





Research Article

Do Residents Living in Transit-Oriented Development Station Catchment Areas Travel More Sustainably? The Impacts of Life Events

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Received 30 October 2022; Revised 6 December 2022; Accepted 18 March 2023; Published 4 April 2023

Academic Editor: Wenxiang Li

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Transit-oriented development (TOD) is an urban designed model aimed at attracting more sustainable travellers. However, not all TOD projects succeed in maintaining a high rate of sustainable travel behaviour. To examine the impacts of TOD on residents' travel behaviour, this paper applies binary logistic regression to analyse survey data for 1,298 residents living in the TOD areas in Hangzhou collected in 2020. The results show that socioeconomic characteristics, built environment factors, and travel attitudes play important roles in influencing their travel mode choices. Furthermore, the number of children in households and higher levels of car ownership significantly influence residents' sustainable travel behaviours. However, it appears that only a limited number of factors can convince car users to shift to sustainable modes of travel, such as their workplace being accessible by metro and attitudes towards changes in accessibility. This research study contributes to the existing literature in terms of enhancing the understanding of travel mode choice behaviours, particularly with regard to people who live near public transport infrastructure, as well as formulating evidence-based TOD policies to achieve more sustainable transport systems.

1. Introduction

Many governments around the world are attempting to tackle the environmental, social, and economic issues caused by widespread motorisation and the overuse of private cars via the development of sustainable transport (e.g., public transport, walking, and cycling) [1–5]. Sustainable travel behaviour, as defined by Sunio and Schmöcker [6], refers to decreased environmental, social, and economic impacts when an individual makes a travel mode choice that often

differs from that of a car. Therefore, sustainable transport development has become widely recognised as a key initiative for developing an environmentally, socially, and economically sustainable neighbourhood [7, 8]. Transit-oriented development (TOD) is an urban development strategy, aiming to maximize the space of working, residential, and other daily activities within the catchment areas of transit nodes [9]. Advocates of transit-oriented development (TOD) regard it as vital to incorporate sustainable transport development into a solution for addressing the

aforementioned issues caused by high car dependency [10–14]. Introducing TOD projects in urban areas could significantly influence the travel decisions of residents living nearby [11, 15]. Increases in sustainable transport behaviours can be attributed to the growth in the level of TOD [16, 17], but changes in travel behaviours can also occur in response to life events, such as residential relocation [18], driving licence ownership [19], and childbirth [20, 21].

As many aspects of travel behaviour are tied to day-to-day routines, life events can have a substantial impact on individuals' travel behaviour by disrupting existing routines [21–23]. Changes in travel behaviours have attracted considerable attention in the transport research field in terms of understanding why and how individuals' travel behaviours change over time during their life cycles [3, 19, 22–25]. For instance, previous studies revealed that childbirth can increase car dependency [26]. This may be explained by the reason that childbirth can increase motorised travel demand associated with child-related maintenance activities (e.g., health and education) [27, 28]. Changes in household composition and income are also found to be associated with changes in travel-related outcomes [29]. Changing jobs can also lead to daily travel pattern changes because it may change people's commuting distances and activity participation [30].

Mobility biography is an approach which maps trajectories in the mobility domain and their connections with life events [31]. Mobility biography studies are based on the idea that day-to-day travel behaviour as a routine-based activity may be events that occur during an individual's life course [3, 18–20, 32–34]. As there is a correlation between the stability of an individual's circumstances and travel behaviour, changes in travel behaviour may occur if one aspect of an individual's circumstances is disrupted (e.g., by a life event) [32, 33]. Changes in travel behaviour may be prompted by certain life events, including residential relocation events, household/family events, educational and employment events, and other broader events relating to an individual's social network. For example, childbirth, whether for the first time or not, may change household roles played by men and women, and it has been found that mothers are more likely to use private cars than fathers [7]. Studies have also suggested that educational and employment events, for example, a change in commuting distance resulting from a job change, may influence an individual's commuting travel mode preference [3, 18]. Using the data from the UK, Clark et al. [18] showed that a change of over two miles in commuting distance resulted in a higher likelihood of an individual switching from nonmotorised travel modes to travelling by car.

