



Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: www.elsevier.com/locate/jth

Research on the rationale of width of disabled parking spaces and correlation of selection by wheelchair users and others



Weite Lu*, Chunqin Zhang, Xunyou Ni

School of Civil and Architectural Engineering, Zhejiang Sci-Tech University, No. 928, Second Avenue, Xiasha Higher Education Zone, Hangzhou 310018, China

ARTICLE INFO

Keywords:

Disability
Parking
Width of disabled parking space
Wheelchair user

ABSTRACT

Objectives: To examine the rationale of width of disabled parking space and to identify factors which may be associated with selection of standard disabled parking space used by different categories of drivers in China.

Method: a) Inviting individuals with disabilities to alight into different sizes of parking spaces in an experimental survey. b) Sociodemographic and transport variables relative to the selection of width of 'disabled parking space' were compared by using logistic regression model.

Result: a) The current disabled parking spaces were oversized for most individuals with disabilities. b) Physical body traits, types of aids (i.e. the degree of disability) and driving experience were potential factors which caused individuals to select wider or narrower parking spaces.

Discussion: Existing disabled parking facilities and policy about width need to be adjusted to meet requirement of individuals with differing degrees of disability. We have proposed a re-configuration of the disabled parking system that may diminish the conflict between wheelchair users and other users. Our study has the potential to contribute to the design of effective disabled parking spaces in order to enhance health and encourage travel for individuals with disabilities.

1. Introduction

Disabled parking spaces are an important infrastructure for the mobility of individuals with disabilities because approximately 40% of individuals in the world depend on private automobiles for transportation (Bascom and Christensen, 2017). These wider-than-regular size parking spaces placed close to destination entrances serve people with disabilities by providing sufficient space to board and alight from motor vehicles with their mobility aids. These parking spaces also serve people with disabilities by shortening the access distance to their destination. The larger-than-usual width of the parking space reduces the total number of spaces that can be accommodated within a given total area and is often a point of contention between planning authorities and service providers (Lambrinos and Dosis, 2013; Lu, et al., 2014; Kiyota et al., 2016).

The values of width of standard disabled parking spaces do not reach complete agreement among different countries. The Americans with Disabilities Act (ADA) stipulations specified that the minimum width for disabled spaces is 3.96 m (13 ft) (Department of Justice in U.S., 2010). The European Union and United Kingdom adopted a minimum width of 3.60 m and the minimum width specified for the alighting area is 1.20 m (Nishidate et al., 2008a; Traffic Advisory Leaflets in UK, 1995). Although the width value is smaller than the American standard, it should be noted that the European Union and United Kingdom standards allow for two adjacent disabled parking spaces to share a single alighting area. The widest minimum allowable alighting space for

* Corresponding author.

E-mail addresses: weitelu@zstu.edu.cn (W. Lu), cqzhang@zstu.edu.cn (C. Zhang), nixunyou@zstu.edu.cn (X. Ni).

<https://doi.org/10.1016/j.jth.2019.01.006>

Received 25 September 2018; Received in revised form 10 January 2019; Accepted 12 January 2019

Available online 22 January 2019

2214-1405/ © 2019 Elsevier Ltd. All rights reserved.

disabled parking has been reported in Australia which is 4.80 m (Australian and New Zealand Governments, 2009) and the narrowest has been reported from South Korea and Japan (Cabinet of Japanese Government, 1994; South Korea National Institute for special education, 2013a). South Korea and Japan adopt the smallest value for the minimum allowable parking space width at 3.50 m (Ministry of Construction of Japan, 1994; South Korea National Institute for special education, 2013b). In addition, South Korean documentation indicates that the width of the space specified is inclusive of the width of lane marking which can be interpreted to mean that the width per parking space can be slightly less than the minimum 3.50 m specified depending on the width of paint mark.

The width of disabled parking has been accurately specified by local law and regulation throughout the world. However, it is unclear how these values were obtained. To the authors' knowledge, there is little explanation in the legal resources of most countries. Only the Japanese government (Japan Institute of Country-ology and Engineering, 2011) has mentioned that the parking space width was defined as the width allowable for a wheelchair to be turned around within the alighting space, but they did not perform any testing. In addition, there was a lack of evidence that the Japanese government considered the disabled people's needs when designing the width of the disabled parking space. Only Lu et al. (2015a) considered that different body sizes of individuals may be the one of main influences. For example, a middle-age Chinese male's average weight and height are 67.7 kg and 170.4 cm, while only 59.1 kg weight and 159.6 cm height for middle-aged females. However, in the USA, a middle-age male's average weight and height are 86.6 kg and 176.3 cm, and middle-age female's average weight and height are 70.3 kg and 162.2 cm (Yang et al., 2005).

Some researchers have doubted the rationale used to determine width for disabled parking set by governments. Nishidate et al. (2008b) listed the different widths of disabled parking spaces in European Union countries and mentioned that the width of disabled parking might be inappropriate in Asia. Brimson et al. (2008) mentioned the width of parking spaces for people with disabilities may be not appropriate for physical standards of access in Australia. Kiyota et al. (2009) did an experiment in Japan to measure the requirement of minimum width in disabled parking for six wheelchair users (most of them being passengers). The results showed the 3.20 m-wide parking space (alighting space is 1.2 m-wide) is enough for wheelchair users. Lu et al. (2014a, b, c) increased the sample group of wheelchair drivers (N = 8) to continue the experiment on the width of parking spaces. They reached agreement with Kiyota's study and considered 3.20–3.30 m as sufficient for wheelchair drivers. Lu et al. (2015b) proposed a new disabled parking system based on using 3.20 m width and two adjacent disabled parking spaces sharing a single alighting area. They presented the new disabled parking system which can increase the number of disabled parking spaces compared to the previous system by saving space. Kiyota et al. (2011) set one 3.20 m-wide disabled parking space in a shopping mall and observed 312 individuals with disabilities using this 'disabled parking space'. The results showed that more than four-fifths of them were able to get off and on in this spot very smoothly. All crutch users and people who have slight trouble with walking were able to board and alight this size of space easily.

As described by these cited studies, it was acknowledged that broad width spaces were required by only wheelchair users as described by previous studies. It was speculated that individuals with mild physical disabilities (i.e. crutch users) may not need the generous width of parking space provided to wheelchair users, though crutch users and people who have slight trouble with walking have the same parking right to board and park in disabled parking spaces as wheelchair users do. There was a public symposium for individuals with disabilities held in Japan in 2013. Based on a simple questionnaire survey, there was a consensus among twelve physically disabled people who had mild trouble with walking that standard disabled parking spaces were oversized for their usage. Twenty-five individuals using wheelchairs pointed out that crutch users should not park in disabled parking spaces because disabled parking resources are limited and most crutch users actually do not need such wide size spaces.

