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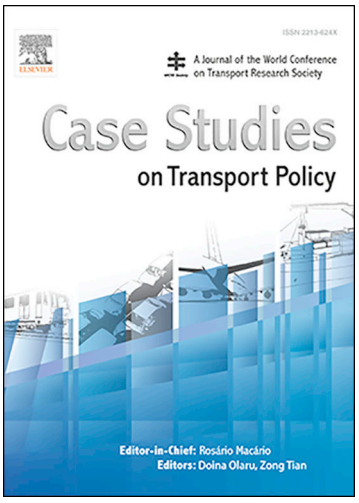

Will citizen participatory transport policies affect people to use cars less? Empirical evidence from car-free day project in South Korea

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Will citizen participatory transport policies affect people to use cars less? Empirical evidence from car-free day project in South Korea

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Abstract

Many cities worldwide are beginning to focus on the Car-Free Policy to increase urban spaces and create sustainable cities considering the public demand for open space. However, existing studies suggest that the car-free day's operating factors and guidelines focus solely on quantitative data of effectiveness. However, existing studies suggest that the car-free day's operating factor and guidelines only bring quantitative data of effectiveness to a halt. Therefore, the analysis of the user perception and behavioral change according to the car-free day operation, and the impact of each factor of the event is insufficient. This study analyzes the user perceptions and behavioral changes according to 10 car-free days in Suwon. Using the data collected from the research, we propose improvement strategies by verifying behavioral changes with user perception. We divide 24 measured variables into six categories: types of event, event operation, infrastructure, change in perception, mobility patterns, and visiting hours. Further, this research sets three premises for the proposal, followed by nine hypotheses to determine the further study of the relationship between customer satisfaction, user perception, and behavioral changes according to the car-free day operation. Using structural equation models and examining path analysis, the user perception is mainly influenced by user satisfaction, satisfaction with transportation and infrastructure, and behavioral change is mainly influenced by factors such as visiting hours and changes in perception. This research identified the detailed factors influencing user perception and behavioral change according to a car-free day operation and aims to contribute to the establishment of activating car-free streets. Moreover, the car-free days in Suwon city increased, and by including cohort research methods, further research can be conducted to determine whether car-free days actually cause behavioral changes and whether user perception is improved every year.

Keywords

Urban mobility, Car-free day, Behavior changes, Mobility management, Sustainable policy

1. Introduction

The introduction of cars has brought mobility, convenience, increase in employment, progress in technology, and economic prosperity to the transportation system. It is unimaginable to think about the world without cars; however, many cities globally are shifting their mobility solutions to more environmentally friendly and citizen-focused solutions rather than relying on private car usage (Nieuwenhuijsen and Khreis, 2016). Many cities are beginning to shift their transportation solutions away from private cars and toward active and public transportation, realizing that these latter modes are more environmentally friendly, healthier, and people-oriented (Khreis and Nieuwenhuijsen, 2021). The global climate change crisis has been a significant driver of such transitions. These cities often refer to such solutions as car-free solutions, including the implementation of car-free city centers, car-free designated areas, and car-free days. Cities including Hamburg, Oslo, Helsinki, and Madrid announced their plans to become (partly) private-car-free cities. Other major cities, including Brussels, Copenhagen, Dublin, Paris, Bogota, Chengdu, Hyderabad, and Milan, have invested in bicycle infrastructure and prioritized pedestrians by restricting motor vehicle use (Cathkart-Keays, 2015).

The United Nations Division for Sustainable Development organized the UN Car-Free Day series to promote the development of sustainable transportation systems through international workshops. These events involved city officials from Latin America, Australia, and New Zealand, who participated in discussions on challenges and strategies for sustainable transportation planning in their respective cities. The workshops identified key global issues, including disproportionate public spending on private vehicles, insufficient investment in public and alternative transportation, the environmental impact of the transportation sector, and urban sprawl. These challenges were highlighted as significant barriers to achieving sustainable transportation systems across different regions (Badiozamani, 2003). The "Car-free day" campaign started from the movement that was first organized in La Rochelle (France) in 1997, which had its slogan, "In town, without my car," to decrease traffic congestion and improve the immediate environment (Naver namu.wiki, 2024). Car-Free Days are being used in various cities around the world as a tool for initiating dialogue between citizens and public officials. By clearing the streets for a day to discuss the needs of the city and develop a long-term vision for urban development, Car-Free Days can play a significant role in shifting the way both citizens and planners perceive and design cities. This initiative has the potential to drive a fundamental change in traditional urban planning paradigms (Ghazal Badiozamani, 2003). Successful Car-Free Days or events should focus not only on dispersing traffic to other areas but also on limiting car use and promoting active modes of transportation. The core objective of Car-Free Days is not to merely shift traffic, air pollution, and noise pollution to other areas, but to fundamentally alleviate environmental stress and health burdens caused by car-centric transportation in urban areas (Glazener et al., 2021). Furthermore, while Car-Free Days and events are often seen as an attractive policy option, intensive planning is required for their success. The organization, execution, public support, and stakeholder involvement of these events have a significant impact on the level of success and the sustainability of these initiatives (Glazener et al., 2022).

Suwon city in Korea has also implemented a "car-free day" in which citizens can participate through planning and organizing the event. Car-free days have started in four areas since 2014 and expanded to 10 areas by 2016. It is necessary to monitor the two events by user satisfaction surveys and improve their operation to further activate the "car-free day" in Suwon and enhance citizens' satisfaction by guiding the direction of Suwon city's policy. Therefore, this research aims to verify each factor for user perceptions, with the results of the exploratory factor analysis and structural equation model based on the "car-free day" satisfaction survey for its advancement.

2. Literature Review

There are few studies on the analysis of user perception and behavioral change from car-free day operation, but this study aimed to review similar existing studies. One of the studies conducted by Min

(2012) focused on identifying problems such as falling short of the connection between the business and its unit and the decline in the walking flow continuity despite the active car-free day event, where Seoul city focuses on the global trend of low carbon, eco-friendly, and pedestrian-friendly environments.

