Modeling the Travel Mode Choice for Outpatient Trips Before and After Bike-Sharing in Beijing

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***Abstract*—Both of the transportation and the public hospital outpatient services are the key public services provided by the government, which guarantee the safe, healthy and worthwhile life for daily living in metropolitan cities such as Beijing and Hong Kong. Since the citizens usually have to see their medical doctors at the appointed time, they should arrive punctually as scheduled for their outpatient services in public hospitals. In order to find out how people travel to the public hospitals for their scheduled outpatient appointments particularly before and after the bike-sharing system in Beijing, two interview surveys with a total of 1,047 valid samples were conducted at the Beijing Friendship Hospital in October 2016 and 2017. One was before the launch of the floating bike-sharing system in November 2016 while the other one was conducted in October 2017 after this new system has been implemented in Beijing for about one year. Compared to the other non-motorized travel modes, the bike-sharing mode could provide the best trip experience with the highest evaluation scores on the satisfaction, the comfort, the convenience and the punctuality of the outpatient trips. Multinomial Logit (MNL) model is calibrated to investigate the factors to influence the travel mode choice for outpatient trips. The results show that the outpatient travelers are likely to choose the bike-sharing mode for their return outpatient visits at public hospitals in Beijing. Other factors like online map-usage, the acceptable maximum walking time and cycling time, the weekend appointment for outpatient services and the household income have positive impacts on the choice of the bike-sharing mode.**

Keywords—bike-sharing; outpatient trip; Multinomial Logit Model; survey

I. INTRODUCTION

Traffic and the medical are two important branches in the root duties of the government to guarantee the safe, healthy and worthwhile life for the civil. The outpatient shall arrive for the clinic treatment at the appointed time. Compared to other trip purposes, these travelers need a more punctual, convenient and reliable travel mode. However, in the developing countries, the accessibility of the public transport network is insufficient to some extent in the current. The subway station may be 2 km or further far away from the public hospital. Even more, driving has the normally high risk of the congestion and the lack of parking space. How to get to the public hospital is a problem for the outpatient. In the other side, it is also the headache for the government. The investigation for the mode choice and trip experience is necessary to analyze this problem.

The great numbers of population and the smart phone users create the huge market of floating bike-sharing system in China. As a successful application of Intelligent Transport System (ITS), it is called one of the new top 4 Chinese invents. It also grows fast in the world. Since it came out in the April of 2016 in Shanghai, in the November of the same year in Beijing, China, it has expanded the market in more than 250 cities over more than 20 countries. The following advantages contribute to its widely implemented: alleviating the 'last mile' problem, relieving the traffic congestion, providing a more environmental-friendly life style, and a user-friendly smart mode of transportation. The advantages of the floating bike-sharing system attract the urban citizens to use it in the daily travel to the workplace, the school, the supermarket and shopping mall, the public park, the public hospital and any other place they want.

Beijing Friendship Hospital (BFH) is the highest level of the hospital in China, rated as the 3rd-grade class-A. It has 43 clinical and medico-technical departments, 2,800 staff members including 400 chief and deputy chief physicians, professors, associate professors, research fellows and senior technical staff, 1,256 inpatient beds. The number of outpatient cases comes to about 8,000 every day. Most of the appointments are made by the smart phone application, website, phone call and the self-feeder in 1 or 2 weeks before

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the treatment. If the outpatients arrive later than the appointed time, the appointment will be canceled. Hence, besides the convenience, the outpatient trip calls for punctuality and reliability. And the evaluation of satisfaction will be more rigorous. The traffic facilities around BFH are shown in Fig. 1. Located inside the 2nd Ring Road of Beijing, as the city center, it is surrounded by 2 subway stations and 23 bus lines at 4 bus stops. Walking from either of the subway stations to BFH takes more than 15 minutes for the healthy adults.

In order to investigate the outpatient trip to this hospital, two interview surveys were conducted at BFH in October 2016. Then in November 2016, the bike-sharing got popularized in the city. With the purpose of investigating the effects the bike-sharing brought to the outpatient trips, a relative survey was proceeded in October 2017 to make the comparative study. The valid respondents, 525 and 522 separately in the two years, were selected with similar Origin-Destination (OD) and age distribution. The survey data were used to determine the factors on the bike-sharing choice by using the Multinomial Logit (MNL) model.

