2021

# Attitudes, perceptions, and walking behavior in a Chinese city

Yingying Lyu

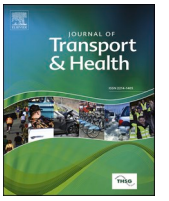
Ann Forsyth

Journal of Transport & Health 21 (2021) 101047

Contents lists available at ScienceDirect

Journal of Transport & Health

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



# Attitudes, perceptions, and walking behavior in a Chinese city

Yingying Lyu [a,b,*], Ann Forsyth [c]

[a] Graduate School of Design, Harvard University, Cambridge, USA
[b] The Harvard-China Project on Energy, Economy and Environment, Harvard University John A. Paulson School of Engineering and Applied Sciences, Cambridge, MA, USA
[c] Urban Planning and Design, Harvard University, Cambridge, USA

ARTICLE INFO

*Keywords:*
Attitudes
Perceptions
Subjective variables
Walking
Transport mode
Environment

ABSTRACT

*Introduction:* An increasing number of studies discuss the relationship of walking with attitudes and perceptions. However, the findings are not consistent, and few studies have examined the relationship between walking and attitudes to overall mobility and multiple modes. In this paper, we contribute to these debates by exploring the relationship between walking for transport and broad attitudes to urban mobility and transport modes.
*Methods:* Using a clustered random sample survey conducted in a second-tier city in China (N = 1048), we hypothesized that people with different attitudes have different amounts of walking for transport. Data analysis methods involved descriptive statistics, t-tests, analysis of variance (ANOVA), hierarchical logistic models, and hierarchical linear models.
*Results:* Positive attitudes and perceptions regarding multiple transport modes and related environments were associated with some walking for transport. T-tests indicated that those with different attitudes walked different amounts. Regression models showed that associations between attitudes and odds of people walking varied between genders. Males who perceived bus frequency was not a problem were more likely to walk. Females tended to walk when viewing transportation in the city as convenient. Both findings contribute to the understanding that positive perceptions of overall mobility in the city were associated with higher odds of walking. Meanwhile, among those who did walk, those with positive attitudes towards pedestrian safety crossing streets and those perceiving traffic jams as a problem in their daily trips spent more time walking.
*Conclusion:* This paper concludes that positive broad attitudes and perceptions of overall mobility and all transport modes are related to more walking activities. A better understanding of such relationships can provide a reference point for urban policies aiming at promoting walking for transport.

## 1. Introduction

Many factors influence which travel mode people choose to take. One set of such factors is attitudes toward transportation alternatives and perceptions about the urban environment. Using a survey-based data set collected in Chengdu City in Sichuan Province, China, this study examines two specific questions. 1) Do people with different attitudes and perceptions toward a wide range of transportation factors walk different amounts? 2) What are the associations of these attitudes and perceptions with both undertaking

* Corresponding author. 29 Oxford Street, Pierce Hall G2C, Cambridge, MA, 02138, United States.
*E-mail addresses:* ylu@gsd.harvard.edu (Y. Lyu), aforsyth@gsd.harvard.edu (A. Forsyth).

https://doi.org/10.1016/j.jth.2021.101047
Received 20 December 2020; Received in revised form 4 March 2021; Accepted 5 March 2021
Available online 24 March 2021

any walking for transport and the amount of walking?

These questions matter because walking is a common form of physical activity in China and elsewhere and encouraging walking can be good for health (Li, 2016). While some factors that influence walking, such as demographic characteristics and the physical environment are fairly stable, attitudes and perceptions may be amenable to change through social marketing and educational programs. If attitudes cause behaviors, rather than the reverse, then knowing which attitudes and perceptions matter for what populations may allow professionals and activists to better target interventions to increase walking.

In the remainder of this paper, we first review previous work on attitudes, perceptions, and walking. This work shows mixed results and while international in scope has rarely focused on China. We then report results from analyzing an existing survey (N = 1048) using descriptive statistics, *t*-tests, analysis of variance (ANOVA), hierarchical logistic modeling, and hierarchical linear modeling. We find people with different attitudes walk different amounts, along with differences between men and women. Differences were subtle, however. Females with higher odds of walking perceived transportation as convenient, while males who perceived that bus frequency was not a problem had higher odds of walking. Meanwhile, more time spent walking was associated with feeling safe when walking across the streets and perceiving more traffic jams in daily trips. For those interested in increasing walking, this means promoting positive attitudes to overall mobility may help increase walking. We also recommend strengthening both intersection design and people's perception of pedestrian safety at intersections.

## 2. Background

The terms perceptions and attitudes are often used interchangeably. In this study perceptions are defined as beliefs about some phenomenon while attitudes involve a sense of seeing something favorably or unfavorably (Willis et al., 2015). Perceptions and attitudes may shape transport behavior, for example leading someone to walk less due to perceptions of crime. They may also be shaped by transport behavior, for example when a motorist may perceive traffic congestion to be a problem while a pedestrian may not. Prior studies examining how attitudes affect transportation have generally focused on motorized transport, cycling, and parental attitudes about children's travel (Hoffmann et al., 2017; Ikeda et al., 2018; Willis et al., 2015). Several reviews summarize relevant work.

Some studies have found that attitudes and perceptions affect transportation choices generally. Hoffmann et al. (2017) systematically reviewed the cognitive mechanisms that have been related to car use and non-car-use among adults, though most of the literature was about car use. Their meta-analysis showed that favorable attitudes to car-use were positively correlated with car use, favorable attitudes to alternative modes were negatively correlated with car use, and favorable attitudes to alternative modes had a positive relationship with non-car-use. Javaid et al. (2020) reviewed determinants of low-carbon transport mode adoption and found that personal norms were among the influential factors that support mode shift. Similar findings have been identified in reviews looking at cycling (Willis et al., 2015; Muñoz et al., 2016).

However, not all studies find a significant influence of attitudes and perceptions on transportation. A review of the effects of workplace relocation on commuting mode change showed that attitudinal variables were poor predictors of commuting mode change when relocating workplaces (Zarabi and Lord, 2019). Similarly, Rhodes et al. (2018) reviewed the effects of interactions between the built environment and social cognition on physical activity. Some studies showed that the relationship between the built environment and physical activity for transport depended on attitudes, while other studies found no interaction effect. Panter and Jones (2010) reviewed the relationship of active transport with attitudes and environments and found mixed results, where only two studies found associations between attitudes and active transport among the four studies involving attitudinal variables.

Many studies have examined health, environments, and walking, but where they have looked at perceptions and attitudes, these have generally related to the built and social environments although some have included perceptions of safety and traffic (Van Dyck et al., 2012; Day, 2016). In contrast, relatively fewer studies have looked specifically at how attitudes to transport modes and perceptions about the overall transport environment affect walking among adults. Such transport-related attitudes include attitudes and perceptions about transport modes and overall mobility, the convenience and safety of different modes, transport costs, and transport-related pollution.