To date, nearly all the empirical studies in the field have focused on the practical impact of life events and life transitions on travel behaviours, i.e., changes in travel mode choices [19–21, 31, 34, 35]. For example, Scheiner and Holz-Rau [20] found that becoming a parent reduced the likelihood of choosing sustainable modes of transport, especially public transport usage. Another study conducted by Scheiner and Holz-Rau in the same year also revealed that childbirth is negatively linked to cycling [36]. However,

findings regarding the effects of childbirth on car usage are mixed, and some studies have shown a significant increase in usage [37], while other studies have found no significant changes [20, 36]. In addition, factors such as changes in monthly income, changes relating to driving licences, household structure, and distance to work are associated with changes in car ownership, which leads to a greater preference for car usage [38–40]. In addition, life events such as getting married and residential relocation also play a vital role in travel decision-making [20, 32, 41]. For example, residential relocation to a cycle-friendly neighbourhood facilitates a more positive attitude towards cycling behaviour [41]. Furthermore, moving to a more urban environment is likely to result in decreased car usage [20], as well as bringing about a significant change in people's attitudes towards nonmotorised modes of transport [18, 41], such as active travel [20].

Existing studies have demonstrated that changes in travel modes are more likely to occur in response to life events, such as childbirth, changes in income, and household structure. However, previous studies on life events and travel mode choices have produced limited insights into sustainable transport mode choices [32, 35]. In addition, studies in this field have primarily focused on specific target groups, such as the general population [3, 20, 35], residential relocators [18, 36, 41], and couples [19], without considering residents living in TOD catchment areas. The latter group should not be overlooked as they are most likely to respond directly to TOD development. Thus, it is important to track significant life events that bring about changes in their daily routines and travel mode choices to achieve higher rates of sustainable transport use within the TOD catchment areas.

Against this backdrop, this study uses data from Hangzhou, in China, to gain further insight into the determinants of sustainable travel mode choices among residents living near TOD facilities. Particular attention is paid to changes brought about by life events, with the aim of providing new insights that urban planners can use to design and implement tailored policies to achieve a higher rate of sustainable transport use within the TOD station catchment areas. This study addresses the aforementioned gaps in two main ways: (1) exploring how life events affect sustainable travel mode choices and (2) gaining insights into the sustainable travel behaviours of residents living in the TOD areas.

The remainder of this paper is organised as follows: Section 2 briefly introduces the study area and explains the data and methodology used in this study. Section 3 presents and discusses the modelling results. Finally, the key findings are highlighted, and policy implications are provided in Section 4.

2. Data and Methodology

2.1. Study Area and the Retrospective Survey. The data for this study were obtained from a retrospective survey conducted in Hangzhou, China, in July 2020. Hangzhou is the capital city of Zhejiang province and had a population of 11.936

million in 2020. Hangzhou is an ideal city to use as a case study in order to gain further insight into the relationship between TOD and sustainable travel behaviour. Hangzhou's metro network has been undergoing rapid expansion since the first line opened in 2012, and it now comprises a total of seven lines, covering a distance of 306 km and 133 stations. By 2022, eleven lines and four interurban railways would be in operation. In addition, Hangzhou is regarded as a pioneering city for the implementation of TOD, which makes it an important indicator of TOD practices in relation to China's urbanisation process more generally. Recently, a few new TOD projects have been implemented, including construction of multiple residential areas around Hangzhou's metro stations. However, it should be noted that, if residents living within the metro station catchment area do not adopt and maintain sustainable travel behaviours, the road traffic system may become flooded with cars. Thus, gaining a greater understanding of Hangzhou residents' sustainable travel behaviours is particularly important because of the implications for TOD and because it can provide crucial insights into subsequent sustainable transport development within the TOD areas.

