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Influence of Road Connectivity and Public Transport Accessibility on Subjective Wellbeing during Travel: An Explanation from Travel Mode: Evidence from five Communities around Subway Stations in Harbin

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1 ABSTRACT

Existing studies have shown that increased subjective wellbeing comes with individual and societal benefits. Now citizens spend a significant amount of time per day on trips. Whether the change of transport environment factors, especially the construction of subway station can effectively improve residents' subjective wellbeing during travel or not is now concerned more than before when creating a “Real Emotional City”. This study aims to explore the relationship between road connectivity, public transport accessibility around subway stations and residents' subjective wellbeing during travel, and the mediating effect of travel modes.

Data form 400 residents were collected from communities in Harbin which included travel modes, subjective wellbeing during travel and basic individual information. It turns out that the cognitive judgments and the emotional feelings (two aspects of travel wellbeing) need to be discussed separately because they are almost independently affected. Although cycling and walking are active, only pedestrians reported higher travel satisfaction when controlling travel time and other confounding factors. We found that for each additional unit of road network density, the number of people travelling by public transport will increase. Residents with better bus station accessibility and who have better road connectivity are likely to have higher travel satisfaction. Pleasant travel mood is not related to bus accessibility, and had a weak relationship with distance to subway station. In addition, residents closer to subway stations have higher levels of satisfaction and positive mood, but the results of subway travelers prove that this does not come from their cognitive judgments during travel, which indicates that some other factors may be more important.

The findings highlight the heterogeneity of relationships between travel mode, transport environment factors and subjective wellbeing and have implications for intervention strategies and policies designed to promote travel environmental and behaviour change.

Keywords: public transport accessibilty, travel mode, road connectivity, subjective well-being, subway station

2 INTRODUCTION

2.1 Subjective wellbeing

According to theories, travel wellbeing (subjective wellbeing during travel; SWT) is the subjective wellbeing of people in the process of travel. Its connotation consists of two levels: cognitive judgments and emotional feelings (Diener, Ed., 1984). Cognitive level includes not only the satisfaction evaluation of people's overall behaviour (for example, travel satisfaction), but also the satisfaction evaluation of one aspect of self-travel behaviour, such as travel mode, travel time and travel distance. At the emotional level, people can also feel and explain their own emotional changes as a whole, for example, whether the current travel is an overall positive or negative emotion, and can also measure a specific aspect of travel. Emotional feelings, for example, are whether the commuting mood is happy, nervous, or stress-sensitive overall. There are many relevant studies on SWT, and the research has been on both levels which is identified as Generalized Wellbeing during Travel (Zhu J, et al., 2018). However, the research on SWT in China confounds the two levels. The number of studies is small, lacking in empirical studies based on the actual situation in China.

Especially in most studies of the impact of travel wellbeing, there is no research that directly links to generalised wellbeing during travel. Research on positive psychology suggests we need to consider both cognitive and emotional aspects (Kahneman and Krueger, 2006; Seligman, 2002). For example, a study examining the relationship between wellbeing and urban green space found that controlling one aspect of wellbeing (life satisfaction) does not eliminate the impact of green space on another (mental suffering), and vice versa, indicating that urban green space may improve people's wellbeing by reducing negative symptoms and promoting positive outcomes through different mechanisms (White et al., 2013). These two aspects can also help understand the relationship between travel mode and wellbeing. For example, cycling to work may encourage positive emotion of commuters (known widely, these emotion are related to general sports activities; Stathopoulou et al., 2006) and enhance wellbeing by reducing mental stress, such as anxiety associated with traffic congestion.

2.2 Public transport connectivity and accessibility with subject wellbeing

Scholars have revealed the impact of traffic environment factors on travel mood. For example, urban transportation facilities have a significant impact on people's wellbeing (Wei Lin, et al., 2016; Yang Songyao, 2012; Ou Yanqin, 2016; Zhao Linna, et al., 2014): the accessibility of public transport systems is negatively correlated with mental distress of bus commuters (Chng, S, et al., 2016). The better the bus accessibility, the better the positive sentiment of bus travelers. Yubing Xiong's analysis provided valuable policy implications (Xiong, Y., et al., 2014). It is revealed that people who choose to live closer to public railway statiosn and bus stops tend to have pleasant affections in each life domain. In addition, the number of highways during commuting will also affect travel mood (Novaco, R. W., et al., 1990). The accessibility of transportation facilities, land use and road layout will also affect travel satisfaction and experience (Yang Songyao, 2012; Ou Yanqin, 2016; Cao, J., 2013; Ettema, D., et al., 2011). However, existing research does not establish a link between transport environment factors around a particular community and travel wellbeing.