In summary, the previous studies have doubted the reasonableness of the standard width of the disabled parking space for individuals with disabilities. Based on the conclusions of previous works, the width of disabled parking space may be oversized in Asian countries. However, some issues have not resolved completely. Most studies only considered wheelchair users as experimental participants, without other types of individuals with disabilities. Additionally, there is a lack of studies about disabled parking space in China. The width of disabled parking spaces which is suitable for other countries may not be suitable for individuals with disabilities in China. More importantly, there is little research on the correlation of selection of 'disabled parking space' by individuals with disabilities. Quantifying behavior in parking spaces selection and the use of disabled parking spaces among individuals with disabilities is a first important step in understanding and improving the disabled parking environment.

In attempt to address these issues in disabled parking spaces, two studies in this paper were carried out. The initial one is an experimental survey to examine the rationale of width of disabled parking space used by different types of physically disabled people. This is an area to fill gaps in the knowledge-base for the disabled parking research field. The other study is a questionnaire survey to identify factors which may be associated with selection of standard disabled parking spaces. We directly examine the association between the sociodemographic and transport variables and outcome variable based on the logit model. This is an area of innovation in research methodology which contributed to the disabled parking research field. In addition, some policy implications and improvement for current disabled parking system are presented at the end of this paper. These studies will help local government officials design more effective disabled parking spaces and provide experimental methodology, questionnaire items, and analyzed data to other countries that also are considering improving disabled parking.

In the following, the experimental survey (the first study) will be introduced and analyzed. After that, the questionnaire survey (the second study) will be described. The first study is an explorative experiment that was performed due to a shortage of literature in China. The results of the first study will provide proof of whether disabled parking spaces are oversized for disabled individuals in China and will also show the potential influential factors which were related to demographic factors. These results from first study are used in the questionnaire survey in the second study as question items. Meanwhile, the results in the second study will also testify to the accuracy of the results of the first study.

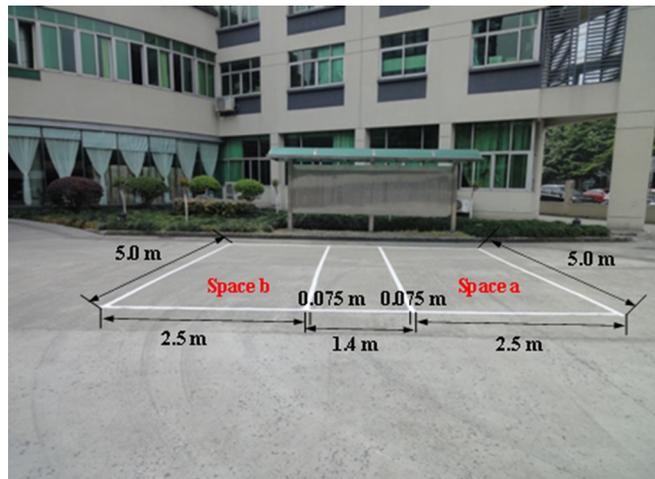


Fig. 1. Schematic layout diagram of the survey site.

2. Experimental survey

2.1. Method

2.1.1. Participants and wheelchairs

Fifty-six participants were randomly recruited from a local car club of disabled drivers. In the participant group, 32 were male and 24 were female. The participants in this survey included wheelchair users, crutch users and other physically disabled people who do not use aids. Their personal information such as gender, age, height, weight, device (wheelchair/crutch/others or none) and driving experience was recorded as well.

The wheelchairs used by participants in the experiment included 0.68 m-wide and 0.92 m-long regular manual wheelchairs and 0.65 m-wide and 0.96 m-long motorized wheelchairs. These two sizes of wheelchairs are very popular in China, though they may be narrow-sized compared with sizes in western countries, which are commonly designed as about 0.71 m-wide and 1.20 m-long (McLaurin and Axelson, 1990; Americans with Disabilities Act of 1990, 1990). It is worth noting that some wheelchairs in western countries are also used as seats in motor vehicles but this type is not common in Asia (Schneider, 2007).

2.1.2. Design

The survey mainly asked the participant to report the degree of difficulty of parking and alighting from the assigned parking space. Four available options were able to be selected: (i) No problem at all; (ii) I can get off but a little narrow; (iii) It is difficult to alight but I could do it; and (iv) It is impossible to get off. For the purpose of this survey, two variable width parking spaces (an experimental vehicle space and a vehicle space) were designed using 0.075 m wide white flexible reflective tape placed on the ground. The width of the lines of parking spaces was not especially stipulated, however, 0.075 m is a commonly used width for parking spaces in China. The experimental vehicle space (Space a), shown in the schematic layout in Fig. 1, is set 2.50 m wide and 5.00 m long which is a standard parking space size in China (Ministry of Housing and Urban-Rural Development of the People Republic of China, 2015). The alighting space (inclusive of paint mark width) indicated by the shaded area between the two vehicle spaces was initially set as 1.40 m wide. This equates to a parking space width (Space a plus alighting space) of 3.90 m which means a 0.20 m-wider-than-standard disabled parking space. The experiment started from 3.90 m because some wheelchair users claimed they expected the disabled space to be wider than a standard disabled parking space. After setting experimental vehicle space and alighting space, a standard vehicle space (Space b in the Fig. 1) was also set as 2.50 m wide and 5.00 m long next to alighting space in the survey.

After the variable width parking spaces were designed, participants including wheelchair users, crutch users and other people slightly troubled with walking were asked to park in the experimental vehicle space and report the ease of alighting. The motor vehicles driven by participants were chosen as a 1.90 m-wide silver sedan and 1.83 m-wide red sedan, examples of two very typical and large sedans in China. Generally, 1.70–1.80 m-wide cars are very popular in China (National Standard of the People's Republic of China, 1992). The reason other small or medium size cars were not used in this experiment is because if disabled individuals are able to alight in a larger size car condition, the condition of other smaller size car should be also acceptable by disabled individuals. Additionally, these cars did not have any automatic parking assistance and all drivers (including female wheelchair users) have to park and board without any aid (e.g. no folded ramps or chairs).



Fig. 2. Measuring the width when turning around by wheelchair.