Guidelines were established through the analysis of the data collected from this research, and the need for a preservable operating system and management from the understanding of citizens and their participation was proposed instead of an administration-focused method. Moreover, the research aims to expand car-free streets to attract more visitors and focuses on the need to establish a car-free city through a business project. Research on the consciousness of participants in the public environmental design in Cheong-ju in by Shin (2012) in the city aimed to review the concept and projects of public environmental design in Korea. Moreover, we analyzed the participants' awareness of the public environmental design. The survey was conducted by users, executives, and specialists who were involved in the "Chung-ju Jungang road car-free day," and the ANOVA method was used during the research. The data collected from the survey suggested that executives showed the highest satisfaction, whereas the specialist and user satisfaction were the lowest. Research conducted by Choi and Kim (2009) focused on the development of Chungjang-ro Street as to how pedestrian environment development to form an art culture street influences the surrounding business. The research aimed to acknowledge the importance of the pedestrian environment and encourage citizens' participation by providing more pedestrian-friendly content with scenic guidelines and policies through urban planning. Consequently, the users' views emphasize "economic efficiency" and "usability" in the public environmental design. The executives' views emphasize "sustainability," "safety," and "landscape" in the public environmental design. The specialists' views emphasize "sustainability" and "landscape" in the public environmental design. Another study by Kim (2016) focused on the methodology of selecting criteria for pedestrian-only streets. It aimed to suggest criteria for future events that surpass the limitation of evaluation from the scale, residence time, and purpose of the passengers. Pedestrian-only streets were analyzed into four categories: commercial, residential, school, and cultural areas, and the purpose was to evaluate indicators through safety, accessibility, amenity, intelligibility, environmental, and continuity. Nieuwenhuijsen and Khreis (2016) reviewed all other research papers on "car-free city" planning, restrictions on car usage, and health to clarify how a car-free city can influence public health. Consequently, cities that run car-free days mainly focus on the reduction of private car use in city centers, which reduces traffic-related air pollution and noise. Moreover, owing to the reduction in the number of cars, there was a reduction in the need for parking zones and road space, providing opportunities to increase green space and green networks in the cities, leading to many positive health effects. A study conducted by Gundlach on people's preferences regarding a car-free city center in Berlin showed that approximately 60 % of the respondents agreed to a car-free city center, and through the improvement in the infrastructure for cyclists, the network of bus stops and train stations increased the acceptance of a car-free city center. Vanderstraeten(2011) presented data collected from particle number concentration to evaluate the average particle pollution originating from traffic during weekdays versus Sundays. Moreover, Badiozamani (2003) elaborated on the goals of the transportation policy and sustainable development, along with a history of car-free days, to propose a shift in the city planning paradigm. Overall, this study aims to explore different methods from the aforementioned research papers and identify the use of the structural equation model as an analysis of user perception and behavioral change according to car-free day operation. This research was also identified based on infrastructure, program content, and event operations. Sareen et al. (2021) highlighted how attention to temporality enables us to not only understand and explain but also engage with and influence changes in sociotechnical matters using the case of transitions to low-carbon mobility in urban transportation in Bergen, Norway. Moreover, their findings showed how the temporal organization of events is a key constraint in the car-free zone project. Urban public spaces are recognized not only as functional areas but also as critical for enhancing residents' quality of life, fostering social bonds, and creating a collective urban identity. Vukmirovic et al. (2019) argue that the strategic design and maintenance of public spaces are essential for cities facing challenges like climate change, as these spaces contribute to urban productivity, inclusivity, and well-being. Their research, which assessed urban public space elements such as paving, greenery, lighting, and seating, highlights the role of comfort-focused design in public spaces as an effective approach for improving life quality. By enhancing these physical

elements, cities can make public spaces more inviting, ultimately promoting social interaction, relaxation, and community engagement.

Moreover, Qi et al. (2024) emphasize that the physical attributes of public spaces, including accessibility, mixed land use, and available amenities like street furniture, are vital for encouraging social cohesion and interaction. They found that these factors, combined with cognitive perceptions such as safety, visual appeal, and place attachment, greatly influence how individuals experience public spaces. Their study suggests that well-designed public spaces can significantly contribute to residents' sense of belonging and overall satisfaction with their urban environment.

In Suwon's "Car-Free Day" initiative, where streets are temporarily repurposed as pedestrian zones, these principles are directly applicable. By transforming streets into public spaces for a day, Suwon's events encourage the use of urban areas for leisure and community-building activities, thereby aligning with strategies that prioritize people over vehicles. Learning from successful public space interventions, future car-free events in Suwon could further emphasize elements like comfortable seating, greenery, and community-centered activities to strengthen residents' connection to public spaces and improve their quality of life. These studies underscore that public space interventions, when thoughtfully implemented, play a critical role in creating liveable, cohesive urban environments. Incorporating these insights into the analysis framework for Suwon's car-free events will allow for a more comprehensive understanding of how temporary public space repurposing influences citizens' quality of life and community perception. European Mobility Week, launched by the European Commission over 12 years ago, has become a key campaign aimed at raising awareness around sustainable urban mobility. Held annually from September 16 to 22, this event now spans approximately 3,000 cities across Europe, focusing on promoting active mobility (such as walking and cycling), public transportation, and other clean, intelligent transportation solutions. The central goal is to encourage citizens to choose sustainable travel options, thereby reducing emissions and promoting healthier lifestyles. Each year, the week includes a "Car-Free Day," along with events like bike festivals, electric vehicle showcases, road safety workshops, and traffic-related job diversity expos. Notably, the 2023 theme, "Save Energy," underscored sustainable transportation's role in reducing energy consumption and emissions, thereby enhancing public health and environmental stewardship(European Mobility Week 2023).

Suwon has undertaken "Car-Free Day" projects since 2004, gradually expanding its program to multiple districts and fostering civic participation in planning and organizing. Unlike in many European cities, Suwon's car-free events are notably citizen-led, which offers a unique model for community engagement. However, lessons from European Mobility Week's comprehensive approach can be incorporated into Suwon's strategy to enhance the effectiveness of its public transit promotion efforts. Specifically, Suwon's program can benefit from a more structured evaluation of public satisfaction, transportation accessibility, and sustained behavior changes—elements that European initiatives have refined over the years.

Integrating the experience from European Mobility Week not only strengthens the theoretical basis for Suwon's initiatives but also enhances our understanding of successful practices that encourage modal shifts from private cars to public transportation. Future research can continue to draw from European successes to develop frameworks that further empower cities like Suwon to optimize car-free days and support a broader sustainable mobility paradigm.

3. Study Area

Since the success of "EcoMobility Suwon 2013" the state officials have been in the process of running citizen-focused "Suwon-city car-free day" allowing citizens to plan, participate, and operate with the event and decreasing automobile usage. This project has expanded through collaboration from four areas in June 2014, eight in 2015, and ten in 2016, leading to a total of 13 areas in 2017. This project is significant because of the voluntary participation of citizens. The procedure includes collaboration from

the citizens, followed by forming an evaluative team to pick the location by checking out on-site. The car-free day is then run by the citizens once or twice every month, and the state officials support customized street improvements in the areas where the car-free day was successful through the operational evaluation at the end of each year.

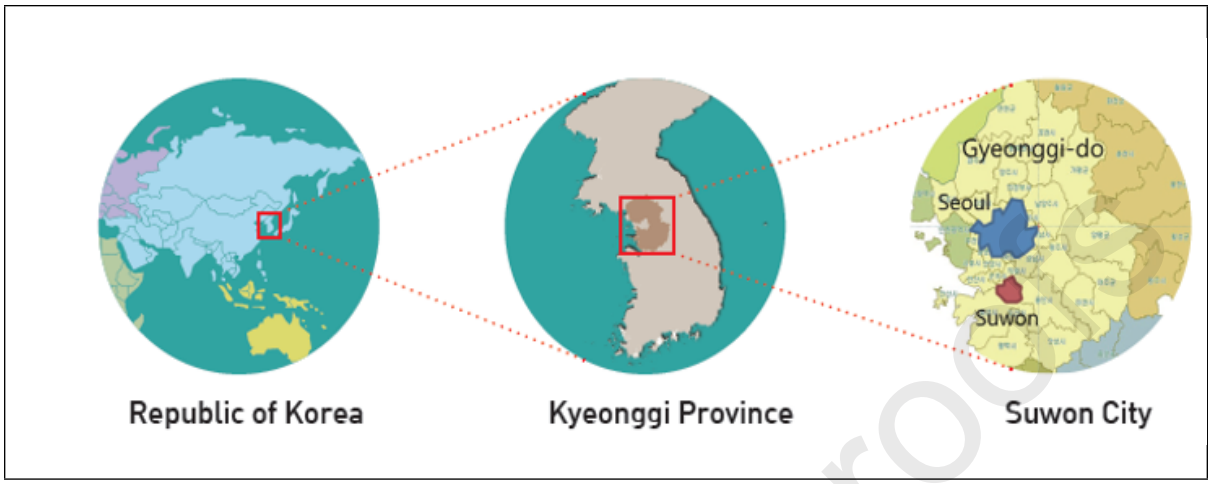

Figure 1. Location of Suwon City (source: 11th EST Regional Forum, EcoMobility, an Urban Innovation For Sustainable City Suwon, 2018)