Road connectivity and public transport accessibility are not likely to directly affect wellbeing, but through travel mood (Ye R., 2016). It is clear that travel patterns are directly related to travel (or commute) wellbeing, both at the level of self-judgment and at the emotional level. However, little research has been done to explain the impact of travel mode on SWB through road connectivity and public transport accessibility (Bergstad, C. J., et al., 2011; Eriksson, L., et al., 2013; Vos, J. D., et al., 2015; De Vos, J., et al., 2016; Ettema, D., et al., 2011; Olsson, L. E., et al., 2013). In summary, traffic environment factors are likely to affect both the travel mode and SWB, but the current studies have not distinguished the impact mechanism in detail. Here, the fine multi-dimensional data from several specific communities makes sense.

This study attempts to identify the following key issues at the community scale:

(1) What is the relationship between road connectivity, public transport accessibility stations around subway stations and SWT of travelers?

(2) Are the cognitive and emotional aspects of SWT affected together or are they affected independently?

(3) Do residents who live closer to subway stations feel happier during travel?

We controlled demographic and socioeconomic factors, as well as travel characteristics such as travel time which are likely to influence travel wellbeing.

3 METHODS

3.1 Data source and sample

The sample was taken from a random survey of travelers in the communities around five major subway stations in Harbin. In recent years, the rapid growth of cars in Harbin has caused a series of problems such as severe congestion. Harbin Metro Line 1 crosses the Outer District and Nangang District, and passes through important city nodes such as the Museum, the First Hospital of Medicine, the Second Hospital of Medical University and the South Railway Station of Harbin. At the same time, the nodes that undertake the functions of urban traffic evacuation are connected in series. In the future, the development of Harbin Metro will be a major focus for solving the congestion in Harbin. At present, only several stations of Line 1 and Line 3 are in service. Considering the study purpose and these conditions, we selected five subway stations in the main urban area of Harbin. Thay are Xuefu Road Station, Museum Station, Hexing Road Station, Birch Street Station and Medical University Second Hospital Station to include commercial, residential, public and mixed subway stations.

Type of subway station	Name
Residential	Birch Street Station, Hexing Road Station
Commercial	Museum Station
Public	Medical University Second Hospital Station
Mixed	Xuefu Road Station

Table 1: Information of the five subway stations

The proportion of cycle trips in Harbin is relatively low. There is a lot of rain and snow in winter and the cold weather last a long time in one year. This it is not suitable for long-term outdoor travel. Because of this, the pedestrian impact radius of Harbin TOD is within 5-minute walk, about 800m; thus the research scale is within 800m around the subway station. The study used a sample survey of 400 respondents in the surrounding areas of the stations, excluding long-distance travel beyond community scales. 352 valid questionnaires were analysed.

3.2 Measures

Traveling wellbeing was measured using the most commonly-used scale of travel wellbeing: Satisfaction with Travel Scale (STS) proposed by Ettema et al. (2011). Although it can be literally translated into the Travel Satisfaction Scale, the scale includes both cognitive and emotional aspects (Eriksson, L., et al., 2013; De Vos, J., et al., 2016), which is identified as Generalized Wellbeing Scale with an assignment of -4 to +4, as shown in table 1 [2]. The STS subscales (cognitive judgment, positive emotional activation and positive emotional deactivation) are obtained by averaging across the rating scales. It is also seen in the table that the correlations are substantial between positive activation and positive deactivation. The two subscales were therefore averaged as emotional feelings and submitted to further analyses.