Data collection was conducted via an online questionnaire due to the coronavirus (COVID-19) pandemic and the resultant restrictions on in-person interactions. In this research study, we define those who use the metro for daily commuting as residents living in the TOD catchment area. At the beginning of the questionnaire, we inquired the respondents whether they use metro in daily life to ensure their eligibility. For this study, we selected two TOD stations in Hangzhou, Ding'an Road Station and Qibao Station (see Figure 1). The first group of stations on Hangzhou Metro Line 1 opened in 2012. Dense residential neighbourhoods surround these two stations, and the land use is mixed. Ding'an Road Station is a regenerated TOD station that exemplifies compact development within an existing older residential district, whereas Qibao Station is a new TOD station outside of the city centre and was newly constructed.

To collect data from residents living within each of the areas studied, the online questionnaire was distributed to the local community social media groups (WeChat) via weblinks in July 2020. Respondents (aged 18 or above) were asked to complete the questionnaire by providing information about the following topics: daily travel behaviours, sociodemographics, perceptions of the built environment, travel attributes, and to recall any life events and behavioural changes dating back over the last five years (2015). A total of 1,298 valid responses were received, comprising 597 samples collected from Ding'an Road Station and 701 samples from Qibao Station, respectively. A description of the variables is provided in Tables 1 and 2.

2.2. Methodology. This study focuses on the sustainable transport mode choice behaviour of residents living within the TOD catchment areas. In this case, the choice of sustainable transport mode is binary; if travel was undertaken

by sustainable transport modes (i.e., metro, bus, cycling, or walking), it was coded as 0; if travel involved using a car or taxi, it was coded as 1. Hence, a binary logistic regression was applied in this study. The estimated equations are represented as

$$P(Y = 1|x_1, x_2, \dots, x_m) = \frac{e^{(\beta_0 + \sum \beta_i x_i)}}{1 + e^{(\beta_0 + \sum \beta_i x_i)}},$$

$$\text{logit } P(Y = 1|x_1, x_2, \dots, x_m) = \ln\left(\frac{P}{1 - P}\right)$$

$$= \beta_0 + \beta_1 x_1 + \dots + \beta_m x_m + \mathcal{E}, \quad (1)$$

where the dependent variable Y has a binary value (0 or 1), x represents the vectors of independent variables, $P(x)$ stands for the probability of $y=1$ given the value of x , β_0 is a constant, the parameters β_i ($i=1, 2, \dots, m$) are the coefficients of each x , β_i reveals the possible impact of each independent variable on the dependent variable, and \mathcal{E} is the error term.

3. Results and Discussion

3.1. Descriptive Statistics. The descriptive statistics for the two TOD sites are shown in Table 3. For this analysis, we individually summarised the questionnaire data relating to Ding'an Road Station and Qibao Station. The results show that the residents of both sites exhibited a relatively high rate of sustainable travel behaviours, particularly in the case of metro travel, for which the figures were approximately 47% for both Ding'an Road Station and Qibao Station. This proves that metro stations can attract metro users to a significant degree within the station catchment areas. However, we also found that the rate of private car use for the area around Qibao Station (a new TOD station) was 7.11% higher than that of residents living in the Ding'an Road Station catchment area. In addition, there were more households with at least one car in the Qibao Station catchment area than in the Ding'an Road Station catchment area (79.6% versus 73.4%). The higher average income and the larger number of parking spaces available at new stations such as Qibao could partly account for this difference. Cyclists' satisfaction with Qibao Station was slightly lower than expected. They complained that the commercial level of development, which is a feature of the mixed land use, creates barriers for cyclists, because they have to navigate several floors before they can get onto the road. Regarding the distance respondents had to travel to their workplaces, the data revealed that the most common distance for Ding'an Road Station residents was 1–5 km, whereas the distance was generally longer for Qibao Station residents. Finally, whether respondents had metro access to their workplaces was also shown to be a variable of a significant difference (P value = 0.003). 54.92% of Qibao Station residents' workplaces were accessible via metro, which is 8.2% higher than the figure for Ding'an Road Station residents. This finding may be partly attributable to residents' self-selection, as this has



FIGURE 1: Hangzhou's metro network.

been shown to be the case in many similar studies [12]. If an individual's workplace is sufficiently well served by public transport, it could influence their choices regarding where to live. In this case, these individuals were attracted to buy a new home close to the TOD stations.