There are differences between each district owing to their characteristics. For example, for the main operating cities, Geumgok-dong ran a program focused on kid-friendly events; Yeongtong 1-dong blocked the road to expand the space for the citizens to comfortably participate in the event; Yeonghwa-dong focused on food and culture themes, thus running eatery booths are placed in the streets; and, Haenggung 1-2-dong focused on small art workshops because the street itself is surrounded by these workshops, thus installing workshop experience booths in the streets. Pyeong-dong also blocked the road to allow citizens to have a spacious environment to experience ecological transportation programs. Jeongja-3-dong presented an event in the form of a flea market, which was operated by an apartment leadership group; however, it was limited by blocking the road and using it to run combined programs such as ecological transportation programs, playgrounds for children, and various event booths, leading to inconvenience for pedestrians. Maesan-dong focused on merchants and customers because it was operated by merchant representatives, and programs such as caricature, magic experiences, and DIY experiences were offered to the users.

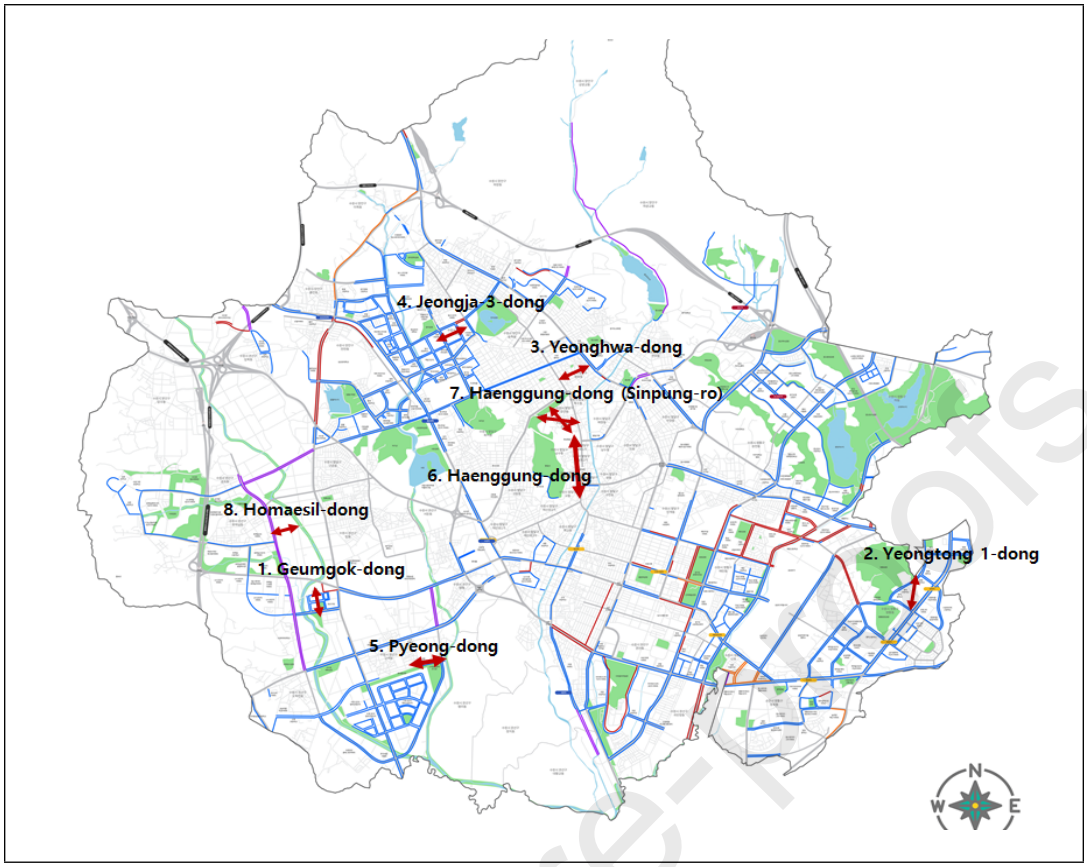

Figure 2. Spatial study area

1.Geumgok-dong	2.Yeongtong 1-dong	3.Yeonghwa-dong	4.Jeongja-3-dong

5.Pyeong-dong	6.Haenggung-dong	7.Haenggung-dong (Sinpung-ro)	8.Homaesil-dong

Figure 3. Detailed Spatial study area

			
Sugar candy experience	Tae kwon do preview	Raindrop games	Bike power generator experience
			
Korean See Saw experience	Event scene	Calligraphy keychain workshop	Korean traditional percussion quartet

Figure 4. Car-free day events in Suwon City

In Suwon's "Car-Free Day" initiative, citizens play an integral role beyond merely attending events. This initiative is largely community-driven, with citizens actively participating in all stages of planning and execution. The collaborative nature of this program aims to foster sustainable travel behavior, encouraging residents to shift away from private car use to more sustainable mobility solutions. Citizens begin by engaging in the development of project plans, collaborating closely with local administrative bodies, such as district and neighborhood centers. They contribute ideas, review event plans, and provide feedback on potential improvements. Additionally, they coordinate with neighborhood centers well in advance of the event to ensure smooth logistics and support, including securing necessary materials and arranging promotional activities. On event day, citizen-led teams manage booths and oversee activities, enhancing community engagement and reinforcing the event's sustainable transportation goals.

Table 1. Roles by Stakeholder in Suwon's "Car-Free Day"

Stakeholder	Role Description
Suwon City Transportation Policy and Eco-transportation Team	- Sets overall direction for the project and announces open calls for community proposals.

	- Allocates necessary funds to neighborhood centers to cover event expenses. - Monitors event progress and facilitates discussions between event leaders and neighborhood centers.
District Economic & Transportation Division	- Identifies new potential areas for the car-free initiative and spearheads district pilot programs. - Compiles applications and final reports for submission to the city. - Monitors the status of event planning and execution.
Neighborhood Centers	- Supports event execution by reviewing business plans, locations, and budget allocations. - Coordinates with event leaders at least 20 days before the event to finalize logistics. - Allocates budget for event operations and assists in managing expenditures.
Event Leaders (Citizens)	- Develops event plans in alignment with approved project goals. - Coordinates with neighborhood centers before the event for feedback and approval on plans. - Requests supplies, promotional materials, and other resources from neighborhood centers. - Organizes and operates event booths, handling logistics on the event day.

Suwon's Context as a Car-Centered Community and Modal Shift

Suwon City has long been characterized by car-centric urban planning, where private vehicle use has dominated local mobility patterns. Despite efforts to promote public transportation, the city has faced challenges in reducing its dependency on cars. To address this, Suwon implemented “Car-Free Day” initiatives, aiming to shift residents' transportation preferences toward more sustainable options like public transit, walking, and cycling. The city’s “Car-Free Day” events have been conducted across various districts, including Geumgok-dong, Yeontong 1-dong, Hoam-dong, and Jeongja 3-dong, each featuring unique community-led activities and operational focuses. For example, Geumgok-dong’s program emphasized child-friendly activities, while Yeontong 1-dong provided expanded public spaces by blocking roads, allowing residents to experience a more pedestrian-oriented environment. These localized activities reflect Suwon’s diverse approach to reducing car use while fostering community

engagement in public space utilization. A key objective of Suwon's "Car-Free Day" initiative is to encourage a modal shift—reducing private car use in favor of public transportation. Survey data from event participants indicate varying levels of willingness to reduce private vehicle usage across different districts. For instance, respondents in Yeonghwa-dong showed the highest intention to reduce car use, with an average score of 3.2 on a 5-point scale (1: No change, 5: Significant decrease). This was followed by Yeontong 1-dong (2.9), Seodun-dong (2.7), and Jeongja 3-dong (2.6). Conversely, Geumgok-dong showed the lowest intention to decrease car use (1.8). These scores suggest a gradual shift in willingness among residents to adopt public transportation, albeit with regional variations.