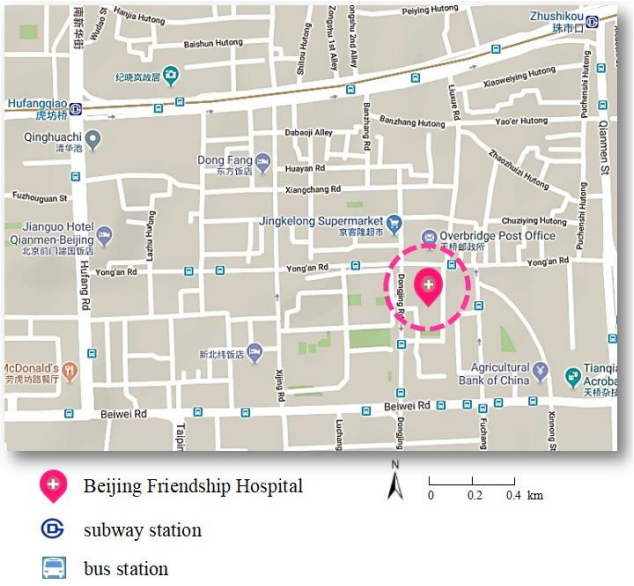

Fig. 1. The traffic facilities around Beijing Friendship Hospital

The next parts of this paper are structured as follow: in Section II, a review of the recent studies on the travel mode choice, the bike-sharing and the outpatient trip is summarized. Section III provides the methodology including the survey design and MNL model. The analysis and results in terms of the travel mode, the trip experience and the influence factors are in Section IV. The conclusion is in the last Section.

II. Literature Review

A way to improve the experience of the travelers and to increase the general understanding of the travel behavior for the traffic police adviser and management department of the government lie in the travel mode choice analysis. The bike-sharing has changed the residents' daily travel modes and spurred widespread concern. The specific demand and character of the trip to the clinic need to be taken into account.

A. Travel Mode Choice

The travel modes in the urban transport contain bus, subway, bus rapid transit (BRT), taxi, bike, walking etc. Studies in travel behavior concerned about how people make a choice to travel between these travel modes and what factors influenced their decision. To encourage residents in Jakarta Greater Area to choose the public transport, Safitri and Surjandari used decision tree to study and predict the travel mode choice [1]. Kroesen analyzed the travel behavior in Dutch and indicated that the multiple-modal travelers, compared to the single-modal travelers, were more likely to switch from one travel mode to another [2]. Comparing travel mode and trip chain choices between weekdays and holidays in Beijing by Nested Logit models, Yang et al. found that travelers prefer to decide the trip chain pattern prior to choosing travel mode in weekdays, but the opposite on holidays [3]. Geng et al. utilized the cluster analysis to discuss social-demographic properties, travel modes and habitat. They suggested that policy interventions should focus on the improvement of public transport especially the bike system, and that tailored policies need to be targeted on specific groups with different goals [4]. The travel mode choice was affected by travel satisfaction. Abenoza et al. identified and characterize current and potential users of public transport from a database of about fifty thousand records in Sweden. Three key attributes addressed on customer interface, operation, network and length of trip time [5]. Susilo and Cats took the experimental survey data in eight European cities to study the key satisfaction factors of the various travel modes such as public transport, car, bicycle and walking. In order to examine the relationships between overall satisfaction and trip experience, the subjective well-being indices, travel-related attitudes were selected as variables [6]. Mao et al. pointed out that travelers with high flexibility are generally more satisfied because of the higher possibility in travel mode choice [7].

B. The Bike-sharing

The bike-sharing developed rapidly in recent years. The number of the bike-sharing has grown at an average of 37% annually [8]. Many researchers believe that the bike-sharing will become a potential answer to some of the urban mobility challenges faced with Chinese development patterns [9]. To some extent, it changed current travel modes and replaced the private car in short trips. With the implement of bike-sharing system such as City Cycle (in Brisbane) and Melbourne Bike Share (in Melbourne), 21% and 19% of the bike-sharing users reduced the frequency of private cars. While in London and Washington D.C., the ratios were only 2% and 7% [10]. Purwanda discussed the design of bike-sharing system, which consisted of Liquid Crystal Display and Near Field Communication modules [11]. Ruffieux et al. collected data in six different European cities and developed a real-time system to provide predictions and slots availability [12].