2.1.3. Procedure

The main procedure involved:

- (i) A 1.83 m-wide red sedan as shown in Fig. 2 was parked in the vehicle parking space (space b). In the survey, in order to create the most difficult parking condition, the parked car was asked to park close to the alighting space but could not touch or exceed the frame.
- (ii) The participants parked the experimental 1.90 m-wide silver sedan in the experimental vehicle space (space a). Participants were asked to alight in that space without any assistance and reported whether the width was sufficient to park and alight. All participants parked nose-in due to using the alighting space from the driver's seat (traffic in China is right-driving) (see Fig. 3). Wheelchair users were especially asked whether they were able to turn around in such an alighting space or not. Due to the same reason as mentioned in step (i), the neighboring parked car tended to be close to the alighting space.
- (iii) The experimental silver sedan was moved from the experimental parking space. The alighting space was then systematically reduced at steps of 0.10 m decrements by rearranging the movable floor markers of the parking space.
- (iv) The participants were asked to repeat step (ii) until they reported the alighting space was too narrow to get off.

We considered fatigue might accumulate when disabled individuals repeated steps in the alighting process so the participants were asked to take a three-minute break between two successive procedures. The experimental survey continued if wheelchair users and other disabled individuals confirmed that their body condition was fine.

The allowable responses for individuals with disabilities in the experiment form were: (a) No problem at all; (b) I can get off but a little narrow; (c) It is difficult to alight but I could do it; and (d) It is impossible to get off. If the response was one of the first three options, then the participant was invited to attempt the next smaller size of the parking space. The experiment continued until the answer option (d) was selected.

It is worth noting that time requirement for the alighting process as well as the boarding process may examine the validity of responses in the questionnaire. The alighting and boarding time was recorded in the experimental process. However, the time requirement in the survey was then found to be quite different based on conditions of individuals with disabilities and conditions of their bodies. It was difficult to match participants' questionnaire responses and the actual time needed to alight. Difficulty of alighting did not necessarily correlate with time needed to complete alighting.



Fig. 3. Open the door fully when alighting.

Table 1
Demographic characteristics of the participant groups.

	Wheelchair user		Crutch user		Others	
	Count	Percentage	Count	Percentage	Count	Percentage
Gender						
Male	10	66.7%	8	53.3%	14	53.8%
Female	5	33.3%	7	46.7%	12	46.2%
Age (years)						
< 18	0	0.0%	0	0.0%	0	0.0%
19–30	1	6.7%	2	13.3%	3	11.5%
31–45	2	13.3%	5	33.3%	13	50.0%
46–60	11	73.3%	7	46.7%	10	38.5%
61–70	1	6.7%	1	6.7%	0	0.0%
> 71	0	0.0%	0	0.0%	0	0.0%
Body weight (kg)						
< 40	0	0.0%	0	0.0%	0	0.0%
40–50	4	26.7%	1	6.7%	4	15.4%
50–60	9	60.0%	6	40.0%	10	38.4%
60–70	2	13.3%	7	46.7%	12	46.2%
> 70	0	0.0%	1	6.7%	0	0.0%
Body height (cm)						
< 150	2	13.3%	0	0.0%	0	0.0%
150–160	8	53.3%	4	26.7%	5	19.2%
160–170	4	26.7%	6	40.0%	13	50.0%
170–180	1	6.7%	5	33.3%	8	30.8%
> 180	0	0.0%	0	0.0%	0	0.0%
Driving experience (years)						
< 3	1	6.7%	2	13.3%	4	15.4%
3–10	5	33.3%	7	46.7%	11	42.3%
> 10	9	60.0%	6	40.0%	11	42.3%

The field survey was carried out on May 2 and 3, 2017. Participants were divided into three groups based on aid devices: wheelchair/crutch/others-none. Wheelchair users attended the survey on May 2 and other two groups were on May 3. The weather was quite clear on the days of the survey.

2.2. Results

2.2.1. Demographics

There were 56 participants (32 male and 24 female) who took part in the survey. Table 1 shows respondent characteristics. All wheelchair users ($n = 15$, 10 males and 5 females), crutch users ($n = 15$, 8 males and 7 females) and people with mild difficulties with walking ($n = 26$, 14 males and 12 females) were long-term disabled. The age distributions of wheelchair users, crutch users and others were similar, although most wheelchair users and crutch users were 45–60 years old and most other individuals were 31–45 years old. The wheelchair users group was more likely to be male, while the other two groups were more likely to be equal ratios of female to male. The weight and height distributions of wheelchair users were 50–60 kg and 150–160 cm. However, crutch users and others were more likely to be 60–70 kg and 160–170 cm. Moreover, more than 80% of participants had driving experience of more than three years. None of them were e-bike users.

2.2.2. Response of participants

Table 2 shows the response of participants related to parking spaces of different widths. In the wheelchair user group, it indicated that there was no difficulty for all fifteen wheelchair users when the width of parking space was reduced from 3.90 to 3.50 m. When the width reduced to 3.40 m, 73.3% of the wheelchair users ($N = 11$) still confirmed the possibility of alighting in these widths, although other 26.7% ($N = 4$) wheelchair users who are using regular manual wheelchairs selected option c: difficult to alight but I could do it. When the width was reduced further to 3.30 m, most wheelchair users could not get off in this width regardless of whether they used a regular manual wheelchair or a motorized wheelchair. Only 13.3% of wheelchair users ($N = 2$) could continue the survey with the width reduced to 3.30 m. No one could get off or get on in a space less than 3.20 m.

In contrast, all crutch users and people with slight trouble with walking without any aids reported there was no difficulty in alighting and boarding in a 3.20 m-wide space. At 3.10 m, more than half of participants (53.3% of crutch users and 69.2% of others) claimed it was possible to alight. Some participants believed that 3.00 m was possible for getting off, but it was impossible to alight at 2.90 m or less.

According to these results, it indicates that the minimum width of acceptable disabled parking spaces was 3.40 m for the wheelchair user group, and 3.10 m was acceptable for users of other mobility aids such as crutches. The gray cells in the table highlighted these possible minimum widths.

Table 2
Responses of participants related to parking spaces of different widths.

Width (m)	Wheelchair user (%)				Crutch user (%)				Others (%)			
	a	b	c	d	a	b	c	d	a	b	c	d
3.90	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
3.80	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
3.70	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
3.60	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
3.50	66.7	33.3	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
3.40	26.7	46.6	26.7	0.0	93.3	6.7	0.0	0.0	100.0	0.0	0.0	0.0
3.30	0.0	0.0	13.3	86.6	33.0	66.7	0.0	0.0	34.6	65.4	0.0	0.0
3.20	0.0	0.0	0.0	100.0	6.7	93.3	0.0	0.0	15.4	84.6	0.0	0.0
3.10	—	—	—	—	0.0	53.3	46.7	0.0	0.0	69.2	30.8	0.0
3.00	—	—	—	—	0.0	0.0	53.3	46.7	0.0	19.2	53.9	26.9
2.90	—	—	—	—	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0

Note: (a) No problem, (b) I can get off but a little narrow, (c) It is difficult to alight but I could do it, (d) It is impossible to get off, (–) This setting was not attempted.