With regard to changes in travel behaviours that occur over time, private car drivers are less likely to switch to sustainable travel modes. According to the survey (Table 3), 108 respondents within the Ding'an Road Station area used cars as their primary mode of transport in 2015; 77 still did so in 2020, representing a 71.3% retention ratio. The situation for Qibao Station residents was similar: 113 out of 165 respondents continued to use unsustainable travel modes, representing a 68.5% retention ratio. It is also worth noting that, although the rate of travel by metro increased by more than 15% in both the TOD areas (from 30% to 47.4% for Ding'an Road Station residents and from 31.2% to 46.5% for Qibao Station residents), many of the new users had transitioned from other sustainable travel modes such as buses and bicycles. Both sites experienced increased car travel over the last five years (from 18.1% to 23.5% in the Ding'an Road Station area and from 23.5% to 31.3% in the Qibao Station area). The increase in car use was more pronounced in the area around the new TOD station. In addition, 42.2% of the car driver respondents answered "I do not know" to the questions about the built environment and metro accessibility. This demonstrates that car drivers have little interest in public transport development once they get into the habit

of travelling by car. Thus, it is imperative to prevent existing sustainable travellers from switching to private vehicles in TOD areas. The associations between travel behaviours and the related variables are discussed in greater depth in Section 3.2.

Additional information about respondents' travel choices, including the main reasons for choosing to travel by private car or metro, weekend travel behaviours, the main purpose of travelling at weekends, and their opinions of public amenities around the sites, was also sought (Figure 2). The most popular reasons for choosing to travel by metro were its reliability and speed (cited by 25% of respondents). Safety, comfort, and low carbon emissions were also cited by many respondents as reasons for using metro. For private car drivers, the flexibility of private vehicles was the biggest attraction (approximately 24%); the same proportion of respondents used cars to transport their families, including doing the school run. Comfort and speed were also mentioned as important factors for using cars (approximately 13%). In addition, 12% of the respondents noted that they needed private cars for their work. With regard to differences in residents' travel behaviours at the weekends (Table 3), private car usage increased by 5% compared to weekday usage among respondents in the Ding'an Road Station area. The difference was even greater for respondents living in the Qibao Station area, where the number of car users increased by 10.1% at weekends. Shopping was identified as the main reason for travelling at weekends as

TABLE 1: Description of the variables.

Categories	Variables (in 2020)	Description
Sociodemographics	Gender	0 = female; 1 = male
	Age	In years
	Education	1 = middle school and below; 2 = secondary school; 3 = college and undergraduate; 4 = postgraduate and above
	Marital status	0 = single; 1 = married
	Monthly income	1 = ¥2,000–3,000; 2 = ¥3,001–5,000; 3 = ¥5,001–10,000; 4 = ¥10,001–15,000; 5 = ¥15,001–20,000; 6 = ¥20,000 and above
	Household size	Number of household members
	Children	0 = no; 1 = yes
	Residential tenure	0 = owner; 1 = renter
	Car ownership	Number of motor vehicles available in the household
	Driving licence	0 = no; 1 = yes
Built environment	Distance to work	1 ≤ 1.0 km; 2 = 1.1–5.0 km; 3 = 5.1–10.0 km; 4 = 10.1–20.0 km; 5 = 20.0 km and above
	Accessibility to workplace by metro	0 = not accessible; 1 = accessible
	Pleasant walking environment	0 = no; 1 = yes
	Pleasant cycling environment	0 = no; 1 = yes
Convenient access to metro stations	Site	0 = Ding'an Road Station; 1 = Qibao Station
	Travel-related attitudes	0 = preference for metro; 1 = preference for car
<i>Changes that took place between 2015 and 2020</i>	Increase in monthly income (from 2015 to 2020) ^a	Change between 2015 and 2020
	Increase in household size (from 2015 to 2020)	Change between 2015 and 2020
	Increase in the number of children (from 2015 to 2020)	Change between 2015 and 2020
	Increase in car ownership (from 2015 to 2020)	Change between 2015 and 2020
	Changes relating to driving licence (from 2015 to 2020)	0 = no change; 1 = obtained a driving licence
	Increase in distance to workplace (from 2015 to 2020)	Change between 2015 and 2020
	Changes in accessibility to workplace by metro (from 2015 to 2020)	0 = no change; 1 = new access to workplace by metro
	Changes relating to the walking environment (from 2015 to 2020)	0 = no change; 1 = improved walking environment
	Changes relating to the cycling environment (from 2015 to 2020)	0 = no change; 1 = improved cycling environment
	Changes relating to access to metro stations (from 2015 to 2020)	0 = no change; 1 = improved access to metro stations

