboratively (Edwards, Dickson, Griffin, & Hayllar, 2010; Hallo et al., 2012).

Against this background, we assume that a better understanding of international tourists' mobility patterns can help resolve problems of overcrowding at popular tourist hotspots (Ashworth & Page, 2011; Bauder & Freytag, 2015). To accurately identify tourists' mobility patterns, we pose three interrelated research questions:

1. To what extent do international tourists from different countries share preferences in desired attributes of urban destinations?
2. Do international tourists show the same extent of interest toward the destination regardless of their countries of origin?
3. Do international tourists demonstrate the same spatio-temporal behaviors regardless of their countries of origin?

To answer these questions, three linked studies were conducted in Osaka City, comprised firstly of graphical representations of tourist locations (Study 1); secondly, analysis of different activity areas of international tourists (Study 2); lastly, analysis of the stock and flow of tourists (Study 3). Importantly, this research is exploratory in nature predicated on testing an approach to understanding tourism mobility. Consequently, the reportage here is largely descriptive with theory development largely outside the scope of this work, and slated to be in the next instalment of this endeavor.

While questionnaire-based survey research serves as the main method for understanding tourists' preferences and behavior characteristics (Albaladejo-Pina & Díaz-Delfa, 2009; Liao & Chuang, 2020), it has been noted to lack accuracy (Hallo et al., 2012). The emergence of advanced tracking technologies using global positioning system (GPS) data loggers is a milestone in tourist mobility studies and is now seen as a more reliable means of understanding tourist mobility (Shoval & Ahas, 2016; Shoval et al., 2010). However, Li, Xu, Tang, Wang, & Li (2018) argue that a major disadvantage is that its small sample size, often results in bias and inaccuracy. Furthermore, data collected from social media are also widely used to analyze tourists' preferences (Leung et al., 2012); however, this type of data is nonlinear, preventing policy makers from understanding tourists' flow as a whole. To overcome these limitations, we employ GPS "big data" collected via a mobile application provided to international tourists focused on transport information. As a data source, it draws from 6,854,629 location records in the wider Osaka Prefecture and 5,925,302 location records in Osaka City from Chinese, Korean, and American tourists collected between April 2016 and March 2017 (this data was a one-off initiative to develop baseline understandings—further aligned research is ongoing).

Until now, the JNTO and Osaka Tourism Bureau have tailored numerous campaigns to tourists depending on their country of origin and the generalized behaviors associated with them. However, this relies on stereotypes and ignoring the diversity of Osaka's inbound tourism market. The findings of this research can help local government, Destination Marketing Organizations (DMOs), and wider tourism industry to better understand

international tourists spatial and temporal behaviors. Additionally, the public transportation system plays a crucial role in responsible tourism management because both local residents and international tourists rely heavily on it to move around the city. Unlike previous work in this field, we applied GPS big data rather than sample-based survey data. The findings, therefore, closely reflect real-world scenarios and can be easily applied to other urban destinations.

Literature Review

Tourists' mobility in destination management

An accurate knowledge of tourist mobility is key to developing a sustainable tourism destination (Zhao, Lu, Liu, Lin, & An, 2018). Mobility patterns reflect tourist preferences and can be used to segment the tourism market (De Cantis, Ferrante, Kahani, & Shoval, 2016; Tchetchik, Fleischer, & Shoval, 2009), predict tourist flow (Xia, Zeephongsekul, & Packer, 2011; Zheng, Huang, & Li, 2017), develop strategies to reduce congestion (An, Yang, Wang, Cui, & Cui, 2016; Bauder, 2015), and assist the government in constructing a tourist-friendly environment (Edwards & Griffin, 2013; Bauder & Freytag, 2015). The idea of recognizing, mapping, and explaining distinctive functional spatial patterns within cities originated with the demarcation of central business districts in the United States (Murphy & Vance, 1954); however, most of these early studies focused on supply side factors rather than tourist demand (Ashworth & Page, 2011). According to Creswell and Merriman (2011), in the field of transport geography from the 1960s to 1970s, mobility research was dominated by the position of "rational mobile persons", defined as those who decide when and how movement occurs. Here, however, mobility is understood as a movement in space by individuals (Bauder & Freytag, 2015, p. 683).

Tourist mobility is an essential concern in tourism (Xia et al., 2011), especially enquiries into urban destination development (Edwards & Griffin, 2013). In their study into tourist mobility, Espelt and Benito (2006) questioned tourists about their length of stay, the time taken for the visit, the time taken to walk to the site, the route walked, and the total distance walked. The mobility-related information was not recorded by GPS loggers but instead, by survey and observation. In contrast, Shoval and Isaacson (2007) pioneered the digital method of tracking tourists' movements by Bluetooth GPS and other advanced tracking technologies, thereby opening up a new perspective for tourist mobility research (Bauder & Freytag, 2015). Exploring further than tourists' spatial and temporal behaviors, Tchetchik et al. (2009) combined spatio-temporal analysis with surveys and segmented visitors based on their decision-making processes. Their research introduced a novel method for better understanding tourist behaviors and provided practical implications for destination management.

Tourist mobility tracking using digital methods is still a relatively young research field; however, the number of studies has grown rapidly since 2010. Movement patterns examined typically include inter-destination movement, which refers to tourists moving from one destination to another, and intra-destination movement, which refers to tourists transferring between attractions within a destination or moving around within an attraction (Zhao et al., 2018). In addition to advanced tracking technologies, such as GPS loggers, social big data (geotagged tweets) has emerged as a distinct digital approach for tracking tourist mobility

(Hardy et al., 2017; Hardy, 2020). Analyses of tourist mobility patterns tend to focus on three main aspects: spatial, temporal, and spatio-temporal behavior (Li et al., 2018). For example, some studies examine urban tourist behaviors using spatial analysis and semi-structured interviews (Bauder & Freytag, 2015; Edwards & Griffin, 2013), whereas others investigate time spent in locations and their intra-diurnal temporal patterns using temporal analysis (Birenboim, Anton-Clavé, Russo, & Shoval, 2013). Most studies, however, employ spatio-temporal analysis to explore tourist mobility patterns (De Cantis et al., 2016; Grinberger & Shoval, 2018; McKercher, Shoval, Ng, & Birenboim, 2012) because it provides a more comprehensive understanding of tourist behaviors than spatial or temporal behavior alone (Zakrisson & Zillinger, 2012). Over time, focus has also changed from an emphasis on methodological contributions to the practical implications for sustainable tourist destination development and destination management.

GPS big data and sustainable urban tourism development

In regard to researching tourist mobility, GPS logger tracking has become a widely used for data collection and has significant advantages in terms of accuracy and richness of information about tourist mobility patterns. However, despite the advantages of obtaining demographic information from samples, the data remain somewhat biased and goal-oriented, and sample sizes tend to be limiting (Li et al., 2018). Big data, which can be viewed as ushering in a new era of the data-driven paradigm, has opened up new possibilities for understanding overcrowding (An et al., 2016). Big data used in destination management can be generally categorized into social big data and GPS big data (Li et al., 2018). With the development of social media, social big data (collected, for example, from Twitter and Flicker) is receiving increasing attention due to the advantages of its low cost and large sample size. Oku, Hattori, & Kawagoe (2015), for instance, identify popular tourism spots with geotagged Twitter data and Chua, Servillo, Marcheggiani, & Moere (2016) apply geotagged Twitter data to track tourist spatio-temporal flows. Social big data has also been used to explore tourist preferences and generate tourist-based knowledge relevant to destination management (Leung et al., 2012; Zhou, Xu, & Kimmons, 2015). However, this type of data is nonlinear, which prevents researchers and policy makers from understanding tourist flow.