Cognitive judgment
This trip is the worst (-4) - better than I thought (4)
The quality of this trip is very low (-4) - the quality of this trip is very high (4)
Traveling is very smooth (-4) - travel is not smooth (4)
Emotional feelings
Positive emotional termination - negative emotional activation
A sense of pressure (-4) - very calm (4)
Have a sense of time urgency (-4) - very relaxed (4)
Worried that you can't arrive on time (-4) - be sure you can arrive on time (4)
Positive emotional activation - negative emotional termination
Tiredness (-4) - alertness (4)
Bored (-4) - full of enthusiasm and vitality (4)
Can't bear it (-4) - enjoy the process very much (4)

Table 2: Satisfaction with Travel Scale (STS, including cognitive judgment and emotional feelings) by Ettema et al.(2011)

Travel mood was assessed using responses to the question "How did you get to your destination?" Responses were categorised as either by a) private car b) cycle c) bus d) commuter car e) taxi f) walk and g) subway. Combination of modes (1.72%) were excluded due to small sample sizes.

Road network density can reflect road connectivity by calculating road network density within a certain range around subway stations. Road network density in this study refers to the length of all roads including the branch road in the 800m buffer centre centered on the subway station. The calculation formula for road network density is:

$$Roadden=l/s$$

In the formula, l - the total length of all roads within 800m of the subway station; s - total area. Many studies have used distance to the nearest bus site as a variable of bus accessibility. These scholars believe that distance to the bus sites can directly reflect the convenience of residents of public transport and their travel mode choice. Different from developed countries, the Chinese are quite dependent on public transportation, and the distribution of bus stations is relatively dense. It was found that the distance to the nearest bus station is no more than 500 meters, so this measurement method does not reflect the difference needed. We selected the bus line number within the investigation scope as the indicator. In addition, the number of subway stations is relatively low in Harbin, so distance to the subway station was selected as an indicator when measuring subway accessibility.

Confounding variables that affect travel wellbeing were also recorded as covariates. Travel characteristics such as travel time was asked and responses were categorised as either: a) 5-10 minutes (ref) b) 20-30 minutes c) 30 minutes - 1 hour d) 1-2 hours and e) 2 hours or more. The responses for travel purpose were categorised as either: a) commuting (ref) b) going to school c) living shopping d) dining and leisure e) picking up children f) visiting relatives and friends g) scenic tour. The traffic congestion was operationalised using Baidu Real-time Road, and scored from -2 to +2. Population density is obtained from the local neighbourhood committee. In addition, gender (ref = male), age (ref = 15-29), household income (ref = 5,000 yuan), education level (ref = primary level), whether the family has children (ref = yes), whether there is a driver's license (ref = No driver's license), the number of cars and cycles and the health condition were also used as control variables. Health condition was obtained by respondets' self-assessment: “Please give your overall health level”, score from -4 to +4.

3.3 Statistical analysis

The cognitive and emotional aspects of travel wellbeing are all scoring items. Previous studies have shown that wellbeing can be considered as a continuous variable (Ferrer-i-Carbonell and Frijters, 2004). Multiple linear regression was used to investigate the relationship between SWB and the traffic environment factors on both cognitive and emotional levels. Here four models were tested at each level. The first model (unadjusted) only included road connectivity (measured by road network density) and public transport accessibility (measured by bus line number and distance to subway station). A second model (Travel mode adjusted) incorporated travel mode (ref = cycle). A third (fully-adjusted) model added variables that affect SWB. A fourth (SWB-controlled) model added the negative wellbeing measure to the positive wellbeing model and vice-versa. Any effect remaining significant once the second wellbeing measure was added indicates independent effects on the positive versus negative aspects of wellbeing, suggesting that both measures tap into different facets of wellbeing.

Next, we focused on travel mode specifically. First we used multivariate logistic regression to explore whether residents living in neighbourhoods with better road connectivity and public transport are more likely to choose public transport. Then we explored whether travelers closer to the subway would experience greater wellbeing if choosing subway.

4 RESULTS

Among the respondents, 52.7% were men, 47.3% were women. Public transport was the most common travel mode with 10.9% from subway and 38.8% were bus. Respondents aged 45 to 59 reported the highest overall happiness, and about 22.5% live in communities with high road connectivity, and about 12.5% live in areas with high public transport accessibility.

4.1 The relationship between road connectivity, public transport accessibility and wellbeing

The results of multiple linear regression are shown in Table 3. All models satisfied the following conditions: The scatter plots of partial regression, student-modified residuals and predicted values showed that there was a linear relationship between independent variables and dependent variables. Model I and V incorporated into road network density, bus line number and distance to the subway into the regressions to establish a relationship with cognitive level and emotional level respectively (only the final selected adjusted R2 model was shown). It was found that all these three factors in model I were retained with significant regression coefficients, suggesting that road network density (B=0.131, p=0.023), bus line number (B=0.051, p=0.011) and distance to subway station (B=0.199, p=0.040) all affected travel satisfaction and the impact of bus line number and distance to subway station were relatively weak. Model V only retained road network density, but the P-value was 0.116, indicating that the inclusion of road connectivity and public transport accessibility alone had no significant impact on travel emotion.