2.2.3. Demographics factors analysis

Although the statistical analysis is difficult to carry out due to the fact that the sample size is small, there are some noteworthy results related to demographic factors in the field survey. First, the participants ability to alight in the minimum width was determined by selection of ‘no problems to alight’ by participants (i.e. participants chose option a or b). Table 3 shows the breakdown of demographics by percentage within this group of participants. Distribution of agreement on minimum width by demographic factors between the three groups were similar. Female participants were more likely to select smaller sized-spaces than males. The younger participants were more likely to choose smaller sizes than older participants. Excepting wheelchair users, the results related to physical body weight and body height were positively correlated with ‘minimum width’. In addition, results related to driving experience indicated increased percentage, although the percentages of three options selected by other individuals were more equal.

3. Questionnaire survey

From the previous section, our findings have indicated different width requirements for wheelchair users and other users. The next stage of this project involved a questionnaire survey to identify the correlates between characteristics of participants and their selection of width of disabled parking space. For this purpose, a short questionnaire was prepared and completed by the individuals with disabilities, not necessarily those who were drivers. The participants included long-term and short-term wheelchair users and other users (such as crutch users and individuals with slight trouble with walking but not requiring aids). The continuous data was difficult to obtain in the survey, and many of the influencing factors of selection of width of disabled parking space are the discrete variables. Therefore, we can use discrete choice analysis to make a quantitative analysis for the factors, which may influence the

Table 3
The effect of demographics factors on minimum width of parking selected by participants.

Items	Wheelchair users (%)	Crutch users (%)	Others (%)
Gender	Male	70.0	57.1
	Female	80.0	83.3
Age (years)	< 45	100.0	87.5
	46–60	72.7	40.0
	> 61	0.0	–
Body weight (kg)	< 50	75.0	100.0
	50–60	88.9	90.0
	> 60	0.0	41.6
Body height (cm)	< 160	80.0	80.0
	160–170	75.0	76.9
	> 170	0.0	50.0
Driving experience (years)	< 3	0.0	50.0
	3–10	60.0	63.6
	> 10	88.9	81.8

Note: (–) No participants over 61 years attended the field survey.

selection. Logistic regression model was selected to analyze the association between characteristics of participants and their selection of width of disabled parking space.

3.1. Method

3.1.1. Participants

This study used an online questionnaire disseminated electronically through Disabled Person Federation of Zhejiang Province in April, 2018. Participants were asked to complete and send the questionnaire back to the Disabled Person Federation by email. The research team then received all anonymous questionnaire data after all participants names were deleted by the Disabled Person Federation. All participants were individuals with disabilities 18 years or older.

3.1.2. Outcome variable

We created three dependent variables: 'narrower-than-standard disabled parking space', 'standard disabled parking space' and 'wider-than-standard disabled parking space'. Participants needed to select one of the dependent variables based on their situation.

3.1.3. Sociodemographic variable

For the analysis, gender, age, body weight, body height and types of aids used were collated. Age was split into five categories: 18–30, 31–45, 46–60, 61–70 and over 71 to approximate different ages (Alsnih and Hensher, 2003). Body weight (kg) was separated as: less than 40, 40–50, 50–60, 60–70, 70–80, and more than 80. Body height (cm) was separated as: less than 150, 150–160, 160–170, 170–180, 180–190, and more than 190. The types of aids used in daily life were divided into four categories: motorized wheelchair, manual wheelchair, crutch and others/none.

3.1.4. Transport variable

We believed frequent use of disabled parking spaces by private cars may be associated with the outcome variable. Therefore, we created the following variables: whether the user owned or had access to a private car, and whether the user had a driver's license. In addition, we also considered the driving experience and frequency of using a private car as a variable. Driving experience (years) was split into four categories: less than 3, 3–5, 5–10 and more than 10. Average frequency of using a private car (per week) was then presented as: less than 3, 3–7, and more than 7.

3.1.5. Analysis

Logistic regression model was used to analyze the association between 'width of disabled parking' and sociodemographic or transport related variable. Statistical analysis was calculated with IBM SPSS Statistics 21 for Windows™ and an α -value of 0.05 was applied to assess statistical significance. In the analysis, a Hosmer-Lemeshow test (H-L test) was used to identify the suitability of fit for the model. P-value > 0.05 is considered as an acceptable fit for the data (Neill et al., 2016). In addition, the logistic regression model was also used to estimate the odds ratio and 95% confidence interval for each characteristic of individuals who selected the option 'standard width of disabled parking space'.

3.2. Results

3.2.1. Descriptive analysis

In total, there were 955 questionnaires received. Cases with missing data for any variable were excluded, leaving a sample of 874 (398 male and 476 female), with the average effective rate being 91.5%. Table 4 shows the descriptive characteristics of participants. There were 739 participants who selected the option 'disabled spaces can be narrower than standard disabled parking spaces' and 128 participants chose 'standard disabled parking spaces'. Only 7 participants required the widths which are wider than standard disabled parking spaces. This result indicates that most participants confirmed the width of disabled parking spaces should be designed to be smaller. On the other hand, close to 15% of participants agreed to maintain the standard space.

As shown in Table 4, propensity for choosing 'standard disabled parking spaces' increased with age (1.3% of 18–30, 2.6% of 41–50 and 3.4% of 51–60). Body weight and body height were associated with increased percentage of 'standard space' (3.3% of 40–50 kg, 4.3% of 50–60 kg and 4.5% of 60–70 kg; 2.3% of 150–160 cm, 2.4% of 160–170 cm and 4.8% of 170–180 cm). In addition, types of aids were also associated with percentage of selection of 'standard space': 5.8% of motorized wheelchair, 8.2% of manual wheelchair and 0.5% of crutch or none. Having a driver's license and having access to a car had a relationship with increased percentage of 'standard space' as compared with having none. However, driving experience was associated with reduced percentage of 'standard space': 9.0% of less than 3 years, 2.1% of 5–10 years and 1.4% of more than 10 years. Similar to driving experience, frequency of using (or taking) a car was also related with reduced percentage of choosing 'standard space'. 6.6% drove less than 3 times per week and 0.7% drove more than 7 times per week.

3.2.2. Logistic regression model

Table 5 presents the odds ratios, 95% confidence interval and p-value for each characteristic in the group of individuals with disabilities who selected 'standard space' in the logistic regression model. The Hosmer-Lemeshow test indicated the model is an acceptable fit for the data due to the p-value of 0.675.

Men were 1.715 times (95% CI = 1.341–2.089) more likely to select 'standard space' than women. Although, the finding did not

Table 4
The characteristics of the participant groups.