GPS-enabled mobile applications are a significantly less expensive means than GPS loggers (Li et al., 2018) of providing a comprehensive view of tourist movement tendencies and understanding tourist flows with time series. Li, Xiao, Ye, Xu and Law (2016), for example, employ GPS big data and location-based sensors to understand tourist flows in historic Chinese towns through space syntax analysis following time series. Their study examines the relationship between street network integration and the urban fabric, as well as tourist preferences, resulting in a theoretical model and approach to better understanding tourist spatial mobility. With a view to resolving congestion problems in an urban destination, An et al. (2016) detect transportation congestion using GPS trajectory data collected from taxis in Harbin, China. Although GPS big data effectively provides real-case scenarios, few scholars and practitioners have applied this data to strategic decisionmaking in tourism destination management.

Methods

Public transportation and tourist attractions in Osaka City

As the second most populous city and major business center of Japan, Osaka has a highly developed public transportation system, comprising of the Osaka Metro (Midosuji, Yotsubashi, Sennichimae, Nagahori Tsurumi-ryokuchi, Tanimachi, Chuo, Sakaisuji, and Imazatosuji lines and New Tram), Osaka City Bus, Japan Railway (JR) West, and five large private railway companies (Kintetsu, Hankyu, Hanshin Electric, Keihan Electric, and Nankai Electric). Osaka Metro's Midosuji, Tanimachi, and Chuo lines and the JR loop line are most frequently used by local residents because they link the office parks (for example, Osaka Business Park Station, Honmachi Station, Yodoyabashi Station, and Tanimachi 4-chome Station) and key commercial areas (for example, Umeda and Namba). The lines of Hankyu Kyoto, Hankyu Kobe, Keihan, JR Kyoto, JR Kobe, Kintetsu Nara, and Nankai are also heavily used by Osaka residents to commute to surrounding cities including Kyoto, Kobe, Nara, and Wakayama.

To examine international tourist mobility patterns in inner Osaka City, this research partitions the city into six regions based on the major tourist attractions promoted by the Osaka Tourism Bureau and where primary transportation interchanges are located (Fig. 2). The six regions are Shin-Osaka, West Bay, Umeda, East Castle, Southern-Central Namba, and Southern. The Shin-Osaka region was chosen because it contains the Shinkansen (bullet train) terminal station. The Umeda and Southern-central Namba regions were partitioned because of their important transportation interchange points and commercial areas, while the West Bay, East Castle, and Southern regions contain iconic and heavily visited attractions.

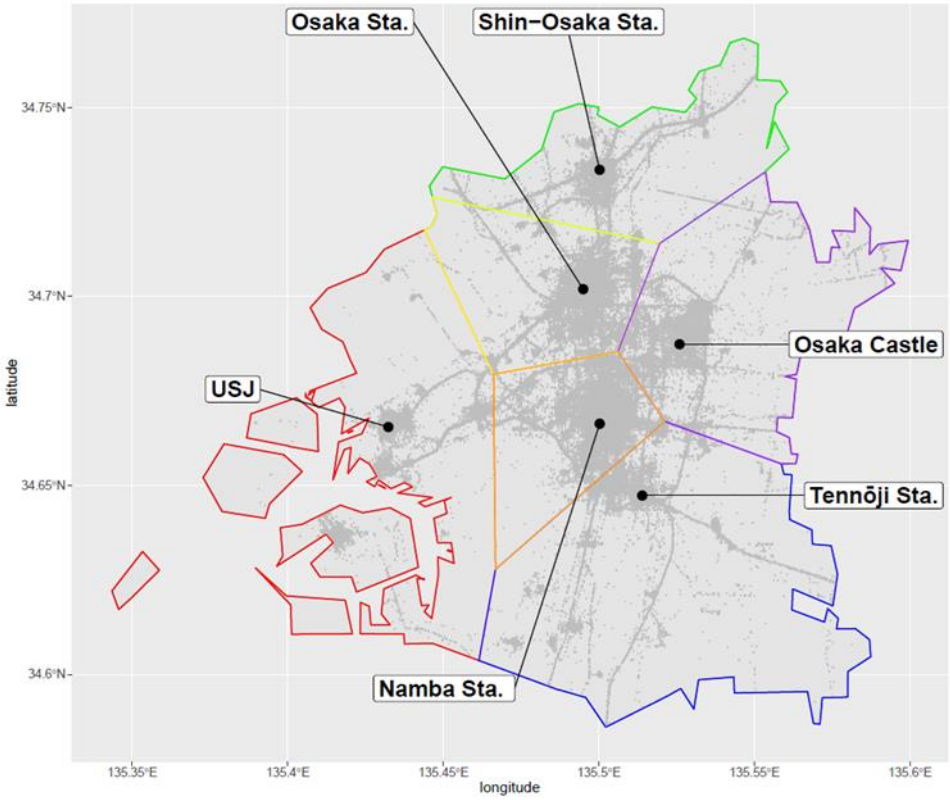


Figure 2: Six regions of Osaka City

Notes: Green indicates “Shin-Osaka region”; red indicates “West Bay region”; light yellow indicates “Umeda region”; purple indicates East Castle region”, dark yellow indicates “Southern-central Namba region”; blue indicates “Southern region”.

Data collection

The data collected was drawn from international tourists use of mobile app, "NAVITIME for Japan Travel" from April 2016 to March 2017 (as of March 20, 2019, it was renamed as "Japan Travel by NAVITIME"). This GPS-enabled mobile app was developed by NAVITIME JAPAN Co. Ltd., a leading company in transport information provision and route direction through mobile phone devices. During the data collection period, the app's main functions comprised providing information on transportation routes and the location of services typically sought by international tourists (for example, tourist information centers, foreign currency exchanges, and automated teller machines). The app operated principally in English, and only selected words were translated into Korean, simplified Chinese, and traditional Chinese (see Appendix).

NAVITIME JAPAN recorded only the movements of app users who agreed to data collection before using the app. The users' personal information, except for nationality and gender, was not recorded. Moreover, users could choose to be tracked all the time or only when using the app. The user's location was recorded approximately every two minutes when they authorized tracking. A new location was recorded only when the user moved more than approximately 200 meters from the last recorded location. Recording of the user's location stopped when the user's mobile device was turned off or when the user was in a basement or inside a building where GPS tracking was not technically possible. If only one or two location records existed in a one-square-kilometer mesh during the data collection period, the company deleted these records to protect user privacy. In addition, the user's identification code (anonymous user ID) was changed at 3 a.m. daily to limit constant tracking of the user's movements.

Data description

After filtering the anonymous user IDs with abnormal location records, the dataset included 6,854,629 location records across 114,134 user IDs in Osaka Prefecture. Of these records, 5,925,302 location records (86.4% of all the records) across 105,194 user IDs (92.2% of all the user IDs) were positioned in the Osaka City region. As a result, the total number of location records for this research was 1,389,566, with 562,316 records from American tourists, 267,789 from Chinese tourists, and 559,461 from South Korean tourists.

Before unique users were distinguished by daily anonymous user ID, NAVITIME JAPAN defined the status of each location record as - "short-stay," "stay," "break," or "other" - each of which signified the period of time that a unique user was situated in a particular one-square-kilometer mesh. Specifically, a consecutive sequence of location records in a one-square-kilometer mesh between 10 minutes and 30 minutes was labelled as "short-stay," between 30 minutes and seven days as "stay," and for more than seven days as "break." The other location records were labelled as "other." Based on the time span definitions, "other" and "short-stay" were understood as tourists moving, for example, taking public transportation or walking. "Stay" suggested tourists' activities at a particular site or their accommodation during their visit to Osaka.

Based on the status of location records, we defined the status of anonymous user ID as "stay" if the user ID contained at least one "stay" location record for a specified period of time in a specified region (either Osaka Prefecture or Osaka City). Otherwise, the status of a user ID

for the specified period of time in the specified region is defined as Non-stay. Table 1 summarizes the characteristics of samples in the dataset.