The survey question posed to participants was: *"After participating in the Car-Free Day event, how much do you think your car usage will decrease?"* Participants could rate their expected change from 1 (no change) to 5 (significant decrease). These results highlight an emerging trend where citizens begin to consider transitioning from private cars to public transit, particularly in districts that have embraced the event's goals more fully.

4. Data

This study builds on existing literature to evaluate the operational satisfaction of car-free days, focusing on user perceptions, behavioral changes, and satisfaction with event execution. Prior research, such as that by Min (2012a), categorized survey respondents into groups—citizens, merchants, and professionals/government workers—and tailored questions to assess satisfaction with district operations, changes in commercial zones, pedestrian environments, and the overall purpose behind car-free streets. Kim (2016) further identified critical indicators for evaluating urban pedestrian zones, such as safety, accessibility, amenity, intelligibility, environmental impact, and continuity, establishing a foundation for assessing public space usability. In addition, Shin (2012) analyzed factors influencing user satisfaction in public spaces, identifying variables such as safety, usability, sustainability, and community capability. These studies underscore the importance of diverse variables in evaluating public space interventions, which are relevant to car-free day events and inform our framework's latent constructs, such as event program satisfaction, infrastructure, and user perception. By organizing these constructs into measurable categories, the model captures specific factors—like transportation access and infrastructure quality—that influence user satisfaction and behavioral change.

Based on this literature, the proposed model divides satisfaction indicators into distinct constructs, aligning with established studies that emphasize a multi-faceted approach to urban event satisfaction. Removing redundant descriptions ensures a streamlined analysis focused on validating latent variables and relationships within the Suwon car-free day context. Through this approach, the model seeks to comprehensively measure factors affecting user satisfaction and to justify the proposed relationships between these variables.

This research focused on the satisfaction of citizens who participated in the event, and big factors focused on event programs, event operation, transportation, and infrastructure based on the actual experience of the citizens to analyze user perception and behavioral change. Our first category of event programs is divided into six variables: environmental transportation experience, district agricultural farmers market, companies giveaway market, street cultural shows and experiences, games, and flea markets. The second category of event operation is further divided into six variables: street event planning, successful operation without troubles, advertising music and noise level, vehicle control within the event area, securing parking space, and interaction between people. The third category is divided into five variables: resting facility and benches, status of sidewalk pavement, cleanliness of sidewalks, pedestrian space and safety, and accessibility to public transportation. The fourth category of perception change is divided into five variables: air pollution due to cars, perception of pedestrians over cars, interest in environmental transportation, bicycle infrastructure, and interest in the activation of car-free streets. The survey was conducted in ten areas, including Suwon and Jeongja-3-dong, which were involved in collaborative work in 2016 to enhance the activation of "Suwon car-free city." The

survey focused on the citizens who participated in the event, and our study analyzed 720 respondents out of 1,430 citizens, dropping the incomplete survey. There is a difference in the expected data and actual respondents due to omitting incomplete surveys. The survey contents include 26 questions related to the users of the "car-free day," including individual characteristics, event usage status, satisfaction, business improvements and intentions of future usage, effects, and perception. The survey method was a person-to-person interview during the event of the "Suwon car-free day" in 2016, where the citizens were easily accessible. An analysis of the basic survey statistics showed that in terms of gender, there were 426 women (60.8 %) and 275 men (39.2 %). In terms of age, 170 (24.3 %) were in their forties, 145 (20.7 %) were in their thirties, 131 (18.7 %) were in their fifties, 112 (16.0 %) were below the age of 10, 85 (12.1 %) were in their twenties, 48 (6.8 %) were in their sixties, and 10 (1.4 %) were in their seventies.

Table 2. Statistics based on gender and age

Gender/Age	Below age of 10	20s	30s	40s	50s	60s	Above 70	Total
Male	45	36	49	53	58	27	7	275 (39.2 %)
Female	67	49	96	117	73	21	3	426 (60.8 %)
Total	112 (16 %)	85 (12.1 %)	145 (20.7 %)	170 (24.3 %)	131 (18.7 %)	48 (6.8 %)	10 (1.4 %)	701

The survey results on modal shift intentions revealed that the anticipated reduction in vehicle usage was highest in Yeonghwa-dong (3.2), followed by Yeongtong 1-dong (2.9), Seodun-dong (2.7), and Jeongja 3-dong (2.6), while Geumgok-dong (1.8) showed the lowest reduction. These findings suggest a gradual willingness among residents to transition from private vehicles to public transportation.

Table 3. Future changes in the reduction of private car usage frequency

Category	Yeongtong 1-dong	Homaesil-dong	Jeongja 3-dong	Geumgok-dong	Haenggung-dong	Pyeong-dong	Maesan-dong	Seodun-dong	Yeonghwa-dong
Future changes in the reduction of private car usage frequency	2.9	2.5	2.6	1.8	2.5	2.3	2.2	2.7	3.2

1: No change, 2: Very slight decrease, 3: Slight decrease, 4: Significant decrease, 5: Very significant decrease.

The primary roles in the event were as follows: the largest group consisted of event participants, with 346 individuals (48.1%), followed by others (199 individuals, 27.6%), local merchants near the event venue (90 individuals, 12.5%), and booth managers (85 individuals, 11.8%).

Table 4. Primary roles in the event

Category	Event Booth Manager	Event Participant	Nearby Merchants	Others
Major roles in the event (N, %)	85(11.8%)	346(48.1%)	90(12.5%)	199(27.6%)

The most frequently used mode of transportation for event visits was walking, reported by 398 participants (55.3%). This was followed by private cars (138 participants, 19.2%), buses (102 participants, 14.2%), and bicycles (55 participants, 7.6%), respectively.

Table 5. Transportation Method Used to Visit the Event

Category	walking	bicycles	motorcycles	subway	buses	private cars	others
Transportation Method Used to Visit the Event (N, %)	398 (55.3%)	55 (7.6%)	4 (0.6%)	7 (1.0%)	102 (14.2%)	138 (19.2%)	16 (2.2%)

Most participants, 300 people (41.7%), reported a travel time of 10 to 30 minutes for event visits, followed by those traveling for less than 10 minutes (279 participants, 38.8%) and those traveling for 30 minutes to 1 hour (119 participants, 16.5%).

Table 6. Travel time to event visits

Category	Under 10 minutes	10 to 30 minutes	30 minutes to 1 hour	1 to 2 hours	More than 2 hours
Travel time to event visits(N, %)	279(38.8%)	300(41.7%)	119(16.5%)	16(2.2%)	6(0.8%)

The duration of stay during event visits was highest for 1 to 2 hours, reported by 230 participants (31.9%). This was followed by less than 1 hour (209 participants, 29.0%), more than 4 hours (118 participants, 16.4%), 2 to 3 hours (102 participants, 14.2%), and 3 to 4 hours (61 participants, 8.5%).