Variable	Characteristic	< standard disabled parking spaces		= standard disabled parking spaces		> standard disabled parking spaces		P
		Count	Percentage	Count	Percentage	Count	Percentage	
All respondents		739	84.6%	128	14.6%	7	0.8%	
Gender	Male	320	36.6%	75	8.6%	3	0.3%	0.430
	Female	419	47.9%	53	6.1%	4	0.5%	
Age	18–30	114	13.0%	11	1.3%	0	0.0%	< 0.001**
	31–40	188	21.5%	30	3.4%	0	0.0%	
	41–50	204	23.3%	23	2.6%	0	0.0%	
	51–60	172	19.7%	30	3.4%	0	0.0%	
	61–70	56	6.4%	12	1.4%	2	0.2%	
	> 71	5	0.6%	22	2.5%	5	0.6%	
Body weight (kg)	< 40	40	4.6%	9	1.0%	0	0.0%	0.027*
	40–50	180	20.6%	29	3.3%	0	0.0%	
	50–60	439	50.2%	38	4.3%	1	0.1%	
	60–70	75	8.6%	39	4.5%	1	0.1%	
	70–80	4	0.5%	9	1.0%	2	0.2%	
	> 80	1	0.1%	4	0.5%	3	0.3%	
Body height (cm)	< 150	67	7.7%	29	3.3%	0	0.0%	< 0.001**
	150–160	258	29.5%	20	2.3%	0	0.0%	
	160–170	269	30.8%	21	2.4%	1	0.1%	
	170–180	96	11.0%	42	4.8%	1	0.1%	
	180–190	32	3.7%	30	3.4%	3	0.3%	
	> 190	1	0.1%	2	0.2%	2	0.2%	
Types of aids	Motorized wheelchair	81	9.3%	51	5.8%	4	0.5%	< 0.001**
	Manual wheelchair	200	22.9%	72	8.2%	2	0.2%	
	Crutch	303	34.7%	3	0.3%	1	0.1%	
	None	155	17.7%	2	0.2%	0	0.0%	
Owns or has access to a car	Yes	276	31.6%	48	5.5%	3	0.3%	< 0.001**
	No	463	53.0%	80	9.2%	4	0.5%	
Has a driver's license	Yes	288	33.0%	54	6.2%	3	0.3%	< 0.001**
	No	451	51.6%	74	8.5%	4	0.5%	
Driving experience (years)	< 3	470	53.8%	79	9.0%	4	0.5%	< 0.001**
	3–5	91	10.4%	19	2.2%	1	0.1%	
	5–10	104	11.9%	18	2.1%	1	0.1%	
	> 10	74	8.5%	12	1.4%	1	0.1%	
Frequency of using (or taking) a private car(/per week)	< 3	147	16.8%	58	6.6%	5	0.6%	0.146
	3–7	253	28.9%	64	7.3%	2	0.2%	
	> 7	339	38.8%	6	0.7%	0	0.0%	

* P < 0.05.

** P < 0.001.

show strong evidence that increasing age was associated with selection of 'standard space', it is worth noting that this finding may not be clinical. For example, the sample size of individuals with age range from 30–60 years old was much larger than individuals with an age of more than 61 years old (See Table 4). Therefore, findings showed odds ratios from 30–60 years old were more than for individuals over 61. Nevertheless, when the count of participants from different age groups was close, increasing age was associated with selection of a standard space. 18–30 year old individuals were 0.556 times (95% CI = 0.413–0.699) less likely to choose a standard space than individuals who were over 71 years old; 61–70 year old individuals were 0.539 times (95% CI = 0.504–0.574) less likely to use a standard space than individuals who were over 71 years old. When accounting for body weight and body height, the results also showed the body weight of 60–70 kg and/or body height of 170–180 cm were more likely to use standard disabled parking spaces.

In addition, there was good evidence that types of aids were significantly related to the standard space. Motorized wheelchair and manual wheelchair users were respectively 22.099 (95% CI = 19.092–25.106) and 54.222 (95% CI = 49.391–59.053) times more likely to choose a standard space than individuals with disabilities but without any aids. Crutch users were 1.358 times (95% CI = 1.050–1.666) more likely to choose a standard space than individuals without any aids.

Having access to a car and having a driver's license was also associated with the selection of a standard space. Participants who had access to cars (Odds ratio = 0.531 and 95% CI = 0.354–0.708) and had a driver's license (Odds ratio = 0.680 and 95% CI = 0.610–0.750) were less likely to use a standard space. Driving experience and frequency of using (or taking) a private car had a significant relationship with the selection of a 'standard space'. Individuals who had less than 3 years driving experience were 7.571 times (95% CI = 6.485–8.657) more likely to choose wider parking spaces than those who had 10+ years of driving experience. Individuals who used a private car less than 3 times per week were 8.177 times more likely to use disabled parking spaces as were disabled people who used a private car more than 7 times a week.

Table 5
The results of logistic regression model of propensity to ‘standard space’.

Variable	Characteristic	Odds ratio	95% C.I	P
Gender	Male	1.715	1.341–2.089	0.375
	Female (ref cat)			
Age	18–30	0.556	0.413–0.699	0.000**
	31–40	1.622	1.334–1.910	0.002*
	41–50	1.137	0.837–1.437	0.003*
	51–60	1.500	1.189–1.875	0.031*
	61–70	0.539	0.504–0.574	0.000**
	> 71 (ref cat)			
Body weight (kg)	< 40	3.010	2.800–3.220	0.015*
	40–50	7.022	6.901–7.142	0.036*
	50–60	10.023	9.801–10.245	0.036*
	60–70	11.049	10.745–11.353	0.098
	70–80	3.051	2.401–3.701	0.119
	> 80 (ref cat)			
Body height (cm)	< 150	5.256	4.789–5.723	0.425
	150–160	2.730	2.112–3.348	0.281
	160–170	3.437	2.758–4.116	0.354
	170–180	16.109	15.700–16.518	0.172
	180–190	11.510	10.917–12.103	0.239
	> 190 (ref cat)			
Types of aids	Motorized wheelchair	22.099	19.092–25.106	0.000**
	Manual wheelchair	54.222	49.391–59.053	0.000**
	Crutch	1.358	1.050–1.666	0.304
	None (ref cat)			
Owns or has access to a car	Yes	0.531	0.354–0.708	0.153
	No (ref cat)			
Has a driver's license	Yes	0.680	0.610–0.750	0.017*
	No (ref cat)			
Driving experience (years)	< 3	7.571	6.485–8.657	0.015*
	3–5	1.769	1.586–1.952	0.285
	5–10	1.598	1.375–1.821	0.215
	> 10 (ref cat)			
	< 3	8.177	7.195–9.159	0.025*
Frequency of using (or taking) a private car (/per week)	3–7	10.851	10.533–11.169	0.332
	> 7 (ref cat)			

* P < 0.05.