Table 1: Characteristics of samples in the dataset

	The number of location records			
	USA	China	South Korea	Total
Total	562,316	267,789	559,461	1,389,566
Status				
Break	2,145	0	0	2,145
Stay	403,672	188,282	405,517	997,471
Short-Stay	48,058	19,274	52,011	119,343
Other	108,441	60,233	101,933	270,607
	The number of user IDs			
	USA	China	South Korea	Total
Total	8,321	6,107	6,312	20,740
Status of user ID for a day in Osaka prefecture:				
Stay user ID	5,446	3,994	5,150	14,590
Non-stay user ID	2,875	2,113	1,162	6,150
Status of user ID for a day in Osaka city:				
Stay user ID	4,892	3,638	4,872	13,402
Non-stay user ID	2,650	1,900	1,172	5,722
Gender:				
Female	3,199	3,454	2,720	9,373
Male	5,102	2,632	3,583	11,317
NA	20	21	9	50
The number of days elapsed:				
1 day	1,240	1,285	1,757	4,282
2 days	1,022	874	1,460	3,356
3 days	942	779	1,268	2,989
4 days	926	683	887	2,496
5 days	855	641	420	1,916
6 days	768	544	195	1,507
7 days	679	430	130	1,239
8 days	559	314	76	949
9 days	421	219	43	683
10 days	320	146	33	499
11 days	233	81	20	334
12 days	172	46	11	229
13 days	109	33	5	147
14 days	55	21	3	79
15 days	20	11	4	35

Fig. 3 plots the data on a map of Osaka Prefecture, illustrating the mobility of American, Chinese, and South Korean tourists. The map indicates that the studied cohorts tended to spend their vacation in Osaka City where the most popular attractions are located.

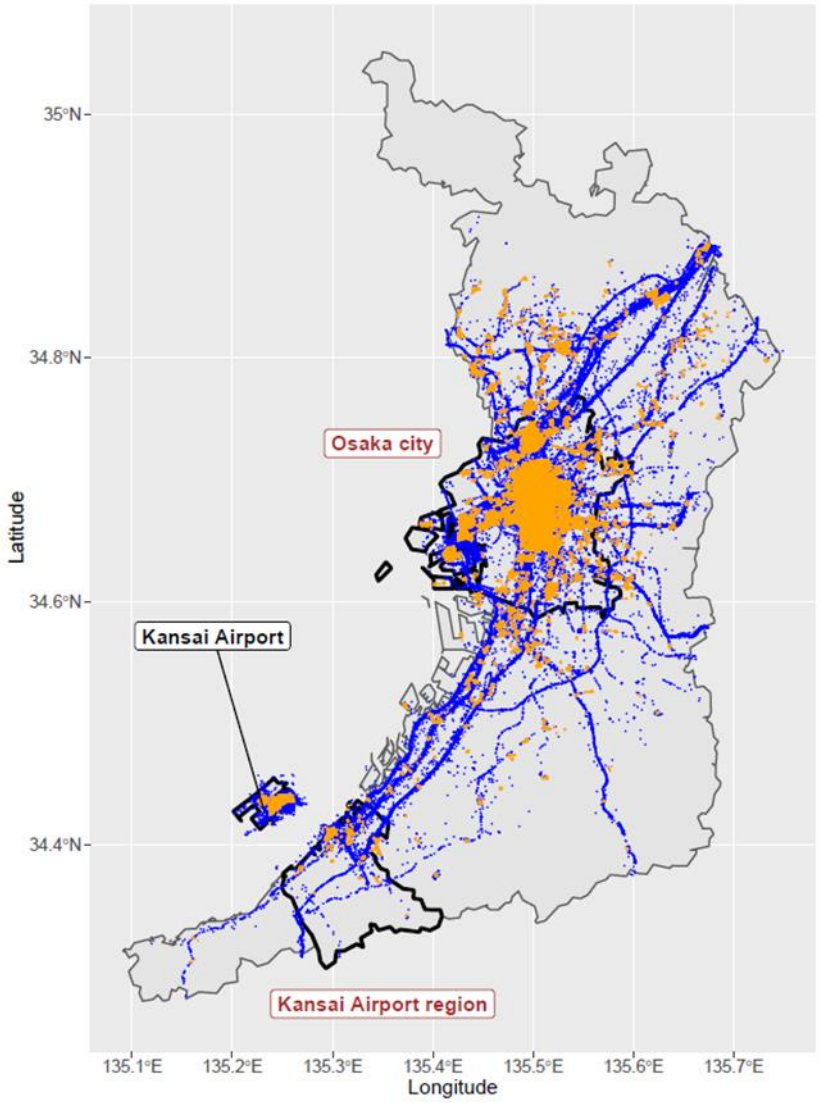


Figure 3: Plot of location records in Osaka Prefecture

Note: Orange indicates "stay" records. Blue indicates "short-stay" and "other" records.

Methodology of data analysis

Both hotspot analysis and path analysis were used to explore international tourist mobility patterns. In hotspot analysis, the recorded points are not connected to form lines but aggregated directly by counting the number of points within a cell (Bauder & Freytag, 2015). In path analysis, single points are typically connected to form a line following the recorded order (Bauder & Freytag, 2015). However, because of the need to maintain privacy of participants, it was forbidden to track individual tourists during their visit. For this reason, instead of reconstructing an individual tourist's path, movement within the six regions were categorized according to the four durations of movement outlined above (short-stay, stay, break, and other), and the movements were grouped according to the tourist nationality.

Hotspot analysis was used in Studies 1 and 2 to ascertain international tourists' travel preferences and compare the different movement ranges of Chinese, South Korean, and American tourists. Path analysis was used in Study 3 to better understand the daily spatial and temporal behaviors of tourists from the three countries, which in turn can help to resolve overcrowding problems in urban destinations. All data analyses were processed using R statistic packages (Fig. 4 presents the methodological flowchart).