Existing studies examining walking behavior and attitudes toward walking have had mixed findings. Some studies find significant correlations between attitudes and walking among adults. A study in Rasht, Iran, showed that positive attitudes toward walking, such as social interaction benefits, were related to a higher amount of walking in commuting trips, based on a sample of 432 commuters with workplaces located in the main streets of the city (Hatamzadeh et al., 2020). Zhang et al. (2019) analyzed a convenience sample of 157 office employees by path analysis and found that attitudes were related to walking for transport. Yang and Diez-Roux (2017) found that neighborhood environment characteristics were correlated with walking among people with a strong positive attitude to walking but not associated with walking among people with a less positive attitude, based on a clustered random sample of 2621 residents in six sites in the U.S. Based on an internet survey of 2660 commuters in a tier-three Chinese city, Ding et al. (2017) examined 1110 respondents who lived no more than 5 km from their workplaces. They found that attitudes towards walking and cycling had a significant association with participants choosing to commute by walking or cycling. Analyzing a random telephone survey of 1159 residents in three neighborhoods in Portland, U.S., Dill et al. (2014) found the relationship between walkable environments and walking trips was mediated by psychological factors including attitudes toward walking.

On the other hand, some studies show moderate or no connection between attitudes about walking and walking behavior for adults. For example, Chan et al. (2021) examined the perceived neighborhood environments, attitudes toward walking, and walking behavior, based on a survey of 890 adults encountered in four neighborhoods in Shenzhen, China. They found attitudes toward walking were not associated with walking for commuting and for household responsibilities, although they were associated with walking for leisure. Bird et al. (2018) studied adults with 1- and 2-year follow-up data (N = 1796 in year 1; N = 1465 in year 2) from three U.K. municipalities.

They examined changes in walking and cycling for transport and recreation. Using eTPB (extended Theory of Planned Behavior) psychological constructs including attitudes, intentions, automaticity of activity, and so on as input variables, their model only weakly predicted behavior. Using data from 437 questionnaires, 20 in-depth interviews, and detailed ethnographic studies of eight households in Lancaster, England, Pooley et al. (2011) found that adults' attitudes and beliefs toward walking and cycling often do not match their daily travel mode choice.

Only a few studies have, however, investigated how attitudes and perceptions related to multiple transport modes and overall transport convenience affect walking. De Vos et al. (2019) examined walking and cycling behavior, travel satisfaction, and attitudes to walking, cycling, car use, and public transport use, using a Structural Equation Model to analyze an internet survey of 1720 adults in the city of Ghent, Belgium. They found that travel satisfaction, attitudes, and mode choice affect each other. Using a stratified random sample and face-to-face surveys of 442 adults and adolescents in Porto Alegre, Brazil, Larrañaga et al. (2016) showed that the attitudes to walking and public transit, and perceptions of safety, were associated with travel by walking, public transport, or other modes. Based on a survey of 1545 car users in three German cities, Haustein and Hunecke (2007) found that one's perceived mobility demand due to personal living circumstances negatively influenced the use of environmentally friendly modes of transportation, especially public transport. Examining physical activity and less subjective indicators, Wang et al. (2019) found that perception of walkable distance to public transport stops was associated with more time in physical activity, based on a clustered random sample of 1568 adults in Nanjing, China.

This study aims to contribute to the limited literature by examining the relationship of reported walking for transport with the attitudes and perceptions about both motorized and nonmotorized transportation modes, overall transportation convenience, as well as pedestrian and cycling safety and infrastructure. In addition, by looking at a case in China it helps expand the geographical scope of such studies.

## 3. Materials and methods

### 3.1. Study area

Chengdu is the capital city of Sichuan Province and a second-tier city of China located in the southwest. The administrative region is large, covering the core city and suburban districts and counties with 16 million inhabitants in 2016, including those with and without Hukou[1] (residency registration) (Chengdu Statistic Bureau et al., 2017, p.293, p.54). This study focuses on the core city of Chengdu, including the five City Municipal Districts: Jinjiang, Qingyang, Jinniu, Chenghua, and Wuhou. In 2016 these districts had 3.8 million inhabitants with Hukou and a likely total population of 4.6–4.7 million, including those without Houkou (Chengdu Statistic Bureau et al., 2017, p.293). The mild climate and flat geography in the city area of Chengdu make active transportation mode choices quite viable (*成都的地理环境* [Geographical Environment of Chengdu], 2016).

### 3.2. Sampling

This study analyzes data from a survey which aimed to investigate land-use, transportation, physical environment, and health issues in Chengdu, China. The survey was led by the Harvard-China Project at the Harvard John A. Paulson School of Engineering and Applied Sciences in collaboration with the Research Center for Contemporary China (RCCC) at Peking University. The latter conducted the sampling and fieldwork in June and July 2016. The team used a clustered random sampling approach with GPS- and GIS-assisted spatial sampling method, implementing face-to-face interviews with strict quality control procedures. The survey included two questionnaires, one on transport and another on public health. This paper uses the transport survey.

Targeted respondents were Chinese adults aged 18 to 70 who had resided at their current addresses for at least one year. Details of the sampling methods have been documented elsewhere (Guan and Forsyth, 2020; Lyu et al., 2021). Briefly, 40 primary sampling units (PSUs) of half-square minutes of latitude and longitude were randomly selected from a pool of 968 PSUs which covered most of the residential areas in the core city of Chengdu. Among the 40 PSUs, 13 were inside and 27 outside the Second Ring Road in proportion to the population size. In total, for the transport survey, 1744 interviewees were randomly selected from these 40 PSUs, among which 1048 interviewees completed in-person surveys administered by trained interviewers, achieving a response rate of 60%. In the case of refusals by the household or the interviewee, the team revisited another four times before giving up. Security staff and managers of some buildings, particularly housing high income groups, were at times reluctant to admit interviewers. Electronic speaker security systems in individual dwellings had a similar effect (RCCC, 2016). As lower-income groups are most vulnerable in terms of transportation options, this had the effect of oversampling an important group while still achieving a relatively high response rate overall.

The transport survey was designed to examine travel behavior across multiple modes, access to different modes and destinations, attitudes and perceptions about the transportation environment, and socio-demographic correlates including occupations. A recall travel diary examined travel on a normal working day. Attitudinal and perception questions related to overall mobility, specific modes, and the transportation environment. This study used de-identified data from this existing survey; therefore it did not need approval for human subject research based on the definition of human subject by the U.S. federal regulations (Electronic Code of Federal Regulations, n.d.).

[1] China's Hukou system is a family residency registration program used to control population movement and restrict urbanization (Cheng and Selden, 1994).

### 3.3. Survey questions and data analysis

We hypothesized that people with different attitudes and perceptions would have different amounts of reported walking for transport. Further, there are significant correlations between attitudes, perceptions, and walking behavior, and the associations depend on socio-demographics. Data analysis methods involved descriptive statistics, t-tests, ANOVA, and two-stage regression analysis using hierarchical logistic models and hierarchical linear models. Descriptive statistics report walking behavior, attitudes to transportation and related issues, socio-demographics, and built-environmental features (Tables 1 and 2).

Considering the complex sampling approach, we compared the sample with the Census and Yearbook data. The results show that education levels and gender proportions in the sample were similar to the Census. However, in figures not reported in tables, compared with the Census the sample had a higher ratio of the unemployed (20% compared with 5%) and people aged 60 and above (18% compared with 9%). This is probably because unemployed and retired people were more likely to be at home. Based on the limited number of respondents who reported annual household income in the last year (2015), the average annual household income was ¥53,875 RMB in the sample, while this number for urban households in the city area of Chengdu was ¥99,089 RMB in 2015 (Lyu et al., 2021). This income difference was perhaps due to lower access to high-end developments with strong security protocols, but people may be less inclined to report high incomes.