C. Outpatient Trip

Clinic is an essential service facility for residents, while the trip of it is thus of great importance. Ghasrodashti and Ardeshiri identified multiple factors that influence their travel modes to clinics. The results indicated that subjective factors such as lifestyle and objective factors such as land

use attributes had impact on travel mode choice. The data were from 900 respondents in Shiraz, Iran [13]. Neutens discussed recent accomplishments on modeling accessibility to clinics. Neutens suggested that clinics need adequate and equitable accessibility compared with other facilities [14]. Rotaris et al. identified different travel modes to the clinic which was located near a university. They focused on the students' travel mode choice decisions when their destinations are clinics [15].

III. METHODOLOGY

In this study, the questionnaire was designed to address the factors of the travel mode choice in outpatient trips. The respondents included bus users, subway users, car users, riders and pedestrians with similar origins. The travel attribute, the travel behavior and the demographic were considered as the potential influence factors of travel mode choice. The valid data from the survey were fed into MNL model to calculate possibility of the impact of these factors.

A. Survey Design

In order to investigate the preference on travel mode choice, a comparative survey was conducted. To ensure the consistency of the sample, data were collected in the same condition in BFH. For the weekday, the survey data were collected on Oct 13th, 2016 and Oct 25th, 2017. The investigate time was both between 8 am and 4 pm, last for 7 hours. The survey weekday in 2016 is Thursday while Wednesday in 2017. The survey weekdays in the two years were not chosen as the same day of the week, because the turnover policy of the car use restriction in Beijing was taken into account. The banned license plate in the urban area (inside the 5th ring road) on these two days were both with tail number 3 and 8. For the weekends, there was no restriction for driving. The survey days were both on Sunday, respectively Oct 16th, 2016 and Oct 29th, 2017. The clinic departments were rest in the Sunday afternoon so the surveys on weekends were conducted during 8 am to 12 am, last for 4 hours. There were 10 trained investigators in the survey. Each of them completed 5-7 surveys per hour. The investigation was controlled in gender and age groups. The valid data were selected after double check and the comparison of the trip origin area. After the above preprocessing work, there were altogether 525 valid respondents in 2016, in which 347 were on weekday and 178 on Sunday. In the second year, the valid sample size was 522, 342 on weekday and 180 on Sunday.

The questionnaire includes two parts: the trip character and demographics. Respondents are inquired with the questions including the departure origin (nearby icon building, cross or bus stop), the travel mode, the departure time, the appointment time, the travel time, the trip experience evaluation indexes and the visit type (primary treatment or the return). The trip experience contains four indicators: the satisfaction, the comfort, the convenience and the punctuality. In order to evaluate the trip accurately, it uses the score range from one to five, representing the level of service from the worst to the best.

The second part is demographics, including the acceptable maximum walking time, the acceptable maximum cycling time, the habit of online map-use, the gender, the age, the home ownership of the car and bike, the education and the household income.

In the second survey questionnaire, the choice of bike-sharing is added. The membership of the bike-sharing system, the unlocking time and the choice under different weather conditions are also appended for further study.

B. Multinomial Logit Model

The MNL model (1) is considered as an ideal research method for its convenience in studying the relationship between various influence factors. The model is used to predict the probabilities of the different possible dependent variables. The influence factors of the bike-sharing choice are estimated by MNL model, which estimates the likelihood of respondents to make the certain choice.

$$P_r(Y_i = K) = 1 - \sum_{k=1}^{K-1} P_r(Y_i = K) e^{\beta_k X_i} \rightarrow P_r(Y_i = K) = (1+x)^n = \frac{1}{1+\sum_{k=1}^{K-1} e^{\beta_k X_i}} \quad (1)$$

X_i: the vector of explanatory variables describing observation i;
Yi is the probability of choosing the mode i;
β_k: the vector of weights (or regression coefficients) corresponding to k.

In this study, the variables are as follows: the travel date, the visit style, the travel time, the acceptable maximum walking time, the acceptable maximum cycling time, the online map-use, gender, age, education, car ownership, bike ownership and the household income. Coefficients are estimated by the survey data.

IV. ANALYSIS AND RESULTS

At source, the survey data are statistics to take a portray of the travel mode choice of the outpatients. Then the trip experiences of non-motorized modes and public travel modes are compared in 2016 and 2017 respectively. In the last part, the influence factors are discussed based on MNL model.