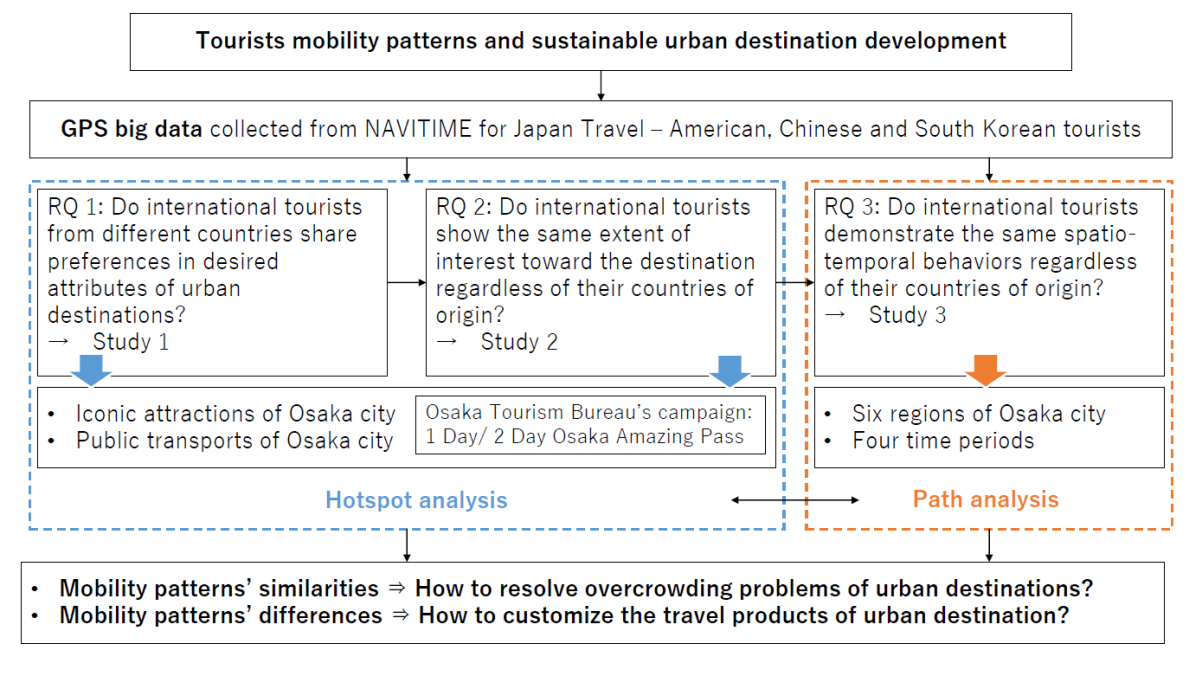


Figure 4: Methodological flowchart

Results

Study 1: International tourists' travel preferences in Osaka City

In the first study, the spatial distribution of location records was examined by plotting the records over Osaka City for each nationality. Based on the analysis results for "stay" location records (Fig. 5), which indicate tourists' activity spots, the spatio-temporal patterns of American, Chinese, and Korean tourists reveal a concentration around iconic attractions and places in Osaka City, including Osaka Castle, Universal Studios Japan, Osaka Aquarium Kaiyukan, and Tsutenkaku Tower. Tourists of all three countries also tended to spend time at Osaka's main terminal train stations—Osaka, Namba, and Tennoji, which also contain shopping centers and historical tourism sites. Notably, though there are few tourist attractions and shopping centers near Shin-Osaka station, this place still attracts numerous international tourists because it is a terminal station of the Shinkansen. Consequently, it can be inferred that tourists studied preferred to stay at hotels near the Shinkansen terminal station.

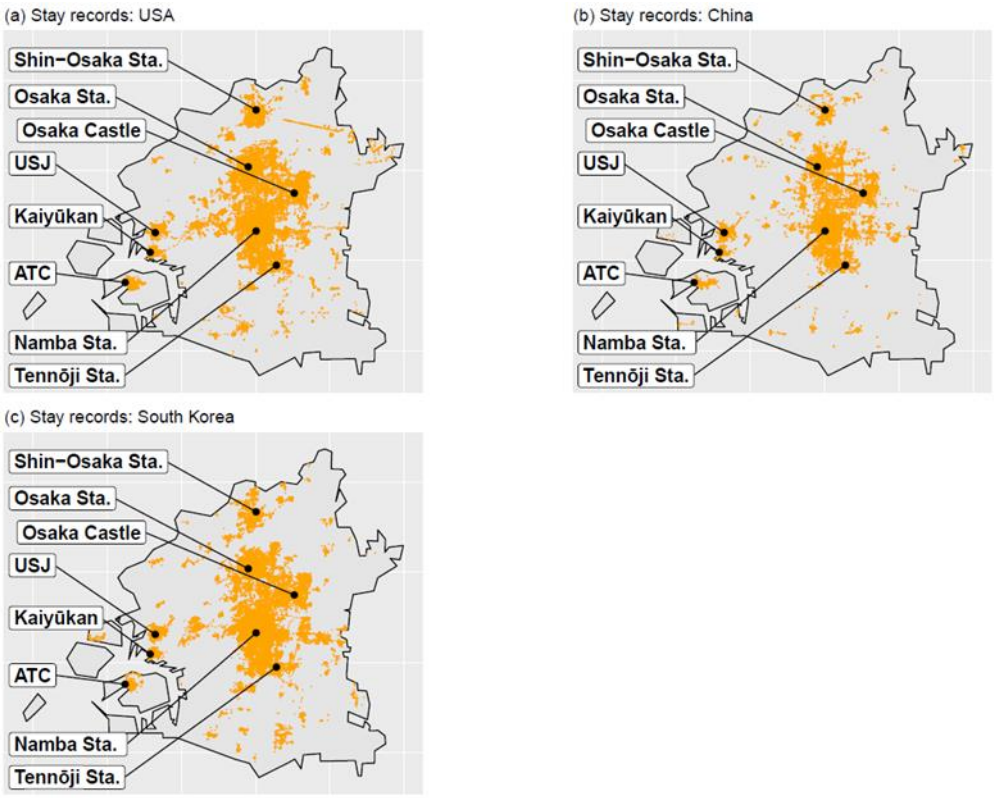


Figure 5: Plot of "stay" location records in Osaka City.

The results of the "other" and "short-stay" location records indicate where and how the tourists moved around Osaka City (Fig. 6). First, the most heavily used means of public transportation were the Chuo and Midosuji lines of the Osaka Metro and the Loop and Yumesaki lines of JR West because they link popular tourist spots and the terminal stations of Osaka City. For example, the Chuo line directly connects Osaka Castle and Osaka Aquarium Kaiyukan; the Midosuji line directly links the Umeda and Namba areas, which contain numerous shopping centers; the Loop line passes the Tsutenkaku Tower, Tennoji station, and Osaka station; and the Yumesaki line is the most convenient transportation option from Osaka station to Universal Studios Japan. As indicated by the "stay" location records mentioned above, the tourists also preferred to take the Shinkansen to destinations outside Osaka Prefecture. This result is specifically significant in the case of American tourists. The average length of stay in Japan for Americans was 7.5 days in 2016, compared with Chinese who stayed 5.9 days and South Koreans 2.9 days (JNTO, 2020b). This relatively long visit implies that Osaka City was not the only destination for American tourists and that they tended to use the Shinkansen to move to or from other destinations. Overall, however, the analysis results of the "other," "short-stay," and "stay" categories show no significant differences in preferences among American, Chinese, and South Korean tourists, despite their diverse cultural backgrounds.

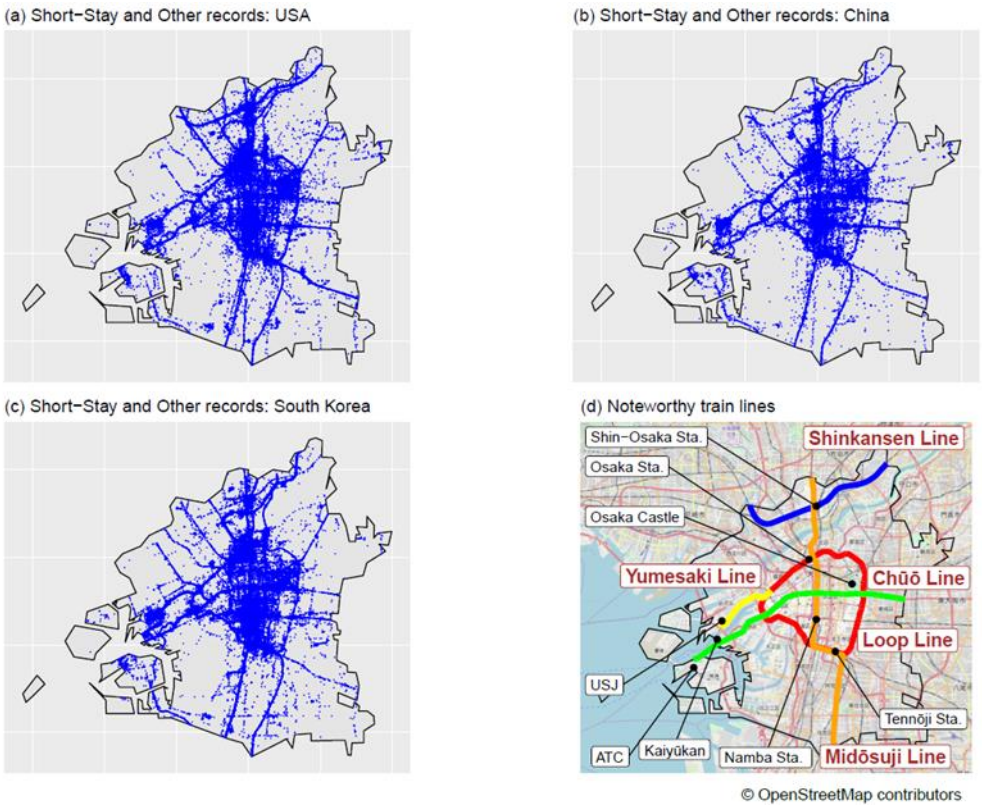


Figure 6: Plot of "Other" and "Short-Stay" location records in Osaka City.