** P < 0.001.

4. Discussion

The purpose of this research is to examine the rationality of current width of disabled parking spaces for individuals with disabilities by an experimental survey and to identify the correlates of selection of ‘standard disabled parking spaces’ and influencing factors based on a questionnaire survey. The findings have shown that the standard 3.70 m-wide parking space is oversized for wheelchair users in China. Previous research in other Asian countries (e.g. in Japan and South Korea) also reported the same results (see Kiyota et al., 2009; Kiyota et al., 2011; Lu et al., 2015b; Taekyung et al., 2009). In addition, the findings also presented that a width of 3.20 m was acceptable for crutch users and other individuals with mild disabilities which was far shorter than 3.70 m. These actual oversized parking spaces have lead to conflicts between planning authorities and service providers in urban China due to limited land resources.

The findings indicated body size, types of aids (i.e. the degree of disability) and driving experience were three potential factors which may cause individuals to select wider or narrower parking spaces. First, physical body size (including body weight and height) is a powerful predictor of using a wider space. Particularly, a person with 60–70 kg weight and/or 170–180 cm height is more likely to use a standard disabled parking space. A similar result that physical body size affects the choice of width of parking spaces was also reported in Japan by Lu et al. (2014a, b, c). However, it is worth noting that the hypothesis that body size influences the choice of width of parking space may not fit in western countries due to their body sizes being generally bigger. However, the method mentioned in this study can be used in other countries to test this hypothesis. Second, wheelchair users appear to be associated with standard spaces. Most questionnaire participants who chose standard parking spaces were wheelchair users. This is not surprising because wheelchair users generally need more space to alight than other users. Third, the frequency of using a private car was also related with less difficulty in alighting. This kind of result also matches the physical experiment which reported participants who had less driving experience needed a wider space as compared to individuals who had more extensive driving experience.

Our findings did not show very strong evidence that gender differences were associated with the selection of ‘disabled parking spaces’. However, in the group selecting the standard disabled parking space, the percentage of males is much greater than females, which indicated gender differences might influence selection. The differences between the genders may be attributable to physical,

psychological and social factors. Males and females are different in terms of parking behaviors, perception of travel safety, and social norms regarding their roles in the family, and that may influence their life course events (Scheiner, 2014). For example, the increased gap in the requirement of a wider space between males and females of older age may be due to the fact that older females were more likely to drive a car for shopping in their daily lives and use disabled parking spaces than older males. Females may have more experience parking in narrow spaces when disabled parking spaces were full. Another possible reason is that the physical body of females is relatively smaller than males (see Yang et al., 2005), therefore male individuals with disabilities may need wider parking spaces, as shown in the results of field and questionnaire surveys.

Similar to gender differences, increasing age was also considered as one of many potential factors which correlated with using wider spaces. On one hand, older users have less chances to travel and park than middle-age users due to their more restricted lifestyle. Most older users are less likely to travel for work or study after their retirement and more likely lose their driver's license. On the other hand, older users confirmed they need a wider space due to lessening physical abilities. Many older users are travelling by wheelchair which means they may board and alight in a wider space than crutch users.

Individuals with disabilities rely on transportation to meet their daily life needs (Páez and Farber, 2012; Chirstensen and Byrne, 2014; Corran et al., 2017). A good parking environment is key to encourage their travel and social participation (Wasfi et al., 2007; Schalock and Alonso, 2002). Although providing wider parking spaces ensures individuals with disabilities can alight and board easily, it is impossible to create many of these wider reserved spaces in cities, especially in urban China. The current disabled parking system accepts both severely disabled (e.g. wheelchair users) and mildly disabled people (e.g. crutch users) as equal users for disabled parking spaces and includes a maximum of 2% total spaces allocated for disabled spaces as the national standard (Ministry of Public Security of the People's of China, 2009). It is clear that the number of parking spaces for individuals with disabilities is not sufficient. Nevertheless, there is currently no good solution. As previous studies reported (see Lu et al. 2014a, b, c; Kiyota et al., 2016; Lu et al., 2017), most wheelchair users believed crutch users and other individuals with slight trouble with walking should leave spaces to them. Although crutch users confirmed they do not need a 3.70 m-wide space, they relied on them because most of them cannot park in 2.50 m-wide regular parking space.

4.1. Reconfiguration of the disabled parking system

Our findings have proven that there are two different width requirements for wheelchair users and other individuals with disabilities. Therefore, if we can separate current disabled parking spaces into two types: a wider one for wheelchair users and a relatively narrow one for others, conflict between them due to a shortage of disabled parking spaces should diminish. Fig. 4 shows the concept of the current disabled parking system and a reconfigured disabled parking system.

The wide type of disabled parking space in China can be set as around 3.5–3.7 m. The narrow type of disabled parking spaces between 3.2–3.4 m can be used by mildly disabled people. A drop-off area should be very helpful for severely disabled passengers, based on a field study by Bascom and Christensen (2017). Their study indicated a large number of severely disabled people actually used transportation to get around and participated in social events with help from their family and friends. Therefore, severely disabled passengers can be dropped off with the help of an able-bodied driver, and volunteers at the drop-off area located closest to the entrance of a destination can assist them as needed. The able-bodied driver can park in regular parking spots, then pick their companion up. Severely disabled drivers can alight and board at reconfigured wide disabled parking spaces. Mildly physically disabled people can use wide or narrow disabled parking spaces or regular parking spaces on the basis of their health conditions. These adjustments should be interesting to community leaders and policy makers who are considering improving disabled parking spaces in resource-limited urban cities, although enforcement in other countries is quite challenging. Nevertheless, this study has proposed one idea as how to avoid conflict among users, and can help government officials in other countries decide how to provide effective disabled parking.

4.2. Limitations

One of the limitations of this study is that the sample of the field experiment consisted of individuals from a car club and we should include passengers who do not have extensive driving experience in the future. We did not implement differently sized cars in the experiment. In a future experiment, we may repeat the experimental survey with the different sized cars. Moreover, the weather in the experiment was favorable. We may perform the experiment in inclement weather conditions (rain or snow) to measure appropriate width for individuals with disabilities.

The other limitation of this study is that we could not ascertain if self-reported data by participants in both surveys was true or not (mentioned by Yang et al., 2018; Zhang et al., 2016). The participants may select a wider disabled parking space that may be easier for them to use. This may be more prominent within the older male group. In the future, we may consider designing an experiment to obtain the allowable width which could maximize the number of disabled parking spaces in urban cities.

Physical strength is important in choosing parking spaces. In the logistic regression model, we considered two variables (weight and height) which identify the participants' physical strength to a certain extent. In the future, we may add more variables such as grasping power (grip strength), chest circumference and chest circumference/height to identify their physical strength.