Table 7. Duration of stay at the event

Category	Less than 1 hour	1-2 hours	2-3 hours	3-4 hours	More than 4 hours
Duration of stay at the event(N, %)	209(29.0%)	230(31.9%)	102(14.2%)	61(8.5%)	118(16.4%)

The most common event participation activity was viewing, reported by 302 participants (28.4%). This was followed by cultural experience (146 participants, 13.7%), snacks and meals (135 participants, 12.7%), others (132 participants, 12.4%), simple accompanying for children's cultural experiences (121 participants, 11.4%), shopping (119 participants, 11.2%), and walking and relaxation (111 participants, 10.4%).

Table 8. Event participation activities

Category	shopping	viewing	snacks and meals	simple accompanying	walking and relaxation	cultural experience	others
Event participation activities. (N, %)	119(11.2%)	302(28.3%)	135(12.7%)	121(11.4%)	111(11.4%)	146(13.7%)	132(12.4%)

The overall satisfaction of Suwon city's car-free day was measured on a scale of 5(1-5), and the results were as follows: event program, 3.57; event operation, 3.57; transportation and infrastructure, 3.6. When these scores were further analyzed, six factors in the event program scored between 3.27 and 3.59, which showed a similar satisfaction score between the factors. Six factors in event operation scored between 3.25 and 3.62 and within the factors, and vehicle control scored the highest. Five factors in the infrastructure scored between 3.21 and 3.59 and within the factors, and accessibility to public transportation scored the highest. The bench and resting facilities scored the least in the analysis; therefore, there needs to be an improvement.

Table 9. Car-free days in Suwon's satisfactory survey results

Satisfaction Measurement Items		Average Satisfaction score
Event program	Environmental transportation experience	3.46

	District agricultural farmers market	3.27
	Companies giveaway market	3.32
	Street cultural shows & experiences	3.59
	Games	3.58
	Flea market	3.43
Event Operation	Street event planning	3.5
	Successful operation without troubles	3.54
	Advertising music and noise level	3.37
	Vehicle control within the event area	3.62
	Securing parking space	3.25
	Interacting between people	3.54
Transportation and Infrastructure	Resting facility and benches	3.21
	Status of sidewalk pavement	3.51
	Cleanliness of sidewalk	3.56
	Pedestrian space and safety	3.54
	Accessibility to public transportation	3.59
Overall satisfaction	Event program	3.57
	Event operation	3.57

	Infrastructure	3.6

5. Analysis

5.1 Factor Analysis

Five factors were derived from the factor analysis, and these were applied to establish structural equation models. This research analyzed how the measured variables influence user perception and behavioral change, set hypotheses that Suwon city's car-free day's satisfactory results will influence changes in perception and behavior, and showed the results using the structure equation model.

Table 10. Result of factor analysis

Measurement Items	Variables	Factor				
		1	2	3	4	5
Event program	Environmental transportation experience	.297	.696	.192	.246	.144
	District agricultural farmers market	.183	.848	.161	.195	-.061
	Companies giveaway market	.199	.810	.217	.208	.124
	Streetcultural shows & experiences	.276	.580	.257	.194	.558
	Games	.257	.576	.212	.310	.542
	Flea market	.127	.695	.205	.317	.257
Event Operation	Street event planning	.336	.396	.290	.597	.273
	Successful operation without troubles	.319	.327	.313	.617	.290
	Advertising music and noise level	.242	.336	.280	.723	.007
	Vehicle control within the event area	.308	.129	.493	.564	.214

	Securing parking space	.248	.318	.366	.684	-.093
	Interacting between people	.272	.287	.280	.647	.260
Transportation and Infrastructure	Resting facility and benches	.257	.470	.519	.382	-.096
	Status of sidewalk pavement	.241	.253	.744	.268	.009
	Cleanliness of sidewalk	.267	.203	.796	.232	.084
	Pedestrian space and safety	.279	.236	.709	.361	.112
	Accessibility to public transportation	.277	.161	.720	.202	.248
Changes in Perception	Air pollution problems caused by car	.767	.283	.151	.245	.013
	Importance of pedestrian versus vehicles	.781	.163	.246	.217	.172
	Interest in environmental transportation	.798	.209	.286	.189	.022
	Bicycle infrastructure	.822	.179	.209	.194	.070
	Interest in expansion of car free day	.800	.160	.268	.196	.172
Traveling time and staying hours	Traveling time to events	.043	.008	.000	.188	.927
	Staying hours	.095	.057	.072	.203	.901

Factor analysis was used to divide the 24 measured variables into five factors. The event program's satisfactory section was composed of the following: environmental transportation experience, district agricultural farmers market, companies giveaway market, street cultural shows and experiences, games, and flea market. The event operation satisfactory section was composed of the following: street event planning, successful operation without troubles, advertising music and noise level, vehicle control within the event area, securing parking space, and interaction between people. The transportation and infrastructure satisfactory section was composed of the following: resting facility and benches, status of sidewalk pavement, cleanliness of sidewalks, pedestrian space and safety, and accessibility to public transportation.

This study aimed to determine the properties of five latent variables that affect the satisfaction of Suwon's car-free days and to prove inner consistency. Cronbach's α value was used to measure the reliability. The closer the Cronbach's α value to 1, the higher the inner consistency between the variables, and it is reliable if the value is above 0.6. Through the analysis of trust in the survey variables, the results were as follows: Car-free day event program (0.920), event operation satisfaction (0.922), satisfaction with transportation and infrastructure (0.903), change in perception (0.928), and behavior change (0.744). All five factors' Cronbach's α values were above 0.6, which proved the high reliability of the measured variables.

Table 11. Reliability test results

Evaluated List	Measurement Variables	Cronbach's α
Car free day event program (δ)	6	0.920
Car free day event operation (λ)	6	0.922
Car free day public transportation and infrastructure (π)	5	0.903
Perception change	5	0.928
Behavioral change	3	0.744

To validate the measured variables for the car-free day satisfaction, the standard load factor value must be above 0.5. However, the result of the confirmatory factor analysis of the measured variables in traveling times was 0.29; therefore, it was removed from the model. The staying hours factor load was 0.951; thus it was included in the model. This shows that the physical distance to participate in the event has no impact on satisfaction, whereas longer staying hours positively influence user satisfaction.

5.2 Model Estimation

Factors that influence user perception and behavioral change on a Suwon car-free day were identified, and the derived factors were processed through factor analysis to establish the research hypotheses.

Premise 1: Relationship between Suwon car-free day operation satisfaction and change in user perception

Hypothesis 1: Event program satisfaction will positively influence the change in user perception
Hypothesis 2: Event operation satisfaction will positively influence the change in user perception

Hypothesis 3: Transportation and infrastructure will positively influence the change in user perception

Hypothesis 4: Visiting and staying hours will positively influence changes in the user perception.

Premise 2: Relation between Suwon's car-free day operation satisfaction and travel behavioral change

Hypothesis 5: Event program satisfaction will positively influence the change in travel behavior

Hypothesis 6: Event operation satisfaction will positively influence the change in travel behavior

Hypothesis 7: Transportation and infrastructure will positively influence change in travel behavior

Hypothesis 8: Visiting and staying hours will positively influence changes in travel behavior.

Premise 3: Relation between user perception and behavioral change

Hypothesis 9: Change in perception will positively influence change in travel behavior

The following are the results from Suwon's car-free city satisfactory studies shown in Figure 5. The evaluated factors and their relationship with the variables were abstracted, and the model suitability and path coefficient were analyzed; the research hypothesis is shown in the next paragraph.