Study 2: International tourists' extent of interest in Osaka City

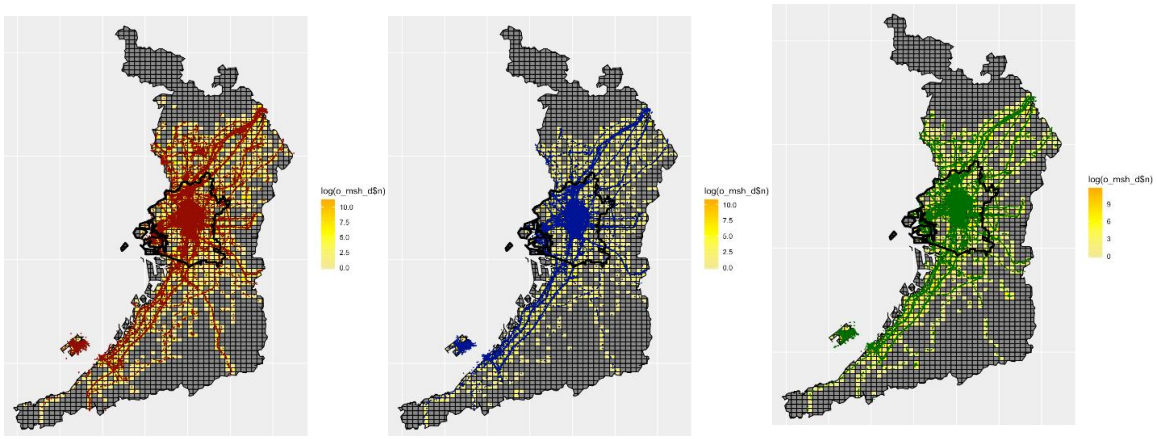
While Study 1 explored the travel preferences of international tourists and the main forms of public transportation they used, it did not provide enough information to understand tourists' mobility patterns. To do so, it is necessary to ascertain the range of tourists' movement and not only focus on tourist hotspots (Bauder & Freytag, 2015). The range of international tourists' mobility reflects their willingness to explore the city and, to some extent, their travel style. An advantage of GPS tracking is the accuracy with which it can record tourists' actual and real-time movements, reflecting, in this study, American, Chinese, and South Korean tourists' travel behavior.

To compare the degree of spatial dispersion in Osaka City between tourists of the three countries, the number of squares of one-kilometer mesh with location records for tourists from each country was counted. The moving range within Osaka Prefecture was also used as auxiliary data to provide a full picture of the tourists' mobility. Fig. 7 graphically displays the results; in each figure, yellow squares represent areas that include at least one location record for the respective country. The larger the colored squares, the wider the range in which the tourists have moved. Based on the analysis results, American tourists tended to disperse widely than Chinese and South Korean tourists in both Osaka Prefecture and Osaka City. However, as there were more Americans than Chinese or South Korean tourists, the large number of tourists may have positively influenced the range of mobility. For this reason, the total number of each country's yellow squares was linearly adjusted by the number of user IDs to compare the moving ranges assuming that the number of tourists is the same among the three countries. With this simple adjustment, Chinese tourists were found to have the widest range of movement, followed by South Koreans and then Americans in both Osaka

Prefecture and Osaka City (Table 2). In other words, Chinese tourists showed the most interest in the city and were curious to explore the whole city during their visit. It can also be inferred that in moving further, their used of public transportation intensified.

Osaka prefecture:

(a) United States (b) China (c) South Korea



Osaka city:

(a) United States (b) China (c) South Korea

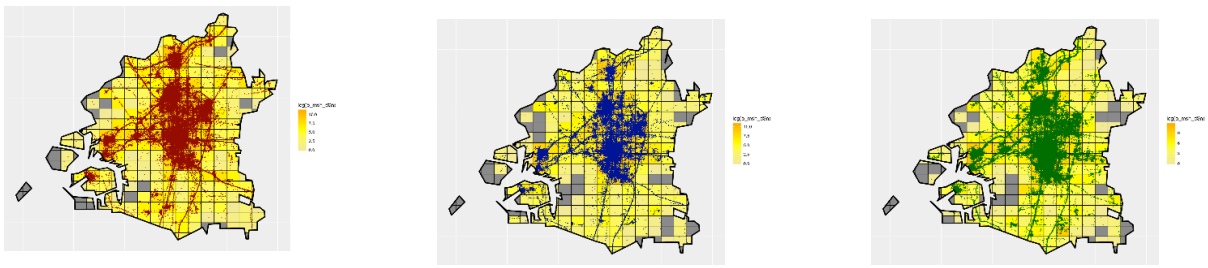


Figure 7: One-square-kilometer meshes that cover all location records

Table 2: Counts of squares of one-kilometer mesh that cover all location records

	Osaka prefecture			Osaka city		
	USA	China	South Korea	USA	China	South Korea
The number of squares that cover location records	981	854	791	232	214	222
Comparison to the number for South Korea	125%	110%	100%	105%	97%	100%
The total number of user IDs	8,321	6,107	6,321	7,542	5,538	6,044
Comparison to the number for South Korea	134%	99%	100%	127%	94%	100%
Weighted percentage	94%	112%	100%	84%	105%	100%

Study 3: International tourists' flow and spatio-temporal behaviors in Osaka City

The previous two studies examined tourists' travel preferences and styles, finding that they are similar among international tourists from different countries. The results also suggest the importance of reducing congestion not only around iconic attractions but also in regards to public transportation. Russo (2002) states that understanding tourist movement can help local

governments to resolve overcrowding problems. Edwards and Griffin (2013) similarly emphasize that a better awareness of tourist movement can inform changes in public transportation and the development of sustainable urban destinations. Accordingly, Study 3 was conducted to examine how international tourists flowed between the six regions of Osaka City (tourist flow) and how they planned their time there (tourists spatio-temporal behavior). Moreover, because destinations can be improved according to the preferences of different tourist demographics (Lew & McKercher, 2006), demographic variables were used to analyze tourist mobility patterns. "Gender" is a demographic variable that relates particularly closely to tourist preferences (De Cantis et al., 2016; Espelt & Benito, 2006). Therefore, gender was assumed to influence tourist spatio-temporal behaviors and was added as a characteristic to provide a more comprehensive tourist profile.

Tourist flow between the six regions in Osaka City and the out-of-city region (i.e., the set difference of Osaka Prefecture and Osaka City) are graphically summarized in Figure 8. To create these subfigures, we computed the percentage of the number of transitions during a specific four-hour period to the number of "stay" user IDs in Osaka Prefecture for each nationality. Only the routes with a 2% or higher percentage of transitions are presented by arrows in each figure. The thin arrows refer to flows of between 2% and 6% of the total user IDs; the thick arrows signify flows of between 6% and 10%; and the single thick red arrow represents a flow of more than 10%. The key findings are summarized as follows. First, American tourists actively flowed in and out of the Shin-Osaka region from 9 a.m. to 3 p.m. (Fig. 8: USA, b). Second, Chinese tourists did not actively move across different regions during the early daytime, but they actively moved in and out of the Umeda and Southern-central Namba regions from 3 p.m. to 9 p.m. (Fig. 8: China, a and c). Third, South Korean tourists actively moved in and out of the six regions from 9 a.m. to 9 p.m., with a particular concentration in the Shin-Osaka, Umeda, Southern-central Namba, and Southern regions (Fig. 8: South Korea, b and c).