As noted earlier, survey-based attitudinal and perception variables were collected on a variety of transportation-related topics. Table 2 presents the attitudinal variables and the original questions asked in the questionnaire. As can be seen, people had diverse opinions about overall mobility, walking, driving, traffic, bus transit, cycling, electric cycling, the physical environment, and safety. However, they generally agreed that bus fares were not a problem for their daily trip (93%). More than 80% of respondents felt it was convenient to move around the city, their homes were conveniently located, and traffic jams had not become a serious urban problem. Other questions were more evenly divided or had small numbers of responses.

Using t-tests the study assessed the differences in walking behavior between groups with negative and positive attitudes and perceptions. Walking behavior was measured by total minutes spent in walking for transport to destinations and transport facilities on a typical weekday, calculated with data from the trip diary-style recall survey. On average, the sample populations (n = 1048) walked 14 minutes for transport on a typical weekday, of which 58% (n = 603) people did not walk for transport at all. Among the people who walked (n = 445), the average time was 33 minutes per weekday with a range from 2 to 149 minutes. In the rest of this paper, we use the term pedestrians to refer to those who reported any walking on a typical weekday. Note that this survey examined travel walking, not walking for recreation, leisure, or within buildings. Therefore, walking in this paper always refers to walking for transport on a weekday. We also used ANOVA to compare the built-environment features amount the groups who did not walk at all, walked a lower amount, and walked a higher amount. We used 30 minutes of walking per weekday as the cut-off between lower and higher amount because it is roughly the average walking time among the pedestrians.

This paper uses a two-stage regression modeling strategy to explore the correlations between walking for transport and socio-demographic features, perceptions, and attitudes. The two-stage strategy was chosen rather than a single model because the mechanisms of (a) whether to walk or not and (b) how much time to walk could be different. Hierarchical modeling was applied due to the clustered random sampling design. Hierarchical or mixed effects regression models are often used to deal with survey data collected in clusters or groups, with hierarchical logistic models analyzing a binary response variable and hierarchical linear models examining a continuous response variable (Wong and Mason, 1985; Raudenbush and Bryk, 2002). In the first stage, we used hierarchical logistic modeling to examine the probability of walking at all among the sample population. Given that 58% of respondents had zero walking

**Table 1**
Descriptive statistics for self-reported walking, socio-demographic, and built-environmental variables.

| Variable | Measure | %/Mean | Min-Max | N |
|---|---|---|---|---|
| **Walk** [a] | Total minutes of walking for transport on a typical weekday | 14 | 0–149 | 1048 |
| **Socio-demographics** | | | | |
| **Age** | | 43 | 18–70 | 1048 |
| **Education Level** [b] | | 3.5 | 1–7 | 1047 |
| **Annual Household Income Level** | 1 = Below 3000; 18 = Above 400,000 (¥RMB Yuan) | 11 | 1–18 | 499 |
| **Gender** | % Female | 50% | | 1048 |
| **Marriage** | % Married | 73% | | 1038 |
| **Car Ownership** [c] | % Owning a car | 30% | | 1016 |
| **Employment Status** [d] | % Working | 67% | | 1048 |
| **Self-reported built-environment features** | | | | |
| **Distance to Work** | Kilometer | 7 | 0–160 | 446 |
| **Distance to City Center** | Minute by driving | 27 | 2–120 | 865 |
| **Distance to the nearest Grocery** | Minute by walk | 8 | 1–60 | 1026 |
| **Distance to the nearest Park** | Minute by walk | 17 | 0–80 | 816 |
| **Number of Bus Routes at the nearest stop** | Route | 4 | 1–20 | 629 |

Note.
[a] Walking time was calculated by adding the time of all walking trips reported in the travel diary.
[b] 1 = Below elementary school, 2 = Elementary school, 3 = Middle school, 4 = High school or vocational school, 5 = Junior college, 6 = Undergraduate, 7 = Graduate.
[c] Car Ownership denotes who have at least one private or employer-provided passenger car.
[d] Employment status includes working and non-working. Twenty-six students were included in the working category.

**Table 2**
Descriptive statistics for attitudinal variables.

| Variable | Measure (question asked in the questionnaire) | Positive (Convenient/ safe/not a problem) (%) | Negative (Inconvenient/ unsafe/problematic) (%) | N |
|---|---|---|---|---|
| ***Overall mobility*** | | | | |
| **City Transport Convenience** [1] | In general, how convenient do you think it is to move around in the city? (Degree of convenience) | **82%** | 18% | 1021 |
| **Home Transport Convenience** | Do you feel that your home has a convenient location with respect to transportation? (Yes or no) | **84%** | 16% | 1046 |
| **Traffic Jam in the City** [2] | Traffic jams have become a serious urban problem. (Degree of agreement) | 18% | **82%** | 975 |
| ***Walking*** | | | | |
| **Pedestrian Safety Crossing Streets** [3] | Walking across the streets is very dangerous. (Degree of agreement) | **56%** | 44% | 929 |
| **Sidewalks** | Is the lack of walkways or sidewalks a problem in your daily trip? (Yes or no) | **66%** | 34% | 1019 |
| **Pedestrian Crowding** | Are many people walking on the road a problem in your daily trip? (Yes or no) | **62%** | 38% | 1018 |
| ***Driving and road traffic*** | | | | |
| **Traffic Jam in Daily Trip** | Are traffic jams a problem in your daily trip? (Yes or no) | 27% | **73%** | 1020 |
| **Traffic Accident** | Do you worry about being in a traffic accident in your daily trip? (Yes or no) | **52%** | 48% | 1015 |
| **Rash Driver** | Are rash drivers on the road a problem in your daily trip? (Yes or no) | 47% | **53%** | 1012 |
| **Expensive Petrol** | Is petrol being expensive a problem in your daily trip? (Yes or no) | **78%** | 22% | 889 |
| ***Buses*** | | | | |
| **Bus Crowding** | Is overcrowding of buses a problem in your daily trip? (Yes or no) | **54%** | 46% | 1006 |
| **Bus Frequency** | Is the frequency of buses a problem in your daily trip? (Yes or no) | **73%** | 27% | 1002 |
| **Bus Fare Cost** | Are bus fares being too expensive a problem in your daily trip? (Yes or no) | **93%** | 7% | 1005 |
| ***Cycling*** | | | | |
| **Cyclist Safety from Traffic** [4] | Even as the number of cars increases, pedal bicycles remain safe. (Degree of agreement) | **57%** | 43% | 940 |
| **Cycling Convenience** [5] | Even as the number of cars increases, pedal bicycles remain convenient. (Degree of agreement) | **76%** | 24% | 959 |
| ***Electric cycling*** | | | | |
| **Electric Biking Safety** [6] | Even as the number of cars increases, electric bicycles remain safe. (Degree of agreement) | **52%** | 48% | 935 |
| **Electric Biking Convenience** [7] | Even as the number of cars increases, electric bicycles remain convenient. (Degree of agreement) | **77%** | 23% | 947 |
| ***Physical environment and safety*** | | | | |
| **Environment Quality** [8] | How do you think the overall environmental quality of Chengdu city (including air quality, water quality, etc.)? (Five levels from very good to very bad) | **67%** | 33% | 1027 |
| **Air Quality** [9] | Do you think the average air quality in Chengdu is: (Five levels from very good to very bad) | **58%** | 42% | 1031 |
| **Vehicle Emission** | Are fumes from vehicles a problem in your daily trip (Yes or no) | 49% | **51%** | 978 |
| **Pedestrian Safety from Crime** | Do you feel safe while you are walking or riding a bike in your neighborhood, with low possibility of being pick pocketed, robbed, or encountering other kinds of crime? (Safe or not safe) | **79%** | 21% | 1047 |
| **Child Walking Safety from Crime** | From the view of public safety, do you feel it is safe to let a child of 6–10 walk on their own from you home to the nearest bus stop? (Safe or not safe) | 17% | **83%** | 213 |
| **Pickpockets** | Are other safety issues such as pickpockets a problem in your daily trip (Yes or no) | **62%** | 38% | 983 |