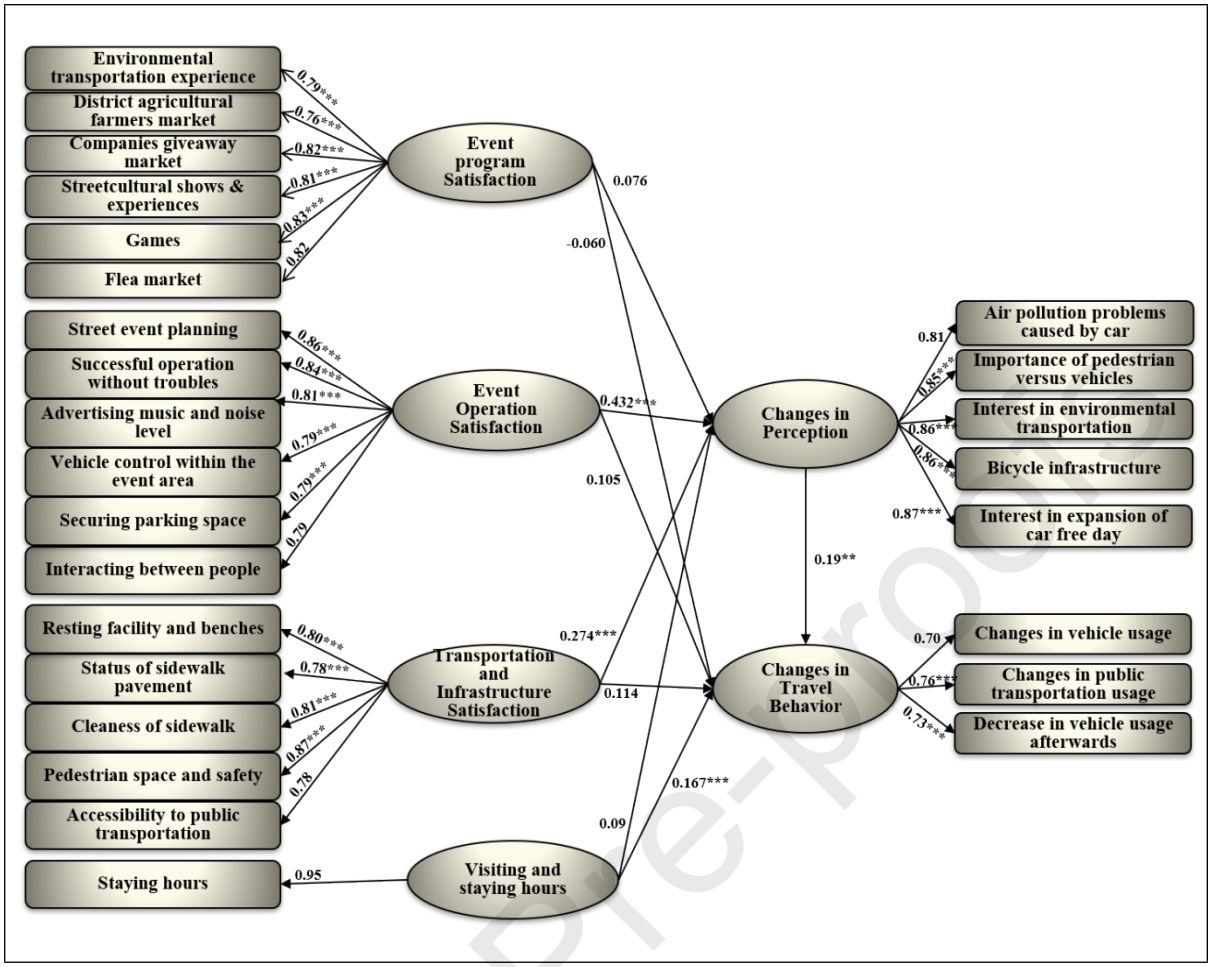

Figure 5. Final design model (standardized coefficient) (***p<0.01, **<p0.05, *p<0.1)

This study's structural equation model fit is evaluated by the goodness-of-fit, facilitating the comparison of the research model with the independent model, which proved that the theoretical model of this research explains the information more effectively than the independent model. The normed fit index (NFI) and comparative fit index (CFI) were used to compare the baseline model with the target model and to prove that the target model is superior to the independent model. The absolute index models include the goodness of fit index (GFI), adjusted goodness of fit index (AGFI), and root mean square error of approximation (RMSEA). According to studies conducted by Kim (2019), when selecting the goodness-of-fit, it is appropriate to stick with simplicity and not rely too much on the size or original data; when viewed with these standards, the goodness-of-fit can be measured with the following: GFI, AGFI, and RMSEA. After the analysis of the goodness-of-fit of the structural equation model, the absolute conformity indices were CMIN/DF (2.880) and RMSEA (0.051), which is significantly lower than the standards, whereas GFI (0.913) and AGFI (0.891) were higher than the standards. The incremental fit indices were IFI (0.960), TLI (0.953), CFI (0.960), and higher than 0.9. Furthermore, NFI (0.940) was above 0.9; therefore, the overall fit of the model was significant and met the goodness-of-fit.

Table 12. Test of goodness of model fit

Class	Absolute fit index				Increment fit index			
	CMIN/DF	GFI	AGFI	RMSEA	IFI	TLI	CFI	NFI
Final model	2.880	.913	0.891	0.051	0.960	0.953	0.960	0.940
Thresholds	<3.00	>0.9	>0.8	<0.1	>0.9	>0.9	>0.9	>0.8
Criterion	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied

After verifying the valency of each factor set in the final structural model, all the measured variables and latent variable values were shown to be significant. All the variables used in the model reflect its concept well because having the value $\beta > 0.5$ showed high credibility with the construct reliability, (CR)>0.7. Moreover, each variable average variance extracted (AVE) was above 0.6, except for the staying and visiting hour variable, which had a value of 0.324, demonstrating the overall validity of the measured model. The reasons for the visiting and staying hours being the exception could be due to the variety of respondents: event participants (48.1 %), others (27.6 %), merchants near the event (12.5 %), and event program managers (11.8 %). When evaluating each variable (event program satisfaction, event operation satisfaction, transportation and infrastructure satisfaction, change in perception, and behavioral change), the standardization factor value was above 0.7, which influences each variable. Further evaluation with specific variables was as follows: event program satisfaction's influence from high to low was games, companies giveaway market, and flea market. The influence of operation satisfaction was street event planning, successful operation without trouble, advertising music, and noise level. Transportation and infrastructure satisfaction influenced the cleanliness of sidewalks and pedestrian spaces. The influence of changes in the user perception satisfaction was in the following order: interest in the expansion of car-free day, interest in environmental transportation, bicycle infrastructure, and importance of pedestrians versus vehicles. The influence of behavioral change satisfaction was in the following order: change in public transportation usage and decrease in vehicle usage afterward. After considering the significance level between the four latent variables according to premise 1 and change in perception, the event operation satisfaction and transportation and infrastructure satisfaction values were 0.432 and 0.274, which were significant ($p > 0.01$). The event program satisfaction and visiting and staying hours showed positive values, yet there was no influence on the change in perception ($p < 0.05$). When considering the significance level between the four latent variables according to premise 2 and the behavioral change, the visiting and staying hours value was 0.177, which was significant ($p > 0.01$), whereas other event program satisfaction, event operation satisfaction, transportation, and infrastructure satisfaction were insignificant. Lastly, when considering the significance level between the change in perception following premise 3 and behavioral change, the result was significant with a value of 0.190 ($p < 0.05$). After complete analysis of the results, event program satisfaction, and transportation, infrastructure positively influences the change in user perception, whereas the hypothesis that the event program satisfaction and staying hours had positively influenced the change in user perception, there was no valency in the statistics. Moreover, it was observed that the longer visiting and staying hours at the event significantly impacted the behavioral change; however, other programs, event programs, transportation, and infrastructure satisfaction were insignificant. However, it was shown that changes in the user perception significantly impacted the behavioral change.