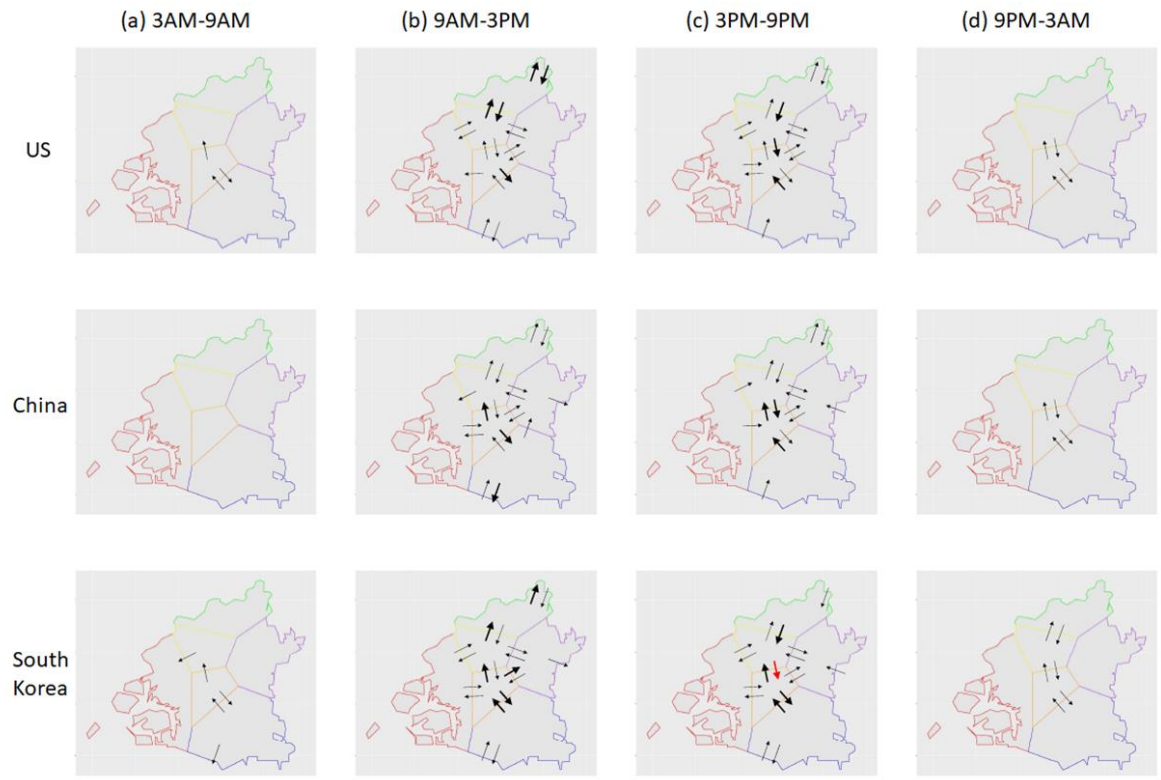


Figure 8: Routes where active transitions by tourists between two regions occur.

In addition to the tourist flows among the six regions of Osaka City, demographic characteristics also appeared to influence their temporal and spatial movements (Fig. 9). In Fig. 9, the vertical axis corresponds with the number of "stay" user IDs in a specific one-hour interval divided by the number of "stay" user IDs in Osaka Prefecture for a specific country-gender combination. The analysis results show variations in spatio-temporal movements according to both nationality and gender. For example, in the Shin-Osaka region, the percentage of user IDs tended to be relatively high for Americans (particularly male). South Koreans showed significant daytime movement in the West Bay region where Universal Studios Japan and Osaka Aquarium Kaiyukan are located, and they moved to the commercial areas of Umeda and Southern-central Namba at night. Notably, in the Southern-central Namba region, South Koreans made up the highest percentage of tourists at all times. Chinese females spent less substantial time in the East Castle region and immediately moved to other regions—a spatio-temporal behavior that reveals their low interest in this historical site. Compared with Chinese and American tourists, male South Korean tourists spent a longer time in the south region at night, which may be their accommodation location.

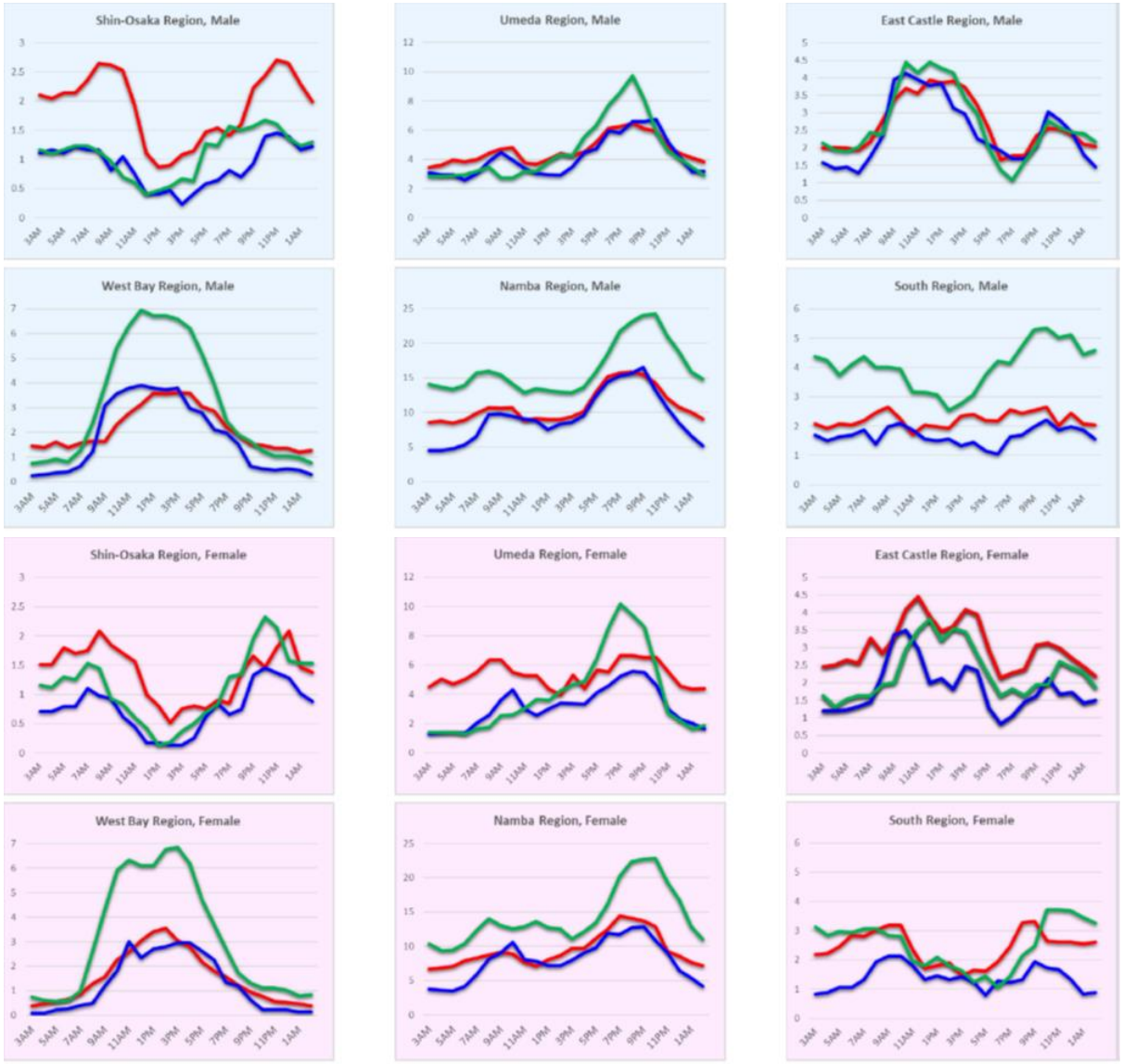


Figure 9: Changes in the number of "stay" users in each region.
Note: Red signifies US; Blue signifies China; Green signifies South Korea.