^aWe asked respondents to answer the question in relation to the changes that occurred between 2015 and 2020. ^b¥100 = \$14.49 in 2020.

TABLE 2: Demographic characteristics of the respondents.

Variables	Category	Qibao Station (N = 695)		Ding'an Road Station (N = 581)	
		Frequency	Percent	Frequency	Percent
Gender	Male	215	30.9	205	35.3
	Female	480	69.1	376	64.7
Age	18–30	255	36.7	148	25.5
	30–45	342	49.2	147	25.3
	45+	98	14.1	286	49.2
Education	Middle school and below	65	9.4	85	14.6
	Secondary school	158	22.7	179	30.8
	College and undergraduate	431	62.0	308	53.0
	Postgraduate and above	41	5.9	9	1.5
Marriage status	Single	120	17.3	112	19.3
	Married	575	82.7	469	80.7
Income 2020	Under ¥5,000	100	14.4	304	52.3
	¥5,000–10,000	183	26.3	205	35.3
	¥10,000–15,000	269	38.7	43	7.4
	¥15,000 or more	143	20.6	29	5.0
Income 2015	Under ¥5,000	454	65.3	423	72.8
	¥5,000–10,000	180	25.9	123	21.2
	¥10,000–15,000	36	5.2	19	3.3
	¥15,000 or more	25	3.6	16	2.8

cited by respondents from both the sites (Figure 2(c)). Dining out and entertainment were also identified as popular reasons for weekend travel, while grocery shopping was more commonly cited by residents living around Ding'an Road Station as a reason for travelling by car at weekends. Although the land use around both the TOD stations is diverse, residents nonetheless claimed that many services were lacking in their respective neighbourhoods, including sufficient employment opportunities, restaurants, and shopping malls. (Figure 2(d)). One notable point was that recreation centres for older people were in demand, especially around regenerated TOD stations, while sports centres were greeted with more enthusiasm when they were located at new TOD stations. The findings confirmed that TOD projects do restrict car usage to some extent on weekdays. Promoting the use of the metro at weekends and holiday times could therefore be a key aim of sustainable transport studies.

3.2. Binary Logistic Regression Model Results

3.2.1. Travel Mode Choices. Before proceeding with the model specification, we applied the variance inflation factor (VIF) to avoid any multicollinearity issues in the final regressions. As a result, we removed car ownership and driving license status. The VIF results showed that all the remaining variables were under the value of 3.0, suggesting that there were no multicollinearity issues in our final regressions. The regression results are summarised in Table 4. Travelling by sustainable travel (metro, bus, cycling, and walking) or car (private car and taxi) were treated as the dependent variables.

Table 4 shows that gender does not have an effect on sustainable transport mode choices. When residents living in the TOD catchment areas grow older, they are more likely to

engage in and maintain sustainable travel behaviours than younger residents. This finding is consistent with those of the existing studies conducted in China [26]. Having a higher educational background increases the probability of individuals using private vehicles, which is in line with a recent study conducted by Zhang and Zhao in China [42]. However, some studies carried out in western countries produced different results; they found that highly educated people tend to prefer more sustainable transport modes [43–45]. It is likely that highly educated people in Hangzhou (and maybe more generally in most Chinese cities) are more concerned with social status and enjoy a more comfortable travel experience offered by private cars. Monthly income is another widely studied sociodemographic variable which has an impact on travel mode choices. This finding is also in line with those of other studies [46, 47]: people on higher incomes are less likely to use sustainable travel methods. This association is still significant even for residents living within the metro catchment area.