Table 13. Estimation of relation between parameter and latent variable

Path (Observable variable→ Latent variable) (Latent variable→ Latent variable)			Non-standardized Coefficient	Standardized Coefficient	S.E.	C.R.	P	CR	AVE
Environmental transportation experience	→	Event program Satisfaction	0.934	0.792	0.039	24.250	***	0.919	0.648
District agricultural farmers market			0.902	0.759	0.040	22.594	***		
Companies giveaway market			1.010	0.822	0.040	25.472	***		
Streetcultural shows & experiences			0.987	0.813	0.043	23.021	***		
Games			1.021	0.835	0.039	25.880	***		
Flea market			1.000	0.821					
Street event planning	→	Event Operation Satisfaction	1.097	0.864	0.041	26.574	***	0.921	0.661
Successful operation without troubles			1.044	0.840	0.041	25.656	***		
Advertising music and noise level			1.041	0.806	0.043	24.379	***		
Vehicle control within the event area			1.055	0.794	0.044	23.810	***		
Securing parking space			1.111	0.792	0.047	23.846	***		
Interacting between people			1.000	0.795					
Resting facility and	→	Transportation and	1.067	0.796	0.051	20.961	***	0.904	0.654

benches		Infrastructure Satisfaction							
Status of sidewalk pavement			0.969	0.780	0.043	22.283	***		
Cleanliness of sidewalk			1.028	0.813	0.44	23.448	***		
Pedestrian space and safety			1.107	0.865	0.44	25.403	***		
Accessibility to public transportation			1.000	0.782					
Staying hours	→	Visiting and staying hours	1.000	0.951				0.904	0.324
Air pollution problems caused by car	→	Changes in Perception	1.000	0.808				0.721	0.737
Importance of pedestrian versus vehicles			1.071	0.845	0.040	26.466	***		
Interest in environmental transportation			1.039	0.862	0.038	27.262	***		
Bicycle infrastructure			1.075	0.859	0.040	27.113	***		
Interest in expansion of car free day			1.114	0.870	0.040	27.627	***		
Change in vehicle usage	→	Changes in Travel Behavior	1.000	0.699				0.835	0.628
Change in public transportation usage			1.616	0.759	0.107	15.110	***		
Decrease in vehicle usage afterwards			1.852	0.726	0.124	14.982	***		

Event program Satisfaction	→	Changes in Perception	0.070	0.076	0.055	1.274	0.202		
Event Operation Satisfaction			0.425	0.432	0.100	4.259	***		
Transportation and Infrastructure Satisfaction			0.268	0.274	0.078	3.420	***		
Visiting and staying hours			0.005	0.010	0.015	0.340	0.746		
Event program Satisfaction	→	Changes in Travel Behavior	-0.029	-0.060	0.041	-0.699	0.487		
Event Operation Satisfaction			0.054	0.103	0.076	0.705	0.494		
Transportation and Infrastructure Satisfaction			0.058	0.112	0.059	0.972	0.339		
Visiting and staying hours			0.047	0.177	0.012	4.028	***		
Changes in Perception	→	Changes in Travel Behavior	0.098	0.190	0.035	2.810	0.05**		

The previously mentioned nine hypotheses were verified and suggested by the degree of statistics through selection and partial selection. The event program satisfaction and transportation infrastructure positively influence change in the user perception and, therefore, adopt hypotheses 2 and 3. The visiting and staying hours positively influence and, therefore, adopt hypothesis 8. The user perception positively influences the behavioral change and, therefore, adopt hypothesis 9. The partial selection was performed for hypotheses 1 and 4 (event program satisfaction and staying hours will positively influence change in user perception), and hypotheses 6 and 7 (event operation satisfaction and transportation, infrastructure will positively influence change in user perception) owing to invalid statistics despite its unity in direction. Moreover, hypothesis 5 (event program satisfaction will positively influence change in user perception) was not adopted because the direction was rather the opposite, being negative.

Table 14. Results of hypothesis testing

Hypothesis	Hypothetical scheme	Accepted
Hypothesis #1	Event program satisfaction will influence the change in user perception	Partially accepted
Hypothesis #2	Event operation satisfaction will influence the change in user perception	Accepted
Hypothesis #3	Transportation and Infrastructure will influence the change in user perception	Accepted
Hypothesis #4	Visiting and staying hours will influence the change in travel behavior	Partially accepted
Hypothesis #5	Event program satisfaction will influence the change in travel behavior	-
Hypothesis #6	Event operation satisfaction will influence the change in travel behavior	Partially accepted
Hypothesis #7	Transportation and Infrastructure will influence the change in travel behavior	Partially accepted
Hypothesis #8	Visiting and staying hours will influence the change in travel behavior	Accepted
Hypothesis #9	Change in perception will influence the change in travel behavior	Accepted

We conducted hypothesis testing using the research model and proved the validity of the direct and indirect effects from the variable analysis. Proving the effect of direct/indirect factors uses a structural equation model, which includes measurement errors that can be absent in the regression analysis and provides goodness-of-fit to the overall model by proving the relationship between the latent variables. Studies by Brown (1997) showed the limitations of using an independent approach and that the structural equation modeling can assess mediation in complex structures and presents a strategy for supplemental details that more accurately measure the magnitude of mediational effects, particularly with indirect effects; Baron and Kenny (1986) presented a potential procedure for treating moderator variable effects in structural equation models. Therefore, this study used a structural equation model to analyze the direct and indirect effects and used the bootstrapping method to determine the capacity of the effect. Overall, all the direct and indirect effects resulted in capacity when observed statistically.

Table 15. Analysis of the direct/indirect effect between latent variables

Path (Latent variable → Latent variable)			Direct effect	Indirect effect	Total effect
Event program	→	Changes in Perception	0.076		0.076
Event Operation			0.432		0.432
Transportation and Infrastructure			0.274		0.274
Visiting and staying hours			0.010		0.010
Event program	→	Changes in Travel Behavior	-0.060		-0.060
Event Operation			0.105		0.105
Transportation and Infrastructure			0.114		0.114
Visiting and staying hours			0.167		0.167
Changes in Perception	→	Changes in Travel Behavior	0.190		0.190
Event program		Changes in Travel Behavior		0.014	0.014
Event Operation				0.109	0.109
Transportation and Infrastructure				0.063	0.063

Visiting and staying hours				0.002	0.002
Event program	→	Changes in vehicle usage		-0.032	-0.032
Event Operation				0.150	0.150
Transportation and Infrastructure				0.123	0.123
Visiting and staying hours				0.118	0.118
Event program	→	Changes in public transportation usage		-0.032	-0.032
Event Operation				0.163	0.163
Transportation and Infrastructure				0.134	0.134
Visiting and staying hours				0.128	0.128
Event program	→	Decrease in vehicle usage afterwards		-0.034	-0.034
Event Operation				0.155	0.155
Transportation and Infrastructure				0.128	0.128
Visiting and staying hours				0.122	0.122

6. Discussion

The findings of this study indicate that satisfaction with event operations and transportation infrastructure significantly influences perception change, emphasizing their critical roles in shaping

attendees' views. This result aligns with Kim, Park, and Lee (2014), who found that environmental factors such as well-maintained pedestrian infrastructure and clear logistical organization are crucial for enhancing user satisfaction and shaping public perceptions of urban environments. Additionally, their study highlights that creating meso- and micro-scale improvements in urban spaces significantly contributes to positive user experiences, which resonates with the findings of this study. Similarly, Litman (2021) underscores that seamless transportation experiences reduce barriers to participation and enhance public perceptions of sustainable mobility systems.