A. Travel Mode

The percentage of the travel modes choice in 2016 and 2017 is in Fig. 2. The multi-modal is classified to compare the difference in travel modes within two years.

In 2016, most travelers choose a single mode. Only 1.1% of them transfer between subway and bus. The public transport takes up the largest proportion. The subway takes up the highest proportion (31.6%), secondly the bus (23.2%). The non-public transport is divided into three groups: the private car, the taxi and the car-hailing. The three travel modes respectively account for 14.9%, 5.0% and 8.6%. Non-motorized travel accounts for the smallest proportion. The proportion of walking is higher than that of cycling.

In 2017, the multi-modal trip combining the bike-sharing and public transport turns out. The proportion of single-mode travel has changed obviously. The choice of driving is decreased almost in half. The bus users raise from 23.2% to 33.1%, increase nearly 40%. Taxi and the car-hailing also increase a little. The outpatient trip is different from the daily commute trip. Outpatients need to arrive at the clinic before the appointed time. The time spent in the treatment is difficult to predict for the outpatients so the parking fee is difficult to make budget. Thus, with similar less walking

distance, the flexible travel modes such as taxi, car-hailing and bike-sharing are preferred than the private car.

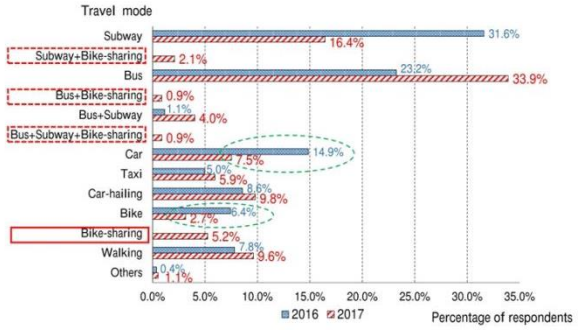

Fig. 2. The percentage of travel modes in 2016 and 2017

It should be noticed that the percentage of the non-motorized modes has a huge change. In 2017, with appearance of the bike-sharing, it takes place 5.2% which is much higher than the private bike (2.7%). To better show the change in detail, the choices of the riding modes in two years are shown in Table I.

TABLE I. The percentage of the riding mode

	2016	2017	Sum
Bike-sharing only	N/A	**5.2%**	**9.1%**
Bus+Bike-sharing	N/A	0.9%	
Subway+Bike-sharing	N/A	2.1%	
Bus+Subway+Bike-sharing	N/A	0.9%	
Private bike	6.4%	**2.7%** (↓**57.8%**)	
Total	6.4%	**11.8%** (↑**84.4%**)	

The widespread layout of bike-sharing makes the previous private bike users switch to this cheap but flexible mode. The percentage of private bikes decreased even over a half just a year after the bike-sharing joined the market. Unlike the private bike riders who have to ride back home after the treatment, the bike-sharing users are not bothered to ride in the return trip. It is the opportunity for them to choose another mode on the return trip to fit their situation or time demand. This is a significant advantage character of the sharing economy, such as the bike-sharing and car-hailing.

With the contribution of bike-sharing, the total choice for cycling (the private bike and the sharing bike) boosted by 84.4% comparing to 2016. It gains recognition from the outpatients. The cycling environment and facilities need to be updated to meet this new trend.

Moreover, it can be deduced that the bike-sharing, as a new travel mode, can be either a feeder in the multi-modal travel link, or a replacement of the former travel mode. It increases the accessibility and redundancy in the transportation system.

B. Trip Experience Evaluation

In order to better analyze the difference between the travel modes from the outpatients, the respondents are investigated for further questions for their trip. Many previous studies assess the subjective trip experience by satisfaction. In fact, the satisfaction cannot fully describe and compare the feeling in detail. This study, a framework with four indicators is set up including the satisfaction, the comfort, the convenience and the punctuality. The score of each evaluate object is from one to five, which means from the worst to the best.

The scores of non-motorized travel modes, i.e. bike-sharing, private bike and walking are shown in Table II. The number in second column of different indicators shows the comparison between their score and average of total sample. Symbols like ↓and↑ are used to indicate the trend of their scores compared to the last year.