In addition, our results also show that residents who rent properties instead of owning them are more likely to use sustainable means of travel. This may be because they do not have their own parking space, or they are not allowed to own a private vehicle that has permission to enter Hangzhou city centre, due to the licensing regulations and peak-hour driving restriction policies. Some previous studies have argued that households with a larger number of family members are more likely to use public transport as the car has to be shared between more people, and couples with dependent children are also more likely to use a car [37, 47]. In our sample, however, both household size and having children under 18 were found to encourage the use of private cars. In addition, the impact of household size on travel behaviour choices was found to be more significant, regardless of whether children were present or not (P

TABLE 3: Descriptive statistics and summary test statistics (chi-squared test).

Variables	Ding'an Road Station		Qibao Station		Chi-square test <i>P</i> value
	Sample size	Percentage	Sample size	Percentage	
Residential tenure					0.000
Owner	478	80.07	488	69.61	
Renter	119	19.93	213	30.39	
Car ownership					0.000
0	159	26.63	143	20.40	
1+	438	73.37	558	79.60	
Distance to work					0.005
<1.0 km	95	15.91	71	10.13	
1.1–5.0 km	207	34.67	216	30.81	
5.1–10.0 km	163	27.30	212	30.24	
10.1–20.0 km	83	13.90	129	18.40	
20.0 km and above	49	8.21	73	10.41	
Pleasant walking environment					0.486
Yes	504	84.42	593	84.59	
No	55	9.21	76	10.84	
I do not know	38	6.37	32	4.57	
Pleasant cycling environment					0.019
Yes	506	84.75	566	80.74	
No	58	9.72	101	14.41	
I do not know	33	5.53	34	4.85	
Convenient access to metro stations					0.085
Yes	448	75.04	548	78.17	
No	128	21.44	126	17.98	
I do not know	21	3.52	27	3.85	
Weekday travel mode choice (in 2020)					0.001
Private car	133	22.28	206	29.39	
Metros	283	47.40	326	46.50	
Bus	83	13.90	65	9.27	
Cycle	66	11.06	73	10.42	
Walk	25	4.19	18	2.57	
Taxi	7	1.17	13	1.85	
Whether the workplace is accessible by metro					0.003
Yes	280	46.90	385	54.92	
No	208	34.84	224	31.96	
Walking/cycling only	83	13.90	76	10.84	
I do not know	26	4.36	16	2.28	
Weekend travel mode choice					0.000
Private car	163	27.30	277	39.52	
Metro	273	45.73	291	41.51	
Bus	71	11.89	53	7.56	
Cycle	51	8.54	51	7.28	
Walk	26	4.36	20	2.85	
Taxi	13	2.18	9	1.28	
Weekday travel mode choice (in 2015)					—
Private car	106	17.76	146	20.83	
Metros	179	29.98	219	31.24	
Bus	198	33.17	219	31.24	
Cycle	87	14.57	72	10.27	
Walk	24	4.02	28	3.99	
Taxi	3	0.50	17	2.43	

The statistically significant differences assessed by the chi-square test were defined as having a *P* value <0.05. We asked respondents to answer the question about changes in travel behaviour between 2015 and 2020.

value = 0.073). One possible explanation for this is that an increase in the number of family members reduces the per capita cost of private car use, as it is a common practice to give family members rides to work in China, and travelling together in one car instead of using public transport also provides a stronger sense of family unity and privacy.

Table 4 also illustrates how the subjective variables of perceptions of the built environment and attitudes towards travel impact residents' travel mode choices. The model demonstrated that, even for residents living in the TOD catchment areas, an increase in distance to work makes it more likely that they will travel by car, which is consistent