In addition, the current study has not included individuals with other types of disabilities, such as intellectual and psychological disabilities in the experiment and questionnaire surveys and this is a potential area for improvement of project results. The future research could also enlarge these types of sample populations and do more research in other countries.

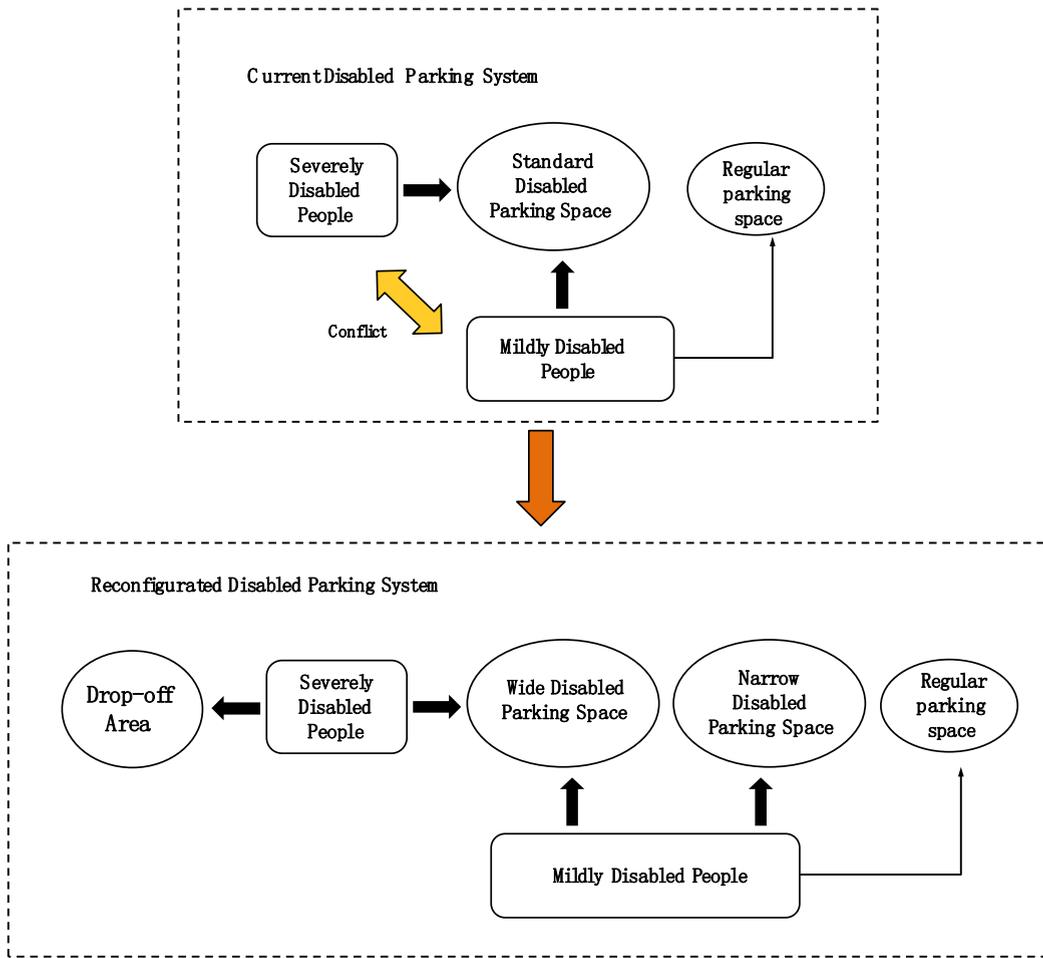


Fig. 4. The concept of the current disabled parking system and reconfigured disabled parking system.

5. Conclusion

This study used two field surveys to examine the rationality of the current width of disabled parking spaces and highlights the correlates of selection of a ‘disabled parking space’. The initial study has shown that the standard 3.70 m-wide parking space is oversize for all individuals with disabilities. All wheelchair users confirmed that 3.50 m was completely suitable for parking and 70% of them believed that even 3.40 m was acceptable. On the other hand, a width of 3.20 m was acceptable for crutch users and other individuals with mild disabilities. The second study analyzed the correlates of selection of ‘disabled parking space’ by using a questionnaire study from a large sample of individuals with disabilities in Zhejiang Province. This study indicated that body size, types of aids (i.e. the degree of disability) and driving experience were three potential factors which may cause individuals to select wider or narrower parking spaces. Based on these two surveys, a reconfigured disabled parking system concept was proposed and would help government officials decide how to provide effective disabled parking.

Acknowledgements

The research described in this paper is largely supported by the National Natural Science Foundation of China (Grant no. 51508512) and National Natural Science Foundation of Zhejiang Province in China (Grant no. LQ18E080010).

Financial disclosure

The Authors (Weite Lu, Chunqin Zhang and Xunyou Ni) did not receive any specific funding for this work.

Conflict of interest

The authors report that they have no conflicts of interest.