Note: All positive attitudes and perceptions such as feeling convenient, safe, and not a problem were coded as 1. Code 0 represents the opposite.
1: The answers of "convenient" and "very convenient" were converted into code 1; "inconvenient" and "very inconvenient" were converted into code 0.
2 and 3: "Disagree" and "strongly disagree" were coded 1; "agree" and "strongly agree" were coded 0.
4, 5, 6, and 7: "Agree" and "strongly agree" were coded 1; "disagree" and "strongly disagree" were coded 0.
8 and 9: "Very good", "good", and "neutral" were coded 1, "bad" and "very bad" were coded 0.

minutes, we created a binary variable to distinguish those who did not walk from those who did. This binary variable became the response variable. The indicator variables were attitudinal and socio-demographic variables, which were discussed in detail later.

The second stage used hierarchical linear modeling to explore those who did walk any amount, examining among the pedestrians how the minutes of walking for transport on a weekday were associated with attitudes, perceptions, and socio-demographics. The response variable was the natural log scale for walking minutes. We used the natural log scale due to a right skew (mean > median) and to reduce the influence of outliers. The indicator variables are discussed in the next paragraph. All hierarchical models assume random

intercept effects, which allows us to account for unexplained between-cluster variability in the participants across the residential areas (PSUs). For the first stage, there is 7.87% of the variance at the residential area level determined in the null model. For the second stage, 9.44% of the variance in walking can be attributed to differences between residential areas. The regression analysis was processed with R version 3.6.3 (2020-02-29) running under Windows. Both hierarchical logistic and linear regression models have been commonly used in quantitative social and urban research (Parra et al., 2010; Wang et al., 2019).

Indicator variables for regressions of the two stages include attitudes and socio-demographics. Household income and built-environmental variables (distances to various destinations and numbers of nearby bus routes) were not used for regressions due to many missing values, though the built-environment variables were analyzed using ANOVA. To maximize the number of observations for regressions, we used parsimonious models with minimized numbers of indicator variable. Five attitudinal variables were selected from attitudes and perceptions about overall mobility and about the four major transport modes–driving, walking, cycling, and taking a bus—with one variable regarding each mode.

The selection of attitudinal variables for regression analysis was based on whether the variable was conceptually important and whether it had a relatively higher Pearson's bivariate correlation with walking measured by minutes on a weekday. We chose the perceptions of city transport convenience variable because the literature showed that perceptions of overall mobility could influence travel choice, and this variable represented perceptions on general mobility in the city better than the other variables. Both perceptions of pedestrian safety crossing streets and presence of sidewalks could be potential indicators of walking behavior. We chose the former because it showed a relatively higher bivariate correlation with walking time. Regarding driving, we chose attitudes to daily traffic jams rather than attitudes to traffic accidents, rash drivers, and expensive petrol, because daily traffic jams are often a major concern for those who travel on weekdays. Regarding buses, we chose attitudes to bus frequency rather than attitudes to bus fare because the bus fare was generally low in Chengdu (refer to Table 2). Both perceptions of cycling convenience and safety could influence the substitution effect of cycling on walking. We used the former due to its relatively higher bivariate correlation with walking.

## 4. Results

### 4.1. Differences in amount of walking time between different attitudes groups

Differences in walking time were statistically significant only for three attitudinal variables (see Table 3). Higher amounts of walking occurred among those who thought it was convenient to move around in the city, did not agree that traffic jams had become a serious urban problem, and did not regard expensive petrol as a problem in their daily trips.

**Table 3**
Comparing walking minutes between groups with different attitudes and perceptions for the whole sample.

| Attitudes/Perceptions | Walking minutes for transport on a typical weekday (Mean value) | | t-statistic | p-value |
|---|---|---|---|---|
| | Positive attitude group (feeling convenient/safe/not a problem) | Negative attitude group (feeling inconvenient/unsafe/it is a problem) | | |
| City Transportation Convenience | **14.7** | **11.1** | 2.052 | **0.041*** |
| Home Transportation Convenience | 14.0 | *14.5* | −0.265 | 0.792 |
| Traffic Jams as an urban issue | **19.3** | **12.6** | 3.147 | **0.002**** |
| Pedestrian Safety Crossing Streets | 14.7 | 12.3 | 1.685 | 0.092 |
| Sidewalks | 13.6 | *14.6* | −0.671 | 0.503 |
| Pedestrians Crowding | 14.1 | 13.5 | 0.426 | 0.670 |
| Traffic Jam in Daily Trip | 14.7 | 13.6 | 0.689 | 0.491 |
| Traffic Accident | 14.0 | 13.5 | 0.335 | 0.737 |
| Rash Driver | 14.5 | 12.9 | 1.181 | 0.238 |
| Expensive Petrol | **13.2** | **9.4** | 2.429 | **0.016*** |
| Bus Crowding | 13.8 | 13.6 | 0.091 | 0.928 |
| Bus Frequency | 14.4 | 12.4 | 1.248 | 0.213 |
| Bus Fare Expensive | 14.2 | 11.0 | 1.318 | 0.191 |
| Cyclist Safety from Traffic | 13.8 | 12.7 | 0.771 | 0.441 |
| Cycling Convenience | 14.1 | 11.6 | 1.536 | 0.125 |
| Electric biking Safety | 13.9 | 12.3 | 1.159 | 0.247 |
| Electric biking Convenience | 13.9 | 11.2 | 1.746 | 0.082 |
| Environment Quality | 14.4 | 13.1 | 0.912 | 0.362 |
| Air Quality | 13.9 | *14.1* | −0.116 | 0.908 |
| Vehicle Emission | 13.6 | 13.4 | 0.111 | 0.912 |
| Pedestrian Safety from Crime | 14.5 | 12.4 | 1.207 | 0.228 |
| Child Walking Safety from Crime | 12.0 | *12.6* | −0.166 | 0.869 |
| Pickpockets | 12.6 | *14.4* | −1.205 | 0.228 |

Confidence levels * 95%; ** 99%.

Moreover, ANOVA indicated that people with different amounts of walking had significantly different self-reported distances to work, the nearest grocery, and the nearest park. The patterns in Table 4 indicate that people who walked more for transport reported that they lived closer to their workplace. High-walk people lived 2.6 km away from work on average, while the numbers were 3.4 km and 8.3 km for the low-walk and no-walk groups, respectively. Moreover, people walked more for transport if they lived farther from a grocery and a park. Note that the nearest grocery and park were within walking distance to all groups, on average, with an average walking time within 10 min to the grocery and within 20 min to the park for all groups.