In contrast, while event program satisfaction and length of stay exhibited positive directional values, they were not statistically significant in driving perception change. This observation is consistent with Jeon and Kim (2019), who suggested that indirect factors, such as the broader context of urban infrastructure and governance, often play a more substantial role in shaping perceptions than localized programmatic features. Their analysis of housing abandonment in shrinking cities emphasized how structural and environmental factors influence broader behavioral and attitudinal trends. These findings extend previous research by suggesting that while event program satisfaction is valuable, infrastructural and operational excellence has a more pronounced effect on perception change.

Further analysis reveals that length of stay plays a pivotal role in influencing changes in travel behavior. This result underscores the importance of prolonged exposure to sustainable practices in reinforcing behavioral changes, as highlighted by Kim et al. (2014). Their research demonstrates that pedestrian-friendly environments and extended engagement can enhance satisfaction and behavioral shifts, particularly when supported by well-maintained infrastructure. Similarly, Gössling et al. (2020) observed that prolonged interaction with sustainable practices fosters lasting behavioral changes. However, in this study, other variables, including event program satisfaction, event operation satisfaction, and satisfaction with transportation infrastructure, did not demonstrate significant impacts on travel behavior. Interestingly, perception change emerged as a critical driver, exerting a significant positive influence on travel behavior shifts. This finding aligns with the Theory of Planned Behavior proposed by Ajzen (1991), which highlights the importance of attitudes and perceived behavioral control as key factors in predicting behavioral outcomes.

These results highlight the necessity of prioritizing effective event operations and maintaining high-quality transportation infrastructure to foster positive perceptions among participants. Optimizing event logistics, minimizing disruptions, and enhancing pedestrian safety and cleanliness are critical measures that can promote favorable attitudes toward car-free and environmentally friendly initiatives. As noted by Kim et al. (2014), satisfaction with the urban environment is closely tied to the perceived quality of infrastructure, further underscoring the importance of comprehensive planning and execution.

The significant influence of length of stay on travel behavior underscores the potential for events to drive meaningful behavioral change by encouraging longer participation. Event organizers should design immersive and engaging programs that motivate attendees to extend their visits, amplifying the impact of the event on sustainable behavior adoption. This approach is supported by Jeon and Kim (2019), who argued that aligning event strategies with broader urban planning efforts is essential for achieving long-term behavioral and attitudinal impacts.

Finally, the strong relationship between perception change and travel behavior emphasizes the value of educational and promotional strategies in advancing sustainable transportation goals. Campaigns that raise awareness and positively shape public perceptions can complement infrastructure improvements and operational efficiency. For example, initiatives that highlight the benefits of public transit and environmentally friendly practices can significantly reduce dependence on private vehicles. These findings provide actionable insights for policymakers and event organizers, suggesting targeted interventions that align with broader urban mobility and sustainability objectives.

7. Conclusion

This study explored the shift toward a sustainable mobility paradigm by examining the case of Suwon's car-free day projects in South Korea. It aimed to assess whether such initiatives can reduce vehicle use and promote sustainable mobility practices. By analyzing satisfaction and perception through survey data, the research identified key factors influencing perception and behavioral changes. The methodology included exploratory factor analysis and structural equation modeling to investigate the relationships between observed variables and underlying latent constructs.

The analysis drew on responses from 720 participants in Suwon's 2016 car-free day survey. The findings revealed that satisfaction ratings across operational factors averaged 3.5 out of 5, indicating room for improvement. Notably, satisfaction with benches and resting facilities received the lowest scores, underscoring specific areas requiring attention. The measured variables were categorized into five groups: event types, event operation, infrastructure, changes in perception, mobility patterns, and visiting hours.

To understand the dynamics of satisfaction, perception changes, and behavioral shifts, the study tested three overarching premises and nine hypotheses. The results showed that event program satisfaction and transportation infrastructure satisfaction positively influenced perception changes, while visiting hours and perception changes were significant drivers of behavioral changes. However, some hypotheses were not supported. For instance, the hypothesis that event program satisfaction directly influences perception changes was not validated, as the relationship was found to be negative. Despite such unexpected findings, the overall statistical results demonstrated the robustness of the analysis.

The novelty of this study lies in its focus on Suwon as a case study, offering valuable insights into the potential for car-free initiatives to foster a sustainable mobility paradigm in a non-European context. European Mobility Week, established over 12 years ago, has become a benchmark for promoting sustainable urban mobility across 3,000 cities annually. However, Suwon's citizen-led approach provides a distinct model of community-driven engagement. Unlike top-down European campaigns, Suwon's car-free day emphasizes grassroots participation in planning and organizing events, showcasing how locally tailored initiatives can foster civic engagement and sustainable mobility practices.

The study highlighted that satisfaction with event operations and transportation infrastructure plays a key role in fostering positive perception changes, while staying hours and perception changes significantly impact behavioral shifts. Enhancing event operation satisfaction requires efficient planning, seamless execution, and minimizing disruptions, including noise management. For transportation and infrastructure, improvements in sidewalk cleanliness, pedestrian safety, and accessibility are critical. Conversely, event program satisfaction was found to have limited influence on perception and behavioral changes, suggesting a greater emphasis on the overall event flow and purpose rather than detailed components. The findings contribute to the broader understanding of whether a shift toward a sustainable mobility paradigm can reduce vehicle use, showing that such initiatives have potential but require targeted improvements to maximize their impact.

However, this study has several limitations. First, it is limited to analyzing survey-based intentions rather than observed outcomes. Second, the findings are drawn from a specific event setting, which may not be fully generalizable to other contexts or long-term behavioral shifts. Third, external factors such as weather conditions, concurrent events, or seasonal variations may have influenced participants' responses but were not explicitly controlled. Lastly, while the study focuses on transportation and event-related factors, individual characteristics such as prior mobility habits and personal preferences may also play a role in perception and behavior changes but were not extensively examined. Acknowledging these limitations helps contextualize the findings and suggests areas for further research.

Future research could address these limitations by employing longitudinal or cohort methodologies to assess the long-term impacts of car-free events. Additionally, integrating lessons from European Mobility Week—such as structured evaluation methods for public satisfaction, transportation accessibility, and sustained behavior changes—could further enhance the effectiveness of Suwon's car-free initiatives. These efforts would provide stronger evidence to support the planning and implementation of future car-free strategies and contribute to the broader discourse on sustainable urban mobility.

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Highlights

- Many cities are beginning to shift their transportation solutions away from coercive measures to reduce private car use toward sustainable mobility management, such as car-free solutions.
- This study analyzes user perceptions and behavioral changes during car-free days in Suwon, South Korea.
- Visiting and staying hours significantly influence changes in travel behavior, and event operation satisfaction is an important factor impacting perception and behavioral changes during car-free days.
- This study demonstrates that psychological changes in perception influence travel behavior changes, and car-free solutions may positively contribute to reducing car use.