Compared with other non-motorized travel modes, the bike-sharing has the highest average scores in trip experiences, 4.57, 4.37, 4.62 and 4.60, respectively on the satisfaction, the comfort, the convenience and the punctuality. It reveals that bike-sharing users feel more satisfied and comfortable than private bike users and pedestrians. The journey time is important to the outpatients with appointment. As the travel time of riding is much shorter than walking in the same distance, the trip experience score of the bike-sharing is higher than walking. At the same time, the bike-sharing users do not have to seek the parking space, which is more convenient than private bike users. The convenience score of bike-sharing is 18.77% higher than the average of the total samples. Another highlight score for bike-sharing is the punctuality, which is 16.46% higher than the average.

In 2016, all the non-motorized travel modes gained a higher score than the average of the total samples. It means that, comparing to the public transport modes (subway and bus), the operate modes (taxi and car-hailing) and driving, the green travel modes were more delighted then. After the bike-sharing became more and more popular, however, walking lost the champion place, especially in the race of convenience.

The bike-sharing is popular in multi-modal trips. It can be considered as a feeder of the public transport, which helps the outpatient to get to the station from home or get to the public hospital from the station more easily and faster than walking. The results under this situation are shown in Table III, where “BS” is the short for bike-sharing.

Though the travel choice of double modes plays not as good as the single travel mode, both the groups of subway and bike-sharing, bus and bike-sharing still keep the advantage than the total travel choices in convenience and punctuality, which are very important for the outpatients.

TABLE II. The evaluation scores of the non-motorized travel modes trip experience

Year	Mode	Satisfaction			Comfort			Convenience			Punctuality		
		Score	*Deviation*	*YoY*	*Score*	*Deviation*	*YoY*	*Score*	*Deviation*	*YoY*	*Score*	*Deviation*	*YoY*
2016	Private Bike	4.15	+4.53%		3.93	+1.03%		4.29	+5.67%		4.46	+9.85%	
	Walking	4.20	+5.79%		4.11	+5.66%		4.32	+6.47%		4.55	+12.07%	

	Total Average	3.97			3.89			4.06			4.06		
2017	Bike-sharing	**4.57**	**+12.29%**		**4.37**	**+15.00%**		**4.62**	**+18.77%**		**4.60**	**+16.46%**	
	Private Bike	4.04	-0.74%	↓2.65%	4.02	+5.79%	↑2.29%	3.92	+0.01%	↓7.23%	4.31	+9.11%	↓3.36%
	Walking	3.92	-3.69%	↓6.67%	4.05	+6.58%	↓1.46%	3.72	-4.37%	↓13.89%	3.73	-5.57%	↓18.02%
	Total Average	4.07		↑2.52%	3. 80		↓2.31%	3.89		↓4.19	3.95		↓2.71%

Score 1-5, the worst to the best; Deviation, + more than the average, - less than the average; YoY= Year on Year, ↓ drop off than 2016, ↑rise up than 2016

TABLE III. The evaluation scores of the combination of the bike-sharing and the public transport trip experience

Year	Mode	Satisfaction			Comfort			Convenience			Punctuality		
		Score	***Deviation***	***YoY***	***Score***	***Deviation***	***YoY***	***Score***	***Deviation***	***YoY***	***Score***	***Deviation***	***YoY***
2016	Subway	4.01	+1.01%		3.78	-2.83%		4.12	+1.48%		4.39	+8.13%	
	Bus	3.89	-2.02%		3.78	-2.83%		4.00	-1.48%		3.89	-4.19%	
	Total Average	3.97			3.89			4.06			4.06		
2017	Bike-sharing	**4.57**	**+12.29%**		**4.37**	**+15.00%**		**4.62**	**+18.77%**		**4.60**	**+16.46%**	
	Subway	4.19	+2.95%	↑4.49%	4.03	+6.05%	↑6.61%	**4.03**	**+3.60%**	**↓2.18%**	**4.05**	**+2.53%**	**↓7.74%**
	Subway+BS	4.00	-1.72%		3.46	-8.95%		**3.92**	**+0.77%**		**3.92**	**-0.76%**	
	Bus	4.22	+3.69%	↑7.82%	3.93	+3.42%	↑3.97%	4.10	+5.40%	**↑2.50%**	4.05	+2.53%	**↑4.11%**
	Bus+BS	4.00	-1.72%		3.80	0.00%		**4.00**	**+2.83%**		**4.00**	**+1.27%**	
	Total Average	4.07		↑2.52%	3. 80		↓2.31%	3.89		**↓4.19**	3.95		**↓2.71%**

"BS"=bike-sharing; , Score 1-5, the worst to the best; Deviation, + more than the average, - less than the average; YoY= Year on Year, ↓ drop off than 2016, ↑rise up than 2016

Compared with the other travel modes, bike-sharing obtains the highest score in all the four evaluation indicators of trip experience. It is necessary to explore what factors contribute to its popularity.