Discussions

The growth of tourism in popular cities presents various challenges, particularly overcrowding which can influence the quality of life for residents and tourist satisfaction. However, the notion of responsible tourism and sustainable development in urban destinations has been largely neglected (Timur & Getz, 2009). Urban destinations are multi-functional (Kádár, 2014) and include not only attractions but also complex public transportation systems (Edwards & Griffin, 2013). For sustainable tourism development to be workable in urban destinations, the wide spectrum of stakeholders with divergent interests must participate in the process of tourism planning and development (Timur & Getz, 2009). To achieve the goal of responsible tourism management and avoid untrammeled growth in cities, a bottom-up approach is necessary (Macleod & Todnem, 2007), including, for example, a comprehensive understanding of international tourist mobility patterns. It is also essential that stakeholders (such as DMOs and public transportation companies) work in partnership

(Welford, Ytterhus, & Eligh, 1999) and that different levels of governments (Eligh, Welford, & Ytterhus, 2002) lead in resolving contentious issues.

[RQ1] Do international tourists from different countries have the same preferences in an urban destination?

Study 1 found that international tourists not only prefer to visit iconic attractions and famous commercial regions (Study 1: Fig. 5) but also tend to use similar public transportation options for movement (Study 1: Fig. 6) regardless of nationality and cultural background. Previous studies have shown that tourists' national culture influences their travel behavior to the extent that tourists from culturally similar origins tend to have similar travel preferences (Wong, 2015). However, in contrast to previous research (e.g., Kim & McKercher, 2011; Wong, 2015), the results of Study 1 indicate that different cultural and national backgrounds (Eastern culture: Chinese tourists and South Korean tourists, and Western culture: American tourists) do not appear to affect tourists' preferences. Extant research (e.g., McKercher et al., 2012) also reveals that tourists, especially first-time visitors, are eager to visit famous sites, which can result in overcrowding - according to the Osaka Tourism Bureau (2017), more than 70% of international tourists were first-time visitors. The findings of Study 1 support the conclusion that travel experience has a greater influence on tourists' preferences than cultural and national background.

This research extends previous studies that have focused exclusively on overcrowding problems at tourism attractions by highlighting the issue of overcrowding on public transportation, specifically on modes of transport that directly link iconic attractions. Building a sustainable urban destination requires reducing congestion not only in iconic locations but also on public transportation. It is crucial for policy makers, DMOs, public transportation companies, and other stakeholders to know exactly when and which modes of transportation are impacted by tourist usage. In the case of Osaka City, the results might be attributed to the "1-day/2-day Osaka Amazing Pass," which does not distinguish between popular and less popular routes. Hence, this study's findings can help both the Osaka Tourism Bureau to improve their marketing promotions and the main public transportation companies to resolve overcrowding problems. Instead of overemphasizing different tourists' interests based on national stereotypes, the Osaka Tourism Bureau is advised to develop and promote a wider range of tourist sites in their marketing campaigns to avoid overcrowding in highly recognized locations. Furthermore, NAVITIME JAPAN could consider adding a function to the app to help international tourists avoid traffic congestion. More importantly, NAVITIME JAPAN actively collaborates with the Osaka Tourism Bureau to add newly developed tourism attractions, which are not widely known, to the application, thus helping to achieve responsible tourism management among various stakeholders.

[RQ2] Do international tourists show the same extent of interest toward the destination regardless of their countries of origin?

The findings of Study 2 showed that tourist range of movement differed according to their country of origin and revealed a positive relationship between the number of tourists and their range of movements. As shown in Fig. 7, American tourists had the widest range of movement because they made up the largest number of user IDs in the data set. However, this research also explored the actual moving range by adjusting the tourist numbers to a similar level, which showed that Chinese tourists moved in the widest range in Osaka City and Osaka

Prefecture. According to JNTO (2020b), South Korean tourists spent only 2.9 days on average in Japan, which was the shortest length of stay when compared with Chinese and American tourists. American tourists stayed the longest, with an average stay of 7.5 days. Chinese tourists stayed for an average of 5.9 days, which was reported as the preferred length of stay in Japan (JTA, 2017). Furthermore, the "short-stay" location records in Osaka City (Fig. 7) used in the current study indicate that American tourists used the Shinkansen Line significantly more than Chinese and South Korean tourists. Their total consumption of transportation services was also higher than that of Chinese and South Korean tourists (JTA, 2017). These results suggest that American tourists treated Osaka City as only one of multiple destinations during their visit to Japan and used the Shinkansen to travel to other places. By contrast, although Chinese tourists spent less time visiting Japan than American tourists, they demonstrated a higher interest in Osaka City.

Previous research has demonstrated that tourists' prior knowledge of a location (Bauder & Freytag, 2015), times of visit (McKercher et al., 2012), and size of the travel party (Zhao et al., 2018) affect moving ranges. The current study indicates that tourists' extent of interest in a certain destination may also be a crucial element that closely influences moving ranges, as interested tourists will stay a longer time than those who are less interested (Espelt & Benito, 2006). Hence, tourists' actual moving range can be used to understand the extent to which they are interested in the destination and their travel styles. In this study, Chinese tourists showed the highest interest in exploring Osaka City and prefecture. The popular "1-day/2-day Osaka Amazing Pass" makes it possible for international tourists to visit various places in Osaka, not only popular locations. Chinese tourists may use more types of public transportation to move compared with American and South Korean tourists. Therefore, enlarging tourists' range of movement may be a solution to overcrowding in certain areas or particular modes of public transportation. To ensure an urban destination's sustainable development, policy makers and DMOs need to cooperate with transportation companies to widen tourists' ranges of mobility.

[RQ3] Do international tourists demonstrate the same spatio-temporal behaviors regardless of their countries of origin?

To meet the planning demands of the tourism industry, it has become increasingly essential to monitor how tourists flow and consume spaces (Kádár, 2014). Tourist movement is the embodiment of their decisions about where, how and when to visit during their travels (Xia et al., 2011). Study 3 profiled international tourists' flow and daily spatio-temporal behaviors in the urban context with two demographic elements—nationality and gender. In contrast to the traditional segmentation of the inbound tourism market based on nationality, this research advocates spatio-temporal behavior as a new way to segment international tourists. The results of the tourist flows indicate that the Southern-central Namba region was the "busiest" region, with highly frequent in-and-out tourist movements between 9 a.m. and 9 p.m. regardless of country of origin (Study 3: Fig. 9), which may be due to the popular shopping centers, various restaurants, and iconic sites in this area. The spatio-temporal behaviors of international tourists described different mobility patterns, which can inform tourism policy and the customization of tourism products (De Cantis et al., 2016). Currently, in Osaka City, there are only limited recommended tours based on themes, for example, "gourmet," "historical sites," and "nature." However, they may not meet the needs of different international tourist groups. The findings of this research can help to identify further "tourists' profiles" and to segment the market in ways not only based on countries of origin.

More importantly, public transportation companies can use the findings regarding tourist flow and tourist spatio-temporal behaviors to predict international tourist mobilities and, in turn, for real-time crowd control (Zheng et al., 2017), thus decreasing conflicts between tourists and local residents (Yun, Kang, & Lee, 2018). By understanding international tourists' daily behavior patterns at the macro level, the Osaka Tourism Bureau and other tourism stakeholders can predict when and where congestion events start, thereby helping tourists to take detours or to change their travel plans accordingly.