### 4.2. Whether to walk and how much to walk have different correlates

Table 5 shows the results of the first stage models, which explore correlates of walking or not walking. Model 1 uses only socio-demographics as indicator variables, and Model 2 includes socio-demographics, attitudes, and perceptions. Results show that adding attitudinal variables in the model did not significantly improve model fit, and none of the attitudinal variables was significantly correlated with whether people walked.

We also ran interaction models to test whether the relationship of walking with attitudes depended on socio-demographic variables. Only the interaction between gender and attitudes significantly improved the model fit (see Model 3 in Table 5). On average, the association between the odds of walking and attitudes to bus frequency depended on gender. If males thought bus frequency was not a problem in their daily trips, they were more likely to walk, but this correlation was not significant for females. If women perceived that transportation in the city was convenient, they had a significantly higher odds of walking. This relationship was not seen among males. Moreover, age and employment status were significantly correlated with whether to walk in all three models. Older and non-working people were more likely to walk. A one-year increase in age was associated with a 4% increase in the probability of walking at all. The average probability of walking among working people was only 16% of that among non-working people.

Note that only 800 out of 1048 observations were obtained from the sample after excluding missing values. Logistic regression was performed to explore possible bias introduced by the missing value issue. A binary variable was created as the outcome to represent cases with any missing value in the variables used in the regressions. Predictors were the socio-demographic variables. Results showed no significant correlation of missing values with socio-demographics except for employment. Working people were less likely to have missing values. The percentage of working people was higher in the complete cases (71%) than in the sample (67%). This is not treated as a serious concern since working people were underrepresented in the sample compared with the Census.

A second round of regressions looked at how many minutes pedestrians walked (rather than looking at the whole sample for whether respondents had any walking) (Table 6). Adding attitudinal variables significantly improved model fit. Those who perceived pedestrians crossing the streets as safe walked 17% more minutes. Those who did not think traffic jams on daily trips were a problem walked 35% fewer minutes. Working people walked 25% less than non-working people. Interactions between attitudes and socio-demographics were further examined in the second stage, but none of the interactions made a better model.

## 5. Discussion

### 5.1. Differences in walking time between positive and negative attitudes groups

T-tests showed that people with positive attitudes walked more minutes if they felt traveling around in the city was convenient in general, road congestion had not become a serious urban problem, and expensive petrol was not a problem for their daily trips. Positive attitudes to transportation conditions may encourage activities which could lead to more walking on average. However, travel experience likely influences attitudes too. It is possible that those who often travel by walking do not experience as many traffic jams as those who often drive, thus being more positive about urban road conditions. Expensive petrol is less likely to be a problem for pedestrians because they are less car dependent. This is in line with findings by De Vos et al. (2019) which suggested a cyclical process between attitudes and mode choice.

**Table 4**
Comparing self-reported built-environmental characteristics among groups with different amount of walking.

| | People who did not walk *(no-walk)* | People who walked a lower amount (≤30 min per weekday) *(low-walk)* | People who walked a higher amount (>30 min per weekday) *(high-walk)* |
|---|---|---|---|
| | Mean | Mean | Mean |
| **Distance to Work (km) ***** | 8.3 | 3.4 | 2.6 |
| **Distance to City Center (Driving minute)** | 28.1 | 26.9 | 26.1 |
| **Distance to the nearest Grocery ** (Walking minute from home)** | 8.0 | 8.2 | 9.9 |
| **Distance to the nearest Park * (Walking minute from home)** | 16.4 | 16.6 | 19.2 |
| **Number of Bus Routes at the nearest bus stop from home** | 4.3 | 4.1 | 4.5 |

Using ANOVA, confidence levels * 95%; ** 99%; *** 99.9%.

**Table 5**
Regression results of Stage 1: Hierarchical Logistic Model with Respondent variable: walking or no walking.

| | Model 1 | | Model2 | | Model 3 (Interaction) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Conditional effect of female | | Conditional effect of male | |
| | Odds Ratio | 95% CI | Odds Ratio | 95% CI | Odds Ratio | 95% CI | Odds Ratio | 95% CI |
| Age | 1.04 *** | [1.02, 1.06] | 1.04 *** | [1.02, 1.06] | 1.04 *** | [1.02, 1.06] | 1.04 *** | [1.02, 1.06] |
| Gender1 (1 = male) | 0.72 | [0.51, 1.02] | 0.70 | [0.50, 1.00] | 0.71 | [0.21, 2.44] | – | |
| Gender0 (0 = female) | – | – | – | – | – | – | 1.41 | [0.41, 4.82] |
| Marriage | 0.65 | [0.41, 1.04] | 0.64 | [0.40, 1.02] | 0.62 | [0.39, 1.01] | 0.62 | [0.39, 1.01] |
| Education Level | 0.97 | [0.83, 1.14] | 0.98 | [0.84, 1.14] | 0.98 | [0.84, 1.15] | 0.98 | [0.84, 1.15] |
| Car ownership | 0.75 | [0.51, 1.11] | 0.74 | [0.50, 1.10] | 0.74 | [0.49, 1.10] | 0.74 | [0.49, 1.10] |
| Working | 0.18 *** | [0.11, 0.28] | 0.17 *** | [0.11, 0.27] | 0.16 *** | [0.10, 0.26] | 0.16 *** | [0.10, 0.26] |
| City Transport Convenience (1 = convenient) | | | 1.40 | [0.87, 2.26] | 2.20 * | [1.08, 4.48] | 0.92 | [0.48, 1.74] |
| Pedestrian Safety Crossing Streets (1 = safe) | | | 1.30 | [0.91, 1.85] | 1.19 | [0.73, 1.94] | 1.44 | [0.86, 2.44] |
| Daily Traffic Jam (1 = no problem) | | | 1.08 | [0.71, 1.67] | 0.74 | [0.42, 1.32] | 1.75 | [0.95, 3.22] |
| Bus Frequency (1 = no problem) | | | 1.42 | [0.94, 2.14] | 0.94 | [0.54, 1.65] | 2.19 * | [1.16, 4.12] |
| Cycling Convenience (1 = convenient) | | | 1.14 | [0.76, 1.72] | 1.33 | [0.74, 2.38] | 0.96 | [0.54, 1.71] |
| Interaction terms *(indicates how effects differ between males and females.)* | | | | | | | | |
| City Transport Convenience: Gender male *(indicates how effects of attitudes to city transport convenience on odds of walking differ between males and females. Similar below.)* | | | | | 0.42 | [0.16, 1.07] | – | – |
| Pedestrian Safety Crossing Streets: Gender male | | | | | 1.22 | [0.60, 2.47] | – | – |
| Daily Traffic Jam: Gender male | | | | | 2.37 * | [1.05, 5.33] | – | – |
| Bus Frequency: Gender male | | | | | 2.33 * | [1.00, 5.39] | – | – |
| Cycling Convenience: Gender male | | | | | 0.72 | [0.32, 1.64] | – | – |
| Transport Convenience: Gender female | | | | | | | 2.40 | [0.93, 6.20] |
| Pedestrian Safety Crossing Streets: Gender female | | | | | | | 0.82 | [0.40, 1.68] |
| Daily Traffic Jam: Gender female | | | | | | | 0.42 * | [0.19, 0.95] |
| Bus Frequency: Gender female | | | | | | | 0.43 * | [0.19, 1.00] |
| Cycling Convenience: Gender female | | | | | | | 1.39 | [0.61, 3.15] |
| N | 800 | | 800 | | 800 | | | |
| Log Likelihood | −425.06 | | −420.62 | | −414.6 | | | |
| ANOVA Chi-square comparing with null model | 208.3 *** | | 217.18 *** | | 229.15 *** | | | |
| ANOVA Chi-square comparing with Model 1 | | | 8.88 | | 20.856 * | | | |
| ANOVA Chi-square comparing with Model 2 | | | | | 11.974 * | | | |

Confidence levels * 95%; ** 99%; *** 99.9%.