Model II and VI included travel mode (F-values were 3.396 and 3.010, respectively), and the model interpretation capacity increased and made sense (adjusted R2 increased by 0.300), with 59.22% coming from travel mode however, not traffic conditions, indicating that travel mode affects travel satisfaction a lot. Only the distance to the subway station still has a significant weak impact, indicating that travelers' satisfaction with subway was not likely to be derived from the subway itself. Compared with cycling, subway (B=0.310, p=0.009), walking (B=0.215, p=0.023), driving (B=0.210, p=0.001) and bus (B=0.201, p=0.004) travelers experienced higher travel satisfaction. No significant differences between walking, car and bus were reported. In the fully-adjusted model, only driving satisfaction increased significantly, because the travelers were largely affected by congestion. When Model IV incorporated emotional feelings, walkers continued to report higher satisfaction than cycling travelers, and also higher than car users, demonstrating that walking provided better conditions for health benefits.

Model VI incorporating travel mode and road network density reported positive correlation with travel mood. But the interpretation capacity decreased after incorporating other confounding variables, indicating that road connectivity had greater correlation with travel mode. Model VIII showed that road connectivity and subway accessibility were weakly related with travel mood. Bus line number and road network density were not associated with significant differences emotional feelings scores in any STS-Emotional feelings model. Distance to subway was, however, negatively associated with STS-Emotional feelings in both the fully-adjusted and life satisfaction-controlled models. In addition, subway accessibility was negatively correlated with travel emotion, which proved that individuals with good subway accessibility reported fewer symptoms of mental distress than individuals with poor one.

	STS-Cognitive judgments（higher score = higher satisfaction）			
	I	II: TM	III: Fully	IV: EF
	Unadjusted	Adjusted	Adjusted	Controlled
Travel mode				
Cycle		0	0	0
Car		.210*/.023	.334**/.010	.111**/.540
Public transport				
Bus		.201*/.041	-.142/.210	.170/.336
Subway		.310*/.100	.011/.099	.039/.600
Active transport				
Walk		.215**/.088	.130*/.010	.134*/.003
Density				
Close to moderate	0	0	0	0
High to very high	.131*/0.310	-.131/0.002	.140/0.028	.141/.110
Bus line number				
Few to moderate	0	0	0	0
Many to rich	.0100*/0.382	-.086/0.280	.061/0.280	.001/.050
Distance to subway station				
Close to moderate	0	0	0	0
Far to very far away	-.099*/0.410	-.140*/0.430	-.050**/0.020	-.081/.030
N	382	382	380	380
	STS-Emotional feelings（higher score = better wellbeing）			
	V	VI: TM	VII: Fully	VIII:CJ
	Unadjusted	Adjusted	Adjusted	Controlled
Travel mode				
Cycle		0	0	0
Car		.002/.400	.002/.397	.001/.810
Public transport				
Bus		.615/.277	.041/.320	.080/.071
Subway		-.141/.333	.120/.033	.140/.069
Active transport				
Walk		.370/.503	-.011/.473	.171/.105
Density				
Close to moderate		0	0	0
High to very high	-.468/.023	.129/.610	.104**/.010	.070/.810
Bus line number				
Few to moderate		0	0	0
Many to rich	0.001/0.269	0.265/0.852	.010/.280	.131/.050
Distance to subway station				
Close to moderate		0	0	0
Far to very far away	-.032/.970	.001/.070	-.020*/.224	-.021*/.159
N	382	382	380	380

Table 3: Results of linear regression models investigating the association between road connectivity, public transport accessibility, travel modes and SWB. Values are Standardized Coefficient/SE. Notes: (*) Indicates statistical significance of the p<0.05 level. (**) Indicates the statistical significance of the p<0.01 level. (a) Fully-adjusted models controlled for travel time, travel purposes, traffic congestion, population density, education level, ownership of cars, health condition, age, gender and household income. (b) The change in n is due to missing values in the following variables: commute time, location relative to the congestion zone, and education level. (c) The models controlled for the other of travel wellbeing (Emotional feelings or Cognitive judgments). (d) Travel mode. (e) Emotional feelings. (f) Cognitive judgments. (g) The change in n is due to the lack of values in the additional welfare variable.