C. *Influence Factors*

In order to better understand the travel mode choice in outpatient trips, the factors and their attribute that may affect the bike-sharing selection need to be studied.

The survey data are collected from registered members of bike-sharing. The results are shown in Table IV. The significance levels (***Sig***) in Table IV are 0.1, 0.05 and 0.01. The factors with a significant result below 0.1 are retained. It is easy to conclude that the travel time and the education do not affect the choice of the bike-sharing. When ***Coef*** is greater than 0, it means that this variable has a positive impact on the bike-sharing choice. If ***Coef*** is less than 0, the variables have a negative impact.

From the coefficient estimates, the maximum coefficient factor is the trip for the return treatment. These outpatients have a better condition than those have not received the medical service. The lowest possibility of choosing the bike-sharing is the primary treatment. When people are in bad physical conditions, they prefer to travel by motorized mode rather than the bike-sharing. Moreover, the return treatment visitors are more familiar with the outpatient trip than the primary-care. Other results show that the travelers who use online map prefer to use the bike-sharing. People with high household income are more likely to choose the bike-sharing. As the acceptable maximum cycling time and walking time increase, people become more willing to choose the bike-sharing. The respondents would be inclined to ride the bike-sharing on weekday compared with the weekend. The male tends to choose the bike-sharing comparing to the female. The possibility of elderly people to choose the bike-sharing is lower than that of young people. The respondents' interest on the bike-sharing will reduce with the increase of numbers of their own cars and bikes.

TABLE IV. MNL model estimation results of the outpatient trip

Correlation	Variables	Control group	Coef.	Sig.
Positive correlation	Visit style (Ref.= other)	Return	1.124	**.009*** **
	Online map-usage(Ref.= no usage)	Using online map	1.023	.061*
	Acceptable maximum cycling time		0.903	**.008*** **
	Travel date (Ref.= weekend)	Weekday	0.829	.084*
	Household income		0.098	.095*
	Acceptable maximum walking time		0.026	.092*
Negative correlation	Gender (Ref.=male)		-0.901	.089*
	Age		-1.071	.067*
	Car ownership		-1.106	.072*
	Bike ownership		-1.609	.065*
	Visit style (Ref.= other)	Primary treatment	-2.490	**.023** **
No correlation	Travel time		-0.671	.290.:
	Education		-0.229	.465.:

Significance levels: .: not significant, * Significant at 0.1, ** Significant at 0.05, *** Significant at 0.01.

V. CONCLUSION

In this paper, the bike-sharing mode has been shown as an effective option for travel to public hospital for outpatient services particularly for the clinics or hospitals not close to the subway stations in Beijing. This travel mode can meet the outpatients' specific requirements on punctuality and convenience. To draw more outpatients' attention on this effective travel mode, it is important to understand the factors that attract outpatients to choose the bike-sharing mode for their outpatient trips.

A comparative survey was conducted at BFH in October of 2016 and 2017. The change in the travel modes after the

launch of the bike-sharing system can be obtained by comparing the constituent ratio of travel modes. The survey results show that the bike-sharing has become a replacement of using private bikes. In 2017, 5.2% of outpatients used the bike-sharing. While only 2.7% of outpatients chose the private bike, which decreased by 57.8% as compared to the survey results in 2016. Moreover, the bike-sharing is shown to be an important mode for the travel with more than one mode. Travelers also use the bike-sharing mode for their trips from bus stops and subway stations to the BFH.

On the basis of the survey data, the trip experience of the respondents who are registered members of the bike-sharing system has been further investigated. For bike-sharing, the scores on the satisfaction, the comfort, the convenience and the punctuality are 4.57, 4.37, 4.62 and 4.60 respectively, which are higher than those of private bikes and walking mode. Compared to other non-motorized travel modes, bike-sharing can provide the best trip experience for outpatient trips. The role of the bike-sharing in public transport is also examined. The results show that the bike-sharing is an effective feeder to public travel modes such as bus and subway. It may be partly due to the fact that the bike-sharing can be used to connect public travel modes to improve the accessibility of the public transport network.