### 5.2. Reported built-environmental features and walking

There were notable associations between walking and built-environmental variables (see Table 4). People walked more if they reported living closer to work, and further from the closest grocery and park, but walking was not related to the distance to the city center. Commuting can contribute to overall walking and was feasible for many of the pedestrians with an average commuting distance

**Table 6**
Regression results of Stage 2: Hierarchical Linear Model with Respondent Variable: Natural Logarithm of Walking Minutes on a Weekday.

| | Model 1 | | Model2 | |
|---|---|---|---|---|
| | Estimate | 95% CI | Estimate | 95% CI |
| Age | 0.00 | [-0.00, 0.01] | 0.01 | [-0.00, 0.01] |
| Male | −0.04 | [0.21, 0.12] | −0.05 | [-0.21, 0.11] |
| Marriage | −0.11 | [-0.33, 0.10] | −0.10 | [-0.31, 0.10] |
| Education Level | −0.03 | [-0.10, 0.04] | −0.02 | [-0.08, 0.05] |
| Car Ownership | 0.03 | [-0.15, 0.22] | −0.02 | [-0.20, 0.16] |
| Working | −0.26 * | [-0.47, −0.05] | −0.25 * | [-0.46, −0.05] |
| City Transport Convenience (1 = convenient) | | | −0.14 | [-0.36, 0.09] |
| Pedestrian Safety Crossing Streets (1 = safe) | | | 0.17 * | [0.01, 0.33] |
| Daily Traffic Jam (1 = no problem) | | | −0.35 *** | [-0.53, −0.18] |
| Bus Frequency (1 = no problem) | | | −0.08 | [-0.27, 0.10] |
| Cycling Convenience (1 = convenient) | | | 0.07 | [-0.12, 0.26] |
| N | 317 | | 317 | |
| Log Likelihood | −342.98 | | −332.64 | |
| ANOVA Chi-square comparing with null model | 21.734 ** | | 42.424 *** | |
| ANOVA Chi-square comparing with Model 1 | 317 | | 20.69 *** | |

Confidence levels * 95%; ** 99%; *** 99.9%. This regression only examined those with some walking.

of 2.6 km (high-walk group) and 3.4 km (low-walk group). In contrast, those who did not walk reported living 8.3 km on average from work. Walking to work within a feasible distance can be enjoyable for some people because it is routine, thus easy to implement and guarantee daily exercise to improve health and well-being. This is consistent with findings from existing studies that proximity to workplace was a significant contributor to walking for transport (e.g. Batista Ferrer et al., 2018; Cerin et al., 2007).

The results about walking and the distances to a grocery and a park may seem to contradict the literature that a longer distance to amenities discourages walking (Wang et al., 2016). However, in this study the average distances to the nearest groceries were within a 10-minute walk for those who did not walk, walked a lower amount, and walked a higher amount. All groups resided within a 20-minute walk to a park. The acceptable walking distance to a park could be longer than that to a grocery because the purposes of going to the park are often to have physical activity. On average, these were walkable distances. Within a walkable service radius, going a bit further to a grocery and a park from home may slightly increase walking for transport. However, if destinations are not accessible by walking, the distance will lower the odds of walking for transport. Wang et al. (2016) recommend that amenities and public spaces locate within a 15-minute walk from homes based on their review.

### *5.3. Attitudes and other correlates of whether and how much to walk*

In models we examined two outcomes—(a) whether people walked at all and (b) the time spent walking among those who walked. These were associated with different factors. The first stage models show that the associations between attitudes and the odds of walking at all depend on gender. Males perceiving bus frequency was not a problem were more likely to walk. Females who felt that transportation in the city was convenient had higher odds of walking. Gender differences in walking behavior have been documented in the literature (Pollard and Wagnild, 2017). Hatamzadeh et al. (2020) reported that females walked more, but males had more positive attitudes toward walking. Similarly, in our study, 49% females walked at least some time, while this number was 36% among males. However, Table 5 showed that gender was not a significant indicator of the odds of walking after controlling for employment and attitudinal variables. In addition, males were more likely to walk when they had positive perceptions of bus frequency, probably because males often walked to bus stops, and females walked to more varied destinations.

Gender differences, while complex, contribute to the understanding that positive attitudes and perceptions about overall mobility and other modes correlate with some walking. When people are positive about overall transportation convenience, they walk to buses and other destinations. It is also consistent with the findings of Wang et al. (2019) that the perception of walkable distance to transit stops was related to more physical activity. However, not much work has been done to explore how attitudes and perceptions of overall transportation convenience directly influence walking.

In the models examining how many minutes pedestrians walked, some of the selected attitudinal variables were correlated with walking time and they significantly improved the model fit. These associations did not depend on socio-demographics. More specifically, among the pedestrians, those who perceived walking across the street as safe walked for a longer time on a weekday. This is consistent with many studies that perceived safety from traffic when crossing streets encourages walking (Krizek et al., 2009).

Note that there were two questions relating to traffic jams in the survey (see Table 2): (A) “Traffic jams have become a serious urban problem” (degree of agreement)” and (B) “Are traffic jams a problem in your daily trip?” (yes or no). Results from t-tests of the whole sample (Table 3) showed that those who did not agree with statement A, that traffic jams have become a serious urban problem,

walked more minutes on average. That is, a positive attitude to general urban traffic conditions was associated with more walking. Looking only at those who had walked, however, using hierarchical linear regression analysis (Table 6), we found that those who perceived traffic jams as a problem in their own daily trips, statement B, walked more minutes. This is consistent to the review and meta-analysis by Hoffmann et al. (2017) which revealed that attitudes such as concerns about traffic congestion were related with less car use.

Older and non-working people tended to walk at least some amount, compared with not walking at all. Among those who walked, non-working people walked more time than others. In the second stage models that looked only at those who had walked, age was not associated with walking time perhaps because older people were overrepresented among the pedestrians. The mean and median age were 50 and 53 among the 445 pedestrians. However, the underlying reason for the association with employment status is not clear. The average time spent walking for transport on a weekday was 29 minutes for non-working and seven minutes for working people for the whole sample. Is it because non-working people have lower incomes and more concerns about travel costs? Many studies have shown that people with lower income walk more (Forsyth and Krizek, 2010). However, in this study, regression analyses with income, based on limited number of observations due to missing values (not reported here), indicated that income was not significantly correlated with whether people walked or with how much time they spent walking. It is more likely that non-working people have more walking time because of a looser schedule and lower time sensitivity. This finding contributes to the debate in the literature, where evidence for the association between employment and walking for transport has been inconclusive (Hilland et al., 2020).