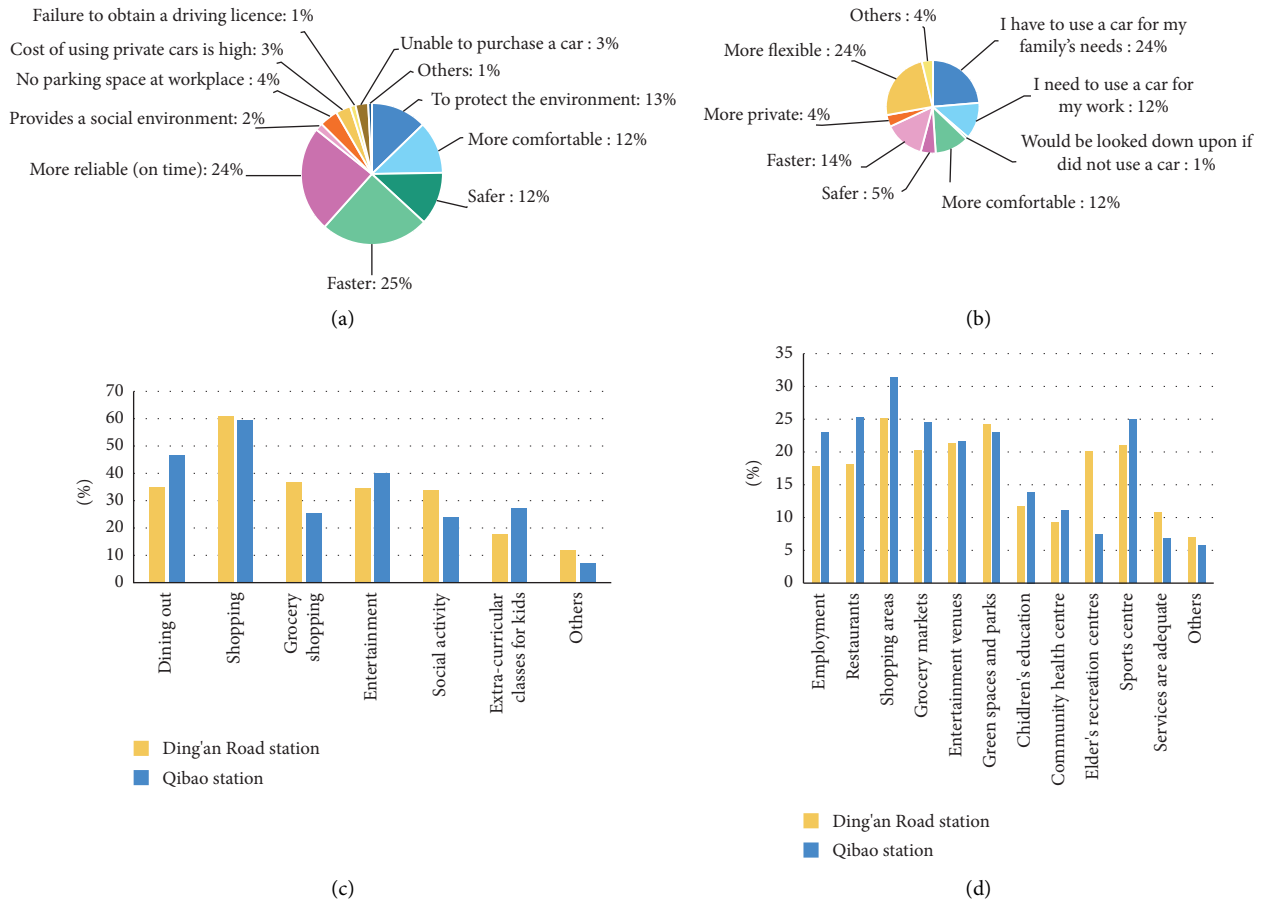


FIGURE 2: Additional travel information chart: (a) reasons for using metro, (b) reasons for using cars, (c) travel purposes at weekends, and (d) lack of services.

TABLE 4: Logistic regression analysis results regarding the travel choices of residents living in TOD catchment areas.