References

- Alsnih, R., Hensher, D.A., 2003. The mobility and accessibility expectations of seniors in an aging population. *Transp. Res. Part A: Policy Pract.* 37 (10), 903–916.
- Australians with Disabilities Act of 1990, 1990. Dimensions of Adult-sized wheelchairs. <www.ada.gov/descript/reg3a/figA3ds.htm>.
- Australian and New Zealand Governments, 2009. Standards Australia/Standards New Zealand. Committee CE-001: Parking Facilities Draft Australian/New Zealand Standard Parking facilities. Part 6: Off-street parking for people with disabilities, Project No: 5431. 2009.
- Bascom, G.W., Christensen, K.M., 2017. The impacts of limited transportation access on persons with disabilities' social participation. *J. Transp. Health* 7, 227–234.
- Brimson, T., Shoukhrallah, R., Cannell, L., 2008. The need for improvements of practices and policies in the provision of parking for people with disabilities. In: National Conference, 2008, PERTH, Western Australia, Australia, pp. 425–434.
- Cabinet of Japanese Government, 1994. Enforcement order of law for buildings accessible to and usable by the elderly and physically disabled persons, No.12, Cabinet Order, No.311, Japan.
- Christensen, K.M., Byrne, B.C., 2014. The built environment and community integration a review of states' olmstead plans. *J. Disabil. Policy Stud.* 25 (3), 186–195.
- Corran, P., Steinbach, R., Saunders, L., Green, J., 2017. Age, disability and everyday mobility in London: an analysis of the correlates of 'non-travel' in travel diary data. *J. Transp. Health* 8, 129–136.
- Department of Justice in U.S, 2010. 2010 ADA Standards for Accessible Design CHAPTER 5: General Site and Building Elements, pp. 149–151. <<http://www.ada.gov/regs2010/2010ADASTandards/2010ADASTandards.pdf>>.
- Japan Institute of Country-ology and Engineering, 2011. Guidelines for Facilitating Movement on the Road. Japan Institute of Country-ology and Engineering Press, Japan.
- Kiyota, M., Hayashida, Y., Maeda, A., 2009. Effectiveness of disabled parking identification card system without penalty and its issue. *Traffic Sci.* 40, 69–74 (in Japanese).
- Kiyota, M., Hayashida, Y., Maeda, A., 2011. Issue of disabled parking identification card system without penalty and effects toward improving the system. *Traffic Sci.* 46, 66–76 (in Japanese).
- Kiyota, M., Ishibashi, K., Inohae, T., Kinashi, M., Hayashida, Y., 2016. Making a new design concept of disabled parking considering a psychological barrier for able-bodied drivers. *J. City Plan. Inst. Jpn.* 51 (3), 1213–1219 (in Japanese).
- Korea National Institute for special education, 2013a. Guide to South Korea disabled Parking. <http://edu.knise.kr/jsp/lesionsee/facility/facility_parking.jsp?Main=4&sub=2>.
- Korea National Institute for Special Education, 2013b. Guide to South Korea Disabled Parking. <http://edu.knise.kr/jsp/lesionsee/facility/facility_parking.jsp?Main=4&sub=2>.
- Lambrinos, L., Dosis, A., 2013. DisAssist: an internet of things and mobile communications platform for disabled parking space management. In: IEEE Global Communications Conference (GLOBECOM), Atlanta, USA, pp. 2810–2815.
- Lu, W., Kiyota, M., Ishibashi, K., 2014a. The limit of disabled parking identification card system at a large-scale retail store and making a new design concept of disabled parking. *J. City Plan. Inst. Jpn.* 49 (1), 59–64 (in Japanese).
- Lu, W., Li, H., Kiyota, M., 2014b. Investigation of the introduction of a formal handicapped parking system and prevailing design standards. International Symposium and Conference on Sustainable city and Low carbon city (SCLC2014), Saga, Japan, pp. 67–62.
- Lu, W., Vandebona, U., Kiyota, M., 2014c. Analysis of experience with formalizing handicapped parking system. *Transp. Res. Part F: Traffic Psychol. Behav.* 26, 62–71.
- Lu, W., Vandebona, U., Kiyota, M., 2015a. Reconfiguration of handicapped parking spaces to maximize utilization of available space. *Int. J. Eng. Technol.* 7 (2), 149–151.
- Lu, W., Vandebona, U., Kiyota, M., 2015b. Reconfiguration of handicapped parking spaces to maximize utilization of available space. *Int. J. Eng. Technol.* 7 (2), 151–155.
- Lu, W., Yang, Y., Zhang, C., Zhu, A., 2017. Investigation on influence of people's awareness of parking spaces for the disabled and signs on parking behavior. *J. Zhejiang Sci-Tech Univ. (Soc. Sci.)* 38 (3), 257–263 (in Chinese).
- Mclaurin, C.A., Axelson, P., 1990. Wheelchair standards: an overview. *J. Rehabil. Res. Dev.: Clin. Suppl.* 5 (2), 100–103.
- Ministry of Construction of Japan, 1994. Ordinance for enforcement of law for buildings accessible to and usable by the elderly and physically disabled persons, No.16, Ordinance of the Ministry of Construction, No.26, Japan.
- Ministry of Public Security of the People's of China, 2009. Code for setting of on-street parking spaces. GA/T 850-2009. <<https://wenku.baidu.com/view/ee1476abdd3383c4bb4cd279.htm>>.
- Ministry of Housing and Urban-Rural Development of the People Republic of China, 2015. Code for design of parking garage building. JGJ100-2015. <<http://jz.docin.com/p-1337546191.html>>.
- National Standard of the People's Republic of China, 1992. Motor vehicles and towed vehicles, dimensions of vehicles, terms and definitions. GB/T3730.3 -1992. <<https://wenku.baidu.com/view/b88218861ed9ad51f11df290.html>>.
- Neill, J.M., Hurwits, D.S., Olsen, M.J., 2016. Alternative information signs: evaluation of driver comprehension and visual attention. *J. Transp. Eng.* 142 (1), 04015036 (01-12).
- Nishidate, A., Mizuno, T., Tokuda, K., 2008a. The condition of parking spaces reserved for people with disabilities in countries that adopted EU model parking card. *Mem. Fac. Hum. Dev.* 2, 58–59.
- Nishidate, A., Mizuno, T., Tokuda, K., 2008b. The condition of parking spaces reserved for people with disabilities in countries that adopted EU model parking card. *Mem. Fac. Hum. Dev.* 2, 58–59.
- Páez, A., Farber, S., 2012. Participation and desire: leisure activities among Canadian adults with disabilities. *Transportation* 39 (6), 1055–1078.
- Schalock, R., Alonso, M., 2002. Handbook on Quality of Life for Human Service Practitioners. American Association on Mental Retardation, Washington, DC., USA.
- Schneider, L., 2007. Using a wheelchair as a seat in a motor vehicle: an overview of wheelchair transportation safety and related standards. *Except. Parent* 37, 44–46.
- Scheiner, J., 2014. Gendered key events in the life course: effects on changes in travel mode choice over time. *J. Transp. Geogr.* 37, 47–60.
- Taekyung, L., Shinyoung, L., Sanghong, L., 2009. Study on the convenient facilities for the disabled, handicapped person in main national universities, Korea. *J. Arch. Inst. Korea* 25, 67–76 (in Korean).
- Traffic Advisory Leaflets in UK, 1995. Parking for individuals with disabilities. Traffic Advisory Leaflet 5/95 April 1995, Traffic Advisory Leaflets. <www.dft.gov.uk>.
- Wasfi, R.A., Levinson, D.M., El-Geneidy, A., 2007. Measuring the transportation needs of people with developmental disability. In: Proceedings of the 86th Annual Meeting of the Transportation Research Board, Washington, DC.
- Yang, X., Li, Y., Ma, G., Hu, X., et al., 2005. Study on weight and height of the Chinese people and the differences between 1992 and 2002. *Chin. J. Epidemiol.* 26 (7), 489–493 (in Chinese).
- Yang, Y., Xu, Y., Rodriguez, D., Michael, Y., Zhang, H., 2018. Active travel, public transportation use, and daily transport among older adults: the association of built environment. *J. Transp. Health* 9, 288–298.
- Zhang, C., Juan, Z., Lu, W., Xiao, G., 2016. Do the organizational forms affect passenger satisfaction? Evidence from Chinese public transport service. *Transp. Res. Part A: Policy Pract.* 94, 129–148.