### 5.4. Implications

These results lead to some implications for urban policy targeting increased walking for transport, especially in a similar urban context. Efforts to promote people's positive attitudes and perceptions regarding overall mobility in the city may increase walking for transport. When they perceive transportation is convenient, people may travel more and thus have chances to walk between destinations and to connect trips. This paper suggests that planning practitioners should not only work for a more walkable environment, but also market it, promoting positive attitudes and perceptions about the transportation modes and transport-related environment.

Further, because the perception of being safe when walking crossing streets is correlated with more walking time, strengthening road safety design at intersections and marketing it with public advertisements, could increase walking time for transport. Improving safety is also useful for health. In addition, promoting the jobs-housing balance could increase walking for transport on a weekday, considering that the pedestrians reported living significantly closer to their workplaces than those who did not walk at all. Lastly, because younger people were less likely to walk for transport than older people, policies could encourage younger people to walk, while urban design could make walking facilities more age-friendly.

### 5.5. Limitations

This study has a few limitations. First, the regression techniques in this paper were not designed to identify causal relationships. Therefore, in this study, we focus on correlations only. Future studies could expand the discussion with new survey data and other regression techniques. Second, older, unemployed, and lower-income people were over-represented in the sample. The results could be different with a sample including more higher-income people. However, this study helps to understand the attitudes and walking behavior among disadvantaged groups. Third, the attitude questions asked about many practical issues such as safety and convenience but less about the specifics of urban design and personal norms that have been the focus of prior studies. In addition, people may have underestimated their walking time in the travel diary. They may have ignored short walking trips if connected to another mode. There were few cases where walking was reported in a trip with multiple modes in the survey. In real life, people often walk some distance to transit stations or parking lots. Future surveys may provide more clarity about the definition of a walking trip. Lastly, no question asked about the subway because the questionnaire was designed before the launching of the subway in Chengdu. With more recent data after the subway became available, scholars may develop different models and have new findings.

## 6. Conclusion

An increasing number of studies have discussed the relationship of walking with attitudes and perceptions. However, the findings are not consistent, and few studies have examined the relationship between walking and attitudes to overall mobility and multiple modes. This article examines a series of broad attitudes toward all transportation modes and explores how the attitudes and other factors, including socio-demographics and reported built-environmental features, are related to walking for transport on a typical weekday.

This study provides further evidence that attitudes are associated with walking behavior. Results of descriptive statistics and t-tests showed that people with positive attitudes to multiple modes and related questions walked a higher amount in general, though there could be a reciprocal relationship between attitudes and behavior. Environmental features matter as well: those who lived closer to their workplace walked more for transport on a weekday. Two-stage regression analysis with selected attitudinal variables further indicated that attitudes are significantly associated with the amount of walking among pedestrians, while the associations between attitudes and odds of walking vary with gender. Males tended to walk some amount if they thought bus frequency was fine. Females were more likely to walk when they viewed overall transportation in the city as convenient. Meanwhile, feelings that walking across the streets was safe and perceiving traffic jams as a problem for daily trips were associated with walking a longer time for transport among pedestrians on a weekday. Moreover, older people are more likely to walk. Not working is associated with both higher

probabilities of walking and more walking time.

This paper concludes that positive broad attitudes and perceptions of overall mobility and all transport modes are related to more walking activities. It implies that promoting transportation convenience based on multiple modes and boosting positive attitudes and perceptions may bring more walking for transport. In addition, improving perceptions of pedestrian road safety could increase walking time.

## Declaration of competing interest

The authors do not have conflicts of interest.

## Acknowledgments

We are truly grateful to the Harvard-China Project at the Harvard John A. Paulson School of Engineering and Applied Sciences for supporting this paper with the survey data. We also sincerely thank the data science specialist Steven Worthington at the Institute for Quantitative Social Science at Harvard University for his advice on regression modeling.

## References

Batista Ferrer, H., Cooper, A., Audrey, S., 2018. Associations of mode of travel to work with physical activity, and individual, interpersonal, organisational, and environmental characteristics. Journal of Transport & Health 9, 45–55. https://doi.org/10.1016/j.jth.2018.01.009.

Bird, E.L., Panter, J., Baker, G., Jones, T., Ogilvie, D., 2018. Predicting walking and cycling behaviour change using an extended Theory of Planned Behaviour. Journal of Transport & Health 10, 11–27. https://doi.org/10.1016/j.jth.2018.05.014.

Cerin, E., Leslie, E., Toit, L. du, Owen, N., Frank, L.D., 2007. Destinations that matter: associations with walking for transport. Health Place 13 (3), 713–724. https://doi.org/10.1016/j.healthplace.2006.11.002.

Chan, E.T.H., Schwanen, T., Banister, D., 2021. The role of perceived environment, neighbourhood characteristics, and attitudes in walking behaviour: evidence from a rapidly developing city in China. Transportation 48, 431–454. https://doi.org/10.1007/s11116-019-10062-2.

Cheng, T., Selden, M., 1994. The origins and social consequences of China's Hukou system*. China Q. 139, 644–668. https://doi.org/10.1017/S0305741000043083.

Chengdu Statistic Bureau, 2017. NBS survey office in Chengdu, & Chengdu statistical association. In: 成都统计年鉴 2017 [Chengdu Statistical Yearbook 2017]. China Statistics Press, Beijing.

Day, K., 2016. Built environmental correlates of physical activity in China: a review. Preventive Medicine Reports 3, 303–316. https://doi.org/10.1016/j.pmedr.2016.03.007.

De Vos, J., Schwanen, T., Van Acker, V., Witlox, F., 2019. Do satisfying walking and cycling trips result in more future trips with active travel modes? An exploratory study. International Journal of Sustainable Transportation 13 (3), 180–196. https://doi.org/10.1080/15568318.2018.1456580.

Dill, J., Mohr, C., Ma, L., 2014. How can psychological theory help cities increase walking and bicycling? J. Am. Plann. Assoc. 80 (1), 36–51. https://doi.org/10.1080/01944363.2014.934651.

Ding, C., Chen, Y., Duan, J., Lu, Y., Cui, J., 2017. Exploring the influence of attitudes to walking and cycling on commute mode choice using a hybrid choice model. J. Adv. Transport., e8749040 https://doi.org/10.1155/2017/8749040, 2017.

Electronic Code of Federal Regulations. (n.d.). Electronic Code of Federal Regulations (e-CFR). Retrieved October 20, 2020, from https://www.ecfr.gov/cgi-bin/text-idx?SID=4583fadfaa2fc398a2f0d93c25a3beb8&mc=true&node=se45.1.46_1102&rgn=div8 [Version October 16, 2020 Title 45 §46.102 (e)(1)(i)(ii)].

成都的地理环境 Geographical Environment of Chengdu, 2016, January 19. 成都市地方志[Chengdu chorography] [Government website]. http://www.cdhistory.chengdu.gov.cn/mlcd_view.asp?NId=48.

Forsyth, A., Krizek, K.J., 2010. Promoting walking and bicycling: assessing the evidence to assist planners. Built Environ. 36 (4), 429–446. https://doi.org/10.2148/benv.36.4.429.