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Overall, road connectivity and public transport accessibility were all related to travel satisfaction, with residents with better road connectivity reporting higher travel satisfaction and reporting more positive emotion. Better subway accessibility was associated with more positive feelings during travel.

4.2 Predicting travel mode with road connectivity and public transport accessibility

Multivariate logistic regression explored the relationship between road connectivity, public transport accessibility and travel mode. Due to more classification of travel modes and model fitting a large error occurred. When the model was re-corrected, the travel modes were divided into three categories, namely, non-motorized travel, public transport, and car travel. In addition, travel mode is a virtual variable. Therefore, when constructing the multivariate logistic model, the last travel mode, namely car travel, is selected as the reference group. Two new regression models were constructed and the influence of transport environment factors on the choice of car and non-motorized vehicle analysed.

	B	Std. Error	Wald	Df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
							Lower Bound	Upper Bound
Constant	-32.858	42.558	1.655	1	.184			
Bus line number	1.034	.987	.163	1	.644	1.044	.556	1.224
Road network density	**3.319**	**1.021**	**2.177**	**1**	**.012**	**27.566**	**.693**	**46.610**
Distance to subway station	.119	1.288	.744	1	.388	4.312	.445	40.001
Family income	-1.146	.652	8.363	1	.003	.112	.035	.701
Population density	.768	.227	2.453	1	.101	.559	.563	5.553
Children number	-3.016	.598	9.296	1	.001	.775	.012	.334
Car number	-6.618	.778	17.040	1	.004	.004	.009	.041
Cycle number	1.990	1.254	3.548	1	.092	.510	.024	2.001
License	.624	1.330	.242	1	.825	2.221	.136	24.550
Travel purpose1	-6.032	2.124	8.068	1	.005	.002	.000	.154
Travel purpose2	-5.379	2.237	5.781	1	.016	.005	.000	.370
Travel purpose3	-3.139	2.527	1.543	1	.214	.043	.000	6.138
Travel purpose4	-6.032	2.378	8.068	1	.042	.003	.000	.154
Travel purpose5	-5.379	2.564	5.781	1	.010	.004	.001	.629
Travel purpose6	-3.139	3.115	1.543	1	.311	.334	.002	66.612
Travel purpose7	-3.139	3.15	1.543	1	.189	.450	.171	12.578
Gender	-.205	1.334	.084	1	.028	.334	.034	4.556
Age	1.144	.475	1.827	1	.178	2.458	.125	15.996
Health status	1.338	1.664	1.036	1	.033	5.000	.444	35.441
Education	-.881	.456	.390	1	.624	3.445	.122	2.556
Subway	-2.456	4.558	4.171	1	.037	.458	.033	.779
Bus	.335	3.556	.008	1	.856	.589	.010	23.445
Cycle	2.775	2.564	2.321	1	.224	4.556	.112	31.010
Walk	2.112	1.995	3.102	1	.055	10.445	.112	19.445
Car	1.214	3.112	1.270	1	.310	6.889	.018	18.553
Travel time²	-.332	.034	29.721	1	.001	.573	.004	.779
Time orientation=0	-9.832	3.145	.025	1	.448	.000	.000	—
Demand orientation=0	-1.034	3.456	.012	1	.826	.000	.000	—

Table 4: Results of logistic regression models investigating the association between road connectivity, public transport accessibility and travel mode.(with choice of car and non-motorized vehicle compared)

The models indicated that when comparing the possibility of car and non-motorised travel, travelers' travel modes were significantly associated with road network density. When comparing the possibility of public transport and car travel, travelers' travel modes were significantly related to bus line number and road network density and the influence of road network density was greater, with a significant negative impact. The Exp (B) indicator is 1.127, that is, compared to car travelers, for every unit of increase in road network density, the number of people traveling on public transport will increase (with other variables controlled).