In addition, MNL model has been used to investigate the factors on the choice of the bike-sharing mode for outpatient trips. The survey results show that the outpatients for the primary treatment are the least inclined to use the bike-sharing, while those who take the return clinic visit are likely to use the bike-sharing mode. Besides, factors like online map-usage, the acceptable maximum cycling time, the acceptable maximum walking time, the weekend appointment and the household income have positive impacts on the choice of the bike-sharing mode.

With the advancement of ITS, attention has recently been given on studies and applications of the bike-sharing systems for outpatient trips particularly for the clinics and public hospitals far from public transport stations. Hopefully, the bike-sharing system can improve the accessibility for outpatients. The bike-sharing system can become more helpful for the citizens to have a healthy and better life future. Further studies can be carried out to assess the effects of bike-sharing mode on accessibility of multi-modal transportation system with taking account of the demand and supply uncertainties.

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REFERENCES

[1] D.M. Safitri and I. Surjandari, “Travel Mode Switching Prediction using Decision Tree in Jakarta Greater Area,” 2017 International Conference on Information Technology Systems and Innovation (ICITSI), Bandung, October 2017.

[2] M. Kroesen, “Modeling the behavioral determinants of travel behavior: An application of latent transition analysis,” Transport Research Part A: Policy and Practice, 65, pp.56-67, April 2014.

[3] L. Yang, Q. Shen and X. Li “Comparing travel mode and trip chain choices between holidays and weekdays,” Transport Research Part A: Policy and Practice, 91, pp.273-285, July 2016.

[4] J. Geng, R. Long and H. Chen, “Impact of information intervention on travel mode choice of urban residents with different goal frames: A controlled trial in Xuzhou, China,” Transport Research Part A: Policy and Practice, 91, pp.134-147, July 2016.

[5] R.F. Abenoza, O. Cats, and Y.O. Susilo, “Travel satisfaction with public transport: Determinants, user classes, regional disparities and their evolution,” Transport Research Part A: Policy and Practice, 95, pp.64-84, January 2017.

[6] Y.O. Susilo and O. Cats, “Exploring key determinants of travel satisfaction for multi-modal trips by different traveler groups,” Transport Research Part A: Policy and Practice, 67, pp.366-380, September 2014.

[7] Z. Mao, D. Ettema, and M. Dijst, “Commuting trip satisfaction in Beijing: Exploring the influence of multimodal behavior and modal flexibility,” Transport Research Part A: Policy and Practice, 94, pp.592-603, November 2016.

[8] R. Meddin, The Bike-Sharing World Map. [Online]. Available: http://www.bikesharingmap.com Accessed November 1, 2015.

[9] A. Andrew, C.R. Cherry, M.S. Ryerson, and X. Yang, “Factors influencing the choice of shared bicycles and shared electric bikes in Beijing,” Transport Research Part C: Emerging Technologies, 67, pp.399-414, March 2016.

[10] E. Fishman, “Bike-sharing: a review of recent literature,” Transport Reviews, 36, pp.92-113, April 2015.

[11] I.G. Purwanda, T. Adiono, S. Situmorang, F. Dawani, H.A. Samhany, and S. Fuada, “Prototyping Design of A Low-Cost Bike Sharing System for Smart City Application,” The International Conference on ICT for Smart Society (ICISS) 2017, London, September 2017.

[12] S. Ruffieux, E. Mugellini, N. Spycher, and O.A. Khaled, “Real-Time Usage Forecasting for Bike-Sharing Systems,” Intelligent Systems Conference, London, September 2017.

[13] R.E. Ghasrodashti and M. Ardeshiri, “Modeling travel behavior by the structural relationships between lifestyle, built environment and non-working trips,” Transport Research Part A: Policy and Practice, 78, pp.506-518, July 2015.

[14] T. Neutens, “Accessibility, equity and health care: review and research directions for transport geographers,” Journal of Transport Geography, 43, pp.14-27, 2015.

[15] L. Rotaris, and R. Danielis, “The impact of transportation demand management policies on commuting to college facilities: A case study at the University of Trieste, Italy,″ Transport Research Part A: Policy and Practice, 78, pp.506-518, August 2014.