Guan, C., Forsyth, A., 2020. The influence of urban form and socio-demographics on active transport: A 40-neighborhoods study in Chengdu, China. J. Transp. Land Use 13 (1), 367–388. https://doi.org/10.5198/jtlu.2020.1697.

Hatamzadeh, Y., Habibian, M., Khodaii, A., 2020. Measuring walking behaviour in commuting to work: investigating the role of subjective, environmental and socioeconomic factors in a structural model. Int. J. Unity Sci. 24 (2), 173–188. https://doi.org/10.1080/12265934.2019.1661273.

Haustein, S., Hunecke, M., 2007. Reduced use of environmentally friendly modes of transportation caused by perceived mobility necessities: an extension of the theory of planned Behavior1. J. Appl. Soc. Psychol. 37 (8), 1856–1883. https://doi.org/10.1111/j.1559-1816.2007.00241.x.

Hilland, T.A., Bourke, M., Wiesner, G., Garcia Bengoechea, E., Parker, A.G., Pascoe, M., Craike, M., 2020. Correlates of walking among disadvantaged groups: a systematic review. Health Place 63, 102337. https://doi.org/10.1016/j.healthplace.2020.102337.

Hoffmann, C., Abraham, C., White, M.P., Ball, S., Skippon, S.M., 2017. What cognitive mechanisms predict travel mode choice? A systematic review with meta-analysis. Transport Rev. 37 (5), 631–652. https://doi.org/10.1080/01441647.2017.1285819.

Ikeda, E., Hinckson, E., Witten, K., Smith, M., 2018. Associations of children's active school travel with perceptions of the physical environment and characteristics of the social environment: a systematic review. Health Place 54, 118–131. https://doi.org/10.1016/j.healthplace.2018.09.009.

Javaid, A., Creutzig, F., Bamberg, S., 2020. Determinants of low-carbon transport mode adoption: systematic review of reviews. Environ. Res. Lett. 15 (10), 103002.

Krizek, K.J., Forsyth, A., Baum, L., 2009. Walking and Cycling International Literature Review. Victoria Department of Transport, Melbourne.

Larrañaga, A.M., Rizzi, L.I., Arellana, J., Strambi, O., Cybis, H.B.B., 2016. The influence of built environment and travel attitudes on walking: a case study of Porto Alegre, Brazil. International Journal of Sustainable Transportation 10 (4), 332–342. https://doi.org/10.1080/15568318.2014.933986.

Li, F., 2016. Physical activity and health in the presence of China's economic growth: meeting the public health challenges of the aging population. Journal of Sport and Health Science 5 (3), 258–269. https://doi.org/10.1016/j.jshs.2016.06.004.

Lyu, Y., Forsyth, A., Worthington, S., 2021. Built Environment and Self-Rated Health: Comparing Young, Middle-Aged, and Older People in Chengdu, China. HERD: Health Environ. Res. Des. J. https://doi.org/10.1177/1937586720982566. In press.

Muñoz, B., Monzon, A., Daziano, R.A., 2016. The increasing role of latent variables in modelling bicycle mode choice. Transport Rev. 36 (6), 737–771. https://doi.org/10.1080/01441647.2016.1162874.

Panter, J.R., Jones, A., 2010. Attitudes and the environment as determinants of active travel in adults: what do and don't we know? J. Phys. Activ. Health 7 (4), 551–561. https://doi.org/10.1123/jpah.7.4.551.

Parra, D.C., Gomez, L.F., Sarmiento, O.L., Buchner, D., Brownson, R., Schimd, T., Gomez, V., Lobelo, F., 2010. Perceived and objective neighborhood environment attributes and health related quality of life among the elderly in Bogotá, Colombia. Soc. Sci. Med. 70 (7), 1070–1076. https://doi.org/10.1016/j.socscimed.2009.12.024, 1982.

Pollard, T.M., Wagnild, J.M., 2017. Gender differences in walking (for leisure, transport and in total) across adult life: a systematic review. BMC Publ. Health 17 (1), 341. https://doi.org/10.1186/s12889-017-4253-4.

Pooley, C.G., Horton, D., Scheldeman, G., Tight, M., Jones, T., Chisholm, A., Harwatt, H., Jopson, A., 2011. Household decision-making for everyday travel: a case study of walking and cycling in Lancaster (UK). J. Transport Geogr. 19 (6), 1601–1607. https://doi.org/10.1016/j.jtrangeo.2011.03.010.

Raudenbush, S.W., Bryk, A.S., 2002. Hierarchical Linear Models: Applications and Data Analysis Methods, second ed. Sage Publications.
RCCC, 2016. Chengdu Survey, 2016 -The Sampling and Fieldwork Report. The Research Center for Contemporary China (RCCC) at Peking University.
Rhodes, R.E., Saelens, B.E., Sauvage-Mar, C., 2018. Understanding physical activity through interactions between the built environment and social cognition: a systematic review. Sports Med. 48 (8), 1893–1912. https://doi.org/10.1007/s40279-018-0934-0.
Van Dyck, D., Cerin, E., Conway, T.L., De Bourdeaudhuij, I., Owen, N., Kerr, J., Cardon, G., Frank, L.D., Saelens, B.E., Sallis, J.F., 2012. Perceived neighborhood environmental attributes associated with adults' transport-related walking and cycling: findings from the USA, Australia and Belgium. Int. J. Behav. Nutr. Phys. Activ. 9 (1), 70. https://doi.org/10.1186/1479-5868-9-70.
Wang, Y., Chau, C.K., Ng, W.Y., Leung, T.M., 2016. A review on the effects of physical built environment attributes on enhancing walking and cycling activity levels within residential neighborhoods. Cities 50, 1–15. https://doi.org/10.1016/j.cities.2015.08.004.
Wang, Z., Ma, Y., Qin, Z., Ye, Q., Xu, Z., Han, L., Jia, P., Xu, F., 2019. Association between perceived access to public transport stops and physical activity among adults in Nanjing, Mainland China: a cross-sectional study. Journal of Transport & Health 13, 12–18. https://doi.org/10.1016/j.jth.2019.03.002.
Willis, D.P., Manaugh, K., El-Geneidy, A., 2015. Cycling under influence: summarizing the influence of perceptions, attitudes, habits, and social environments on cycling for transportation. International Journal of Sustainable Transportation 9 (8), 565–579. https://doi.org/10.1080/15568318.2013.827285.
Wong, G.Y., Mason, W.M., 1985. The hierarchical logistic regression model for multilevel analysis. J. Am. Stat. Assoc. 80 (391), 513–524. https://doi.org/10.1080/01621459.1985.10478148.
Yang, Y., Diez-Roux, A.V., 2017. Adults' daily walking for travel and leisure: interaction between attitude toward walking and the neighborhood environment. Am. J. Health Promot. 31 (5), 435–443. https://doi.org/10.1177/0890117116669278.
Zarabi, Z., Lord, S., 2019. Toward more sustainable behavior: a systematic review of the impacts of involuntary workplace relocation on travel mode choice. J. Plann. Lit. 34 (1), 38–58.
Zhang, R., Zhang, C., Gan, Y., Li, D., Rhodes, R.E., 2019. Predicting transport-related walking in Chinese employees by integrating worksite neighbourhood walkability and social cognition. Appl. Psychol.: Health and Well-Being 11 (3), 484–498. https://doi.org/10.1111/aphw.12164.