In terms of transport public accessibility, bus line number had a significant impact on travel mode. Bus line number had a positive impact and the Exp (B) indicator was 1.200, showing that compared with car travel, each additional standard unit of the bus line around subway stations increased the likelihood of choosing public transport. In addition, more bus lines help radiate to a larger area, which increases the accessibility of residents' travel destinations, thus prompting them to choose public transport more. The results were also supported by the return visits to the residents: about 63% of the respondents in communities with high road network density (> 10.000) chose bus over walking and cycling.

	B	Std. Error	Wald	Df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	Upper Bound
Constant	30.225	19.365	2.002	1	.154			
Bus line number	**3.134**	**.005**	**8.224**	**1**	**.003**	**1.200**	**1.060**	**1.363**
Road network density	**-2.650**	**.777**	**5.445**	**1**	**.015**	**1.127**	**.034**	**.849**
Distance to subway station	-.720	1.176	.375	1	.560	.487	.049	4.878
Family income	-.708	.276	6.610	1	.010	.492	.287	.845
Population density	.406	.409	.990	1	.286	1.502	.674	3.344
Children number	-1.721	.634	7.371	1	.004	.179	.052	.620
Car number	-7.036	1.468	22.966	1	.001	.001	.000	.016
Cycle number	-1.742	.671	6.736	1	.001	.175	.047	.653
License	2.399	.980	5.987	1	.010	11.011	1.612	45.220
Travel purpose1	-4.592	1.951	5.542	1	.010	.010	.000	.464
Travel purpose2	-4.181	2.074	4.065	1	.007	.015	.000	.890
Travel purpose3	-1.189	2.181	.297	1	.420	.304	.004	21.874
Travel purpose4	-2.338	1.793	1.701	1	.402	.097	.003	3.240
Travel purpose5	-1.323	2.289	.334	1	.475	.266	.003	23.662
Travel purpose6	.371	1.137	.106	1	.852	1.449	.156	13.456
Travel purpose7	-1.550	1.018	2.318	1	.128	.212	.029	1.561
Gender	-3.600	.458	15.885	1	.444	.073	.009	.420
Age	-.405	.996	.445	1	.345	.614	.445	3.112
Health status	-.444	2.445	.631	1	.465	.558	.088	3.442
Education	-.711	.535	5.669	1	.008	.454	.253	.346
Subway	-6.771	1.225	9.885	1	.023	.524	.005	.781
Bus	-3.556	2.389	10.455	1	.010	.005	.001	.333
Cycle	2.001	2.458	.225	1	.611	2.738	.078	11.456
Walk	2.600	1.224	3.44	1	.107	13.584	.500	28.113
Car	2.776	1.983	.342	1	.560	2.791	.088	6.459
Travel time^2	.556	.003	11.575	1	.000	.967	.489	3.785
Time orientation=0	11.442	2.987	11.445	1	.001	31.264	45.4	78.965
Demand orientation=0	-2.003	1.225	2.649	1	.100	.135	.778	1.546

Table 5: Results of logistic regression models investigating the association between road connectivity, public transport accessibility and travel mode.(with car and public transport compared)

	STS-Cognitive judgments（higher score = higher satisfaction）			
	All public transport		Subway	
	I: Fully	II:EF	III: Fully	IV: CJ
	Adjusted	controlled	Adjusted	controlled
Travel mode				
Commute bus	0	0		
Bus	.340**/.116	.152/.550		
Subway	.256/.225	.220/.036	.200/.099	.331/.589
Distance to subway station				
Close to moderate	0	0	0	0
Far to very far away	-.321*/.008	.230/0.072	.201**/.040	.170/.080
N	382	380	382	380
	STS-Emotional reactions（higher score = better wellbeing）			
	All public transport		Subway	
	I: Fully	II:EF-	III: Fully	IV: CJ
	Adjusted	controlled	Adjusted	controlled
Travel mode				
Commute bus	0	0		
Bus	.120/.051	-.022/.651		
Subway	.290*/.225	.271/.044	-.179*/.032	-.032/.309
Distance to subway station				
Close to moderate	0	0	0	0
Far to very far away	-.071**/.008	.230/0.072	-.121*/.040	-.125*/.080
N	382	380	382	380

Table 6: Results of logistic regression models investigating the association between road connectivity, public transport accessibility and travel mode. (with car and public transport compared)