Theoretical Implications

Unlike previous work in this field, the current research constructed the models based on actual GPS-equipped applications and urban tourist spots rather than simulation data (e.g., Zheng et al., 2019) and goal-oriented data collected by GPS loggers (e.g., Bauder & Freytag, 2015; De Cantis et al., 2016). In this way, the method very closely reflects real-world scenarios and can be applied to other urban destinations to address overcrowding. Moreover, according to Miah, Vu, Gammack, & McGrath (2017), key analytics derived from big data analysis can help support tourist destination management to understand tourist flows (Chua et al., 2016; Orellana, Bregt, Ligtenberg, & Wachowicz, 2012) identify choke points (Oku et al., 2015), and deconstruct how tourist preferences are manifested (Zhou et al., 2015). This article extends extant literature on tourist tracking and makes the case for generating new knowledge regarding tourist movement patterns in urban destinations. Furthermore, exploring the differences in mobility patterns among different cohorts of international tourists reveals how markedly different tourist behavior can be (Edwards & Griffin, 2013). Moreover, to the best of our knowledge, despite the critical role that public transportation plays in responsible tourism management, few studies have explored this issue.

Managerial Implications

Specifying patterns of movements across regions for different tourist cohorts is useful in regards to forecasting tourist demand and approached to mitigating congestion. Responsible and sustainable tourism requires the preservation of ecosystems, the promotion of human welfare, inter and intra generational equity, as well as public participation in decision-making (Bramwell, 2015). In past studies (e.g. Abe, 2019; Visentin & Bertocchi, 2019), overtourism has been discussed based on a whole-of-city basis instead of focusing on tourist hotspots and the related tracking of tourist spatio-temporal mobility patterns. Separating an overcrowded city into different micro-regions and analyzing respective tourist mobilities with demographic variables (for example, nationality and gender) can provide planners with a comprehensive understanding of the drivers of congestion. Therefore, it is necessary to tailor services for each particular tourist segment by forecasting their mobility patterns to prevent overcrowding in popular tourist spots and in the efficient provision of public transportation. As a sustainable tourism destination is a service ecosystem (Bramwell, 2015) and all stakeholders are resource integrators (Wang, Li, & Li, 2013), aligning with responsible urban tourism destination approaches is vital.

Conclusion

This research showcased a typical urban destination, Osaka City, to compare the nuances of international tourist spatial and temporal mobilities via GPS big data. Results indicate that tourists' spatio-temporal behaviors and the nature of their interest in the city differed. It was established that overcrowding problems occur not only at popular attractions but also at public transportation choke points where local resident-tourist encounters take place. Destination managers and public transportation providers play a critical role in responsible and sustainable urban tourism planning, insofar as being able to exercise congestion control. Moreover, although urban destinations typically attract millions of international tourists, few studies explore the distinctive spatial and temporal behaviors exhibited by international tourist cohorts. As international visitation increases in popular urban destinations, there is an urgency to identify specific tourist mobility patterns, which also helps provide an understanding of tourists beyond their countries of origin, to reduce hotspot overcrowding and transportation congestion. As an exploratory attempt to analyze the spatio-temporal behaviors of international tourists via the application of GPS big data, this study's findings not only provide useful insights that can help practitioners improve the design of tourism experiences as well as encourage co-creation and cooperation among stakeholders.

There are several limitations in this regard, especially concerns about user privacy - mobile-tracking data used in this research does not include detailed demographic information. Additionally, because the data code has been automatically changed daily to prevent tracking individual tourists' spatio-temporal behaviors, it is impossible to explore how this information might influence international tourists' mobility patterns and how individual tourists make their travel plans during their visits to Osaka City. Further research should integrate more detailed information about tourist characteristics and integrate survey-based data on tourist type, motivations, type of trip, and other variables to enrich the results of the movement ranges (Study 2) and tourist daily flows (Study 3). Secondly, as this research employed existing data collected by NAVITIME JAPAN, the research design was influenced by the data set at hand which limited exploration of marketing campaigns, tourism-related policies, and other stimuli that affects tourist spatio-temporal behaviors. Hence, further research should test interventions to modify movement in time and space, then explore effective ways to reconcile overcrowding problems in iconic tourist spots (Study 1). Thirdly, this research employed only one type of big data - GPS big data; however, one data source is insufficient to analyze the presence of tourists in cities (Salas-Olmedo, Moya-Gómez, García-Palomares, & Gutiérrez, 2018). Therefore, further research should employ multiple data sources - for example, combining GPS with social networking big data to offer more nuanced insights.

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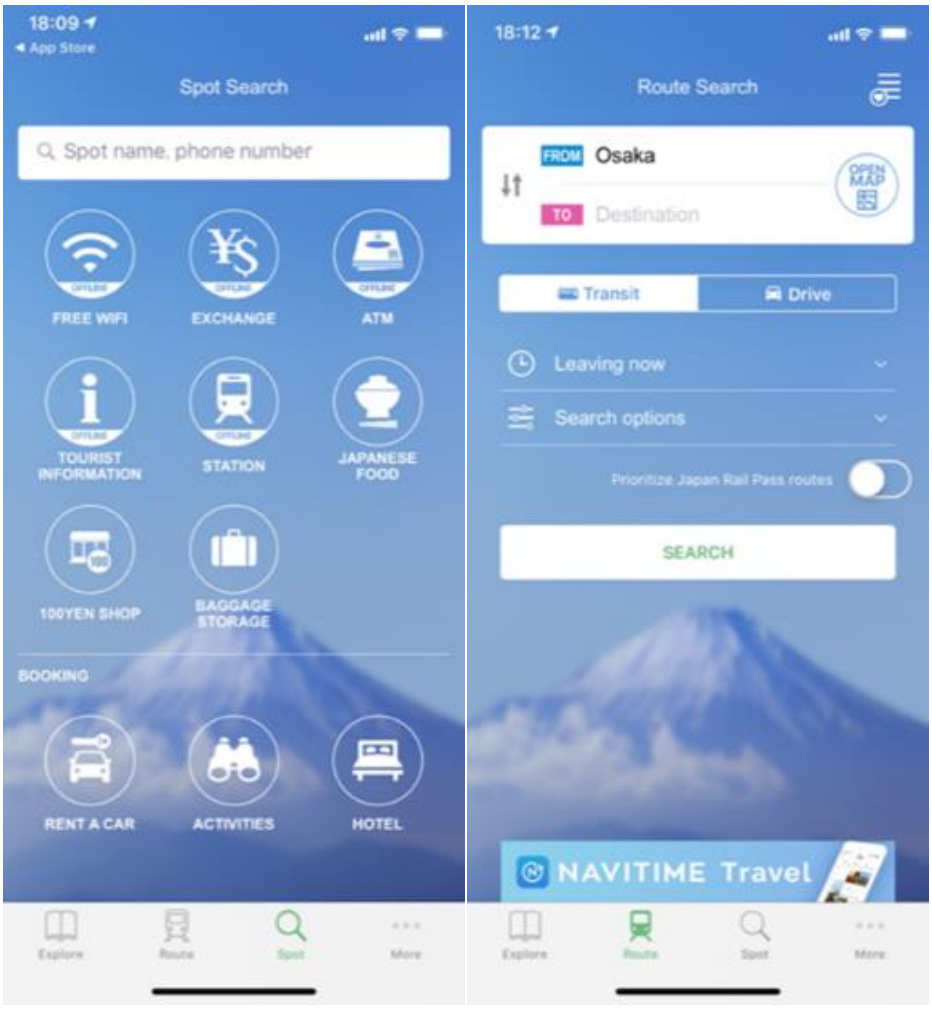
Appendix

Application of NAVITIME for Japan Travel



Note: The photos were taken by the authors using a smartphone's screen capture function.