4.3 Wellbeing among subway travellers

Did residents who choose to live in areas closer to subway stations report higher level of happiness? Analyses were run for all public transport travelers (ref = commute car) and also subway separately and are presented in Table 6. Here we focus only on fully-adjusted and wellbeing-controlled results. When

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considering all public transport travelers, those who live at a short distance to subway stations reported higher travel satisfaction ($B = 0.321$, $p < 0.01$) and more positive travel emotion ($B = 0.071$, $p < 0.01$). Adding the alternative wellbeing measure to these models rendered both effects non-significant, suggesting that the influence of accessibility on wellbeing may be operating through the general or shared variance assessed by both wellbeing measures. In the fully-adjusted individual transport mode models, similar as results above, distance to the subway station was associated with higher satisfaction ($B=0.201$, $p < 0.01$) and better mood ($B= -0.121$, $p < 0.05$).

In the fully-adjusted model for STS-Emotional feelings, subway travelers reported significantly higher ones than travelers in cars. This effect was not replicated in cognitive judgments models, suggesting that for subway travelers, positive travel health was related to emotion rather satisfaction. Finally, when satisfaction was added, travel mood of subway travelers with a relatively close subway station distance was almost unchanged, which almost proved the above results.

5 CONCLUSION

We explored the relationship between road connectivity, public transport accessibility, travel mode and travel wellbeing, while controlling for a range of area and individual level factors. Our use of 6 specific commute mode categories and both cognitive and emotional wellbeing measures revealed complex patterns of associations previously untested. By analysing the details of the regression, we answered the question: do residents living in neighbourhoods with better road connectivity and public transport accessibility have higher level of travel wellbeing? It turns out that the cognitive judgments and the emotional feelings need to be discussed separately because they are almost independently affected. Our findings suggest that while travel satisfaction appears to be more closely related to travel mode, emotional feelings appears more closely related to transport environment factors. This is supported by the observation that the relationship between walking and travel satisfaction remains even after controlling for travel mood, and the relationships between subway accessibility and mental distress remains for subway traveler even after controlling for satisfaction. Emotion during travel is almost not affected by travel modes. Except for the factors in this study such as travel time, travel purpose and traffic congestion, this can also be explained by factors mentioned by residents in return visits: about 1/8 of the respondents said that their travel companion and the things they did affected their travel mood.

Although cycling and walking are active, only pedestrians reported higher travel satisfaction (when controlling travel time and other confounding factors). Although shared bicycles have been slowly promoted in recent years, cycling in Harbin is still an unpleasant experience, as bike paths and bike ramps on overpasses are very scarce, and residents often have to cut in with cars when the weather is cold and are forced to stop when crossing an overpass.

For each additional unit of road network density, the number of people travelling by public transport will increase. This result is different from previous studies. Garrett's (2008) study of the North Bay city of New Zealand found that an increase in road network density around residential areas would facilitate the possibility of non-motorised commuting. Our results may be caused by the following three reasons: First, areas with high road network density in Harbin is mostly in the old region. Most of the streets have insufficient red line receding distance and walking space is small. Poor walking environment and inconvenient crossing facilities are also not conducive to walking and cycling. Secondly, old regions lack parking lot and road parking is difficult. Finally, areas with high road density have better accessibility, which alleviate excessive traffic load on some roads, making traffic flows more evenly distributed and improving the utilisation rate of the road. Thus, dense road network, to a certain extent promotes car travelling and increases travel wellbeing.

Travel mode is very important in the impact of bus accessibility and road connectivity on travel satisfaction, meaning that residents with better bus station accessibility and who have better road connectivity are likely to have higher travel satisfaction. Pleasant travel mood is not related to bus accessibility, but had a weak relationship with distance to subway station. In addition, residents closer to subway stations have higher levels of satisfaction and positive mood, but the results of subway travelers prove that this does not come from their cognitive judgments. This indicates that some other factors may be more important. For example, respondents in return visits mentioned that most of the areas where the subway was opened in Harbin have developed rapidly with convenient living facilities, which brings a sense of superiority when travelling, although they may not take the subway. The sample size of this study is limited and if conditions permit, we hope that more relevant research would use big data and small data at the same time (such as refining it to a certain group or even individuals). Big data is used to analyse the influencing effect and path of on travel wellbeing more accurately, and small data is used to prove and explain. In addition, travel mode is important, and we need to separate travel modes as much as possible in the future.

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