Independent variables	Coeff	S.E.	Sig.
Constant	-2.537***	0.600	0.000
Sociodemographics			
Gender	0.270	0.161	0.093
Age	-0.248***	0.059	0.000
Education	0.268**	0.124	0.031
Marital status	0.181	0.276	0.512
Monthly income	0.231***	0.068	0.001
Household size	0.169***	0.063	0.008
Children	0.432*	0.240	0.073
Residential tenure	-0.758***	0.198	0.000
Built environment			
Distance to work	0.195***	0.066	0.003
Accessibility to the workplace by metro	-1.073***	0.157	0.000
Pleasant walking environment	0.156	0.268	0.561
Pleasant cycling environment	-0.136	0.247	0.581
Convenient access to metro stations	-0.649***	0.179	0.000
Site	0.001	0.161	0.996
Attitudes			
	1.825***	0.247	0.000
Model fit			
Nagelkerke's R^2	0.311		

Note. * $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$.

TABLE 5: Logistic regression analysis results related to changes in sustainable transport users' travel behaviour.

Independent variables	Coeff	S.E.	Sig.
Constant	-1.233***	0.431	0.004
Variables entered			
Age	-0.314***	0.069	0.000
Monthly incomes	0.273***	0.081	0.001
Residential tenure	-0.820***	0.233	0.000
Accessibility to the workplace by metro	-1.157***	0.211	0.000
Convenient access to metro stations	-0.508**	0.226	0.024
Attitudes towards travel	1.599***	0.302	0.000
Increase in the number of children (computed)	0.417***	0.158	0.009
Car ownership increase (computed)	0.810***	0.171	0.000
Model fit			
Nagelkerke's R^2	0.306		

Note. * $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$.

with findings for other cities [48, 49]. The results showed that, when individuals' workplaces are better connected to the metro network, they are more likely to use sustainable methods of transport instead of private vehicles. Regarding their views about the local built environment, the quality of the walking and cycling environment had a less impact on the travel mode choices of residents living in the TOD catchment areas. However, better access to metro stations significantly increased the likelihood of individuals choosing to travel by sustainable transport modes; it follows that good accessibility to metro stations offers more opportunities to use metro, and travelling by metro is tied to first/last mile trips involving walking/cycling to and from metro stations [50, 51]. Thus, policymakers could consider redesigning the internal pathways and neighbourhood entrances to improve the use of sustainable transport modes within the station catchment area. Regarding attitudes towards travel, a preference for metro significantly increased the likelihood of residents in the TOD catchment areas choosing sustainable transport modes, a finding which is also in line with those of previous studies [48, 49].

3.2.2. Travel Behaviour Changes. Two additional binary logistic regression models were employed to capture the determinants of changes in residents' travel behaviour relating to their daily routines (during the period from 2015 to 2020). The independent variables were augmented, including the existing descriptive variables used in the travel choice model and the computed variables which were used to measure internal and external changes that took place between 2015 and 2020, such as an increase in the monthly income and an increase in the number of children in a household. Thus, it is difficult to manually delete unnecessary factors in order to avoid the problem of underlying multicollinearity between each variable. We applied a forward selection (likelihood ratio) approach to data entry, that is, a stepwise selection method, in which entry testing is based on the significance of the score statistic and deletion testing is based on the probability of the likelihood-ratio statistic.

The results of the analysis of changes in residents' travel behaviour relating to their use of sustainable transport modes are shown in Table 5. We originally considered

twenty independent variables in the initial model but reduced these to eight variables in the final model after applying the forward selection. The results show that residents living in the TOD station catchment areas are less likely to switch from using sustainable transport modes to private cars as they age. This is probably because older generations are less willing to make changes in their lifestyles than their younger counterparts. Earning a higher income could make it more likely that people will switch from using sustainable modes of travel to private cars. People on higher incomes often seem to prefer more comfortable travel experience and greater flexibility offered by a car.

The results displayed in Table 5 show that renters, including residents whose workplaces have good links to metro stations, are less likely to change their sustainable travel behaviours. Similarly, if metro stations have a high level of accessibility, this could serve to prevent sustainable travellers from switching to unsustainable modes of transport [51]. Furthermore, having a positive attitude towards metro encourages residents living in the TOD catchment areas to maintain sustainable travel behaviours [52]. Regarding the effect of life events, it was found that childbirth significantly increases the likelihood of an individual switching from sustainable transport modes to car travel, echoing the findings of previous studies [1, 36, 37]. A possible explanation is that newborn children may bring about child-related maintenance activities, such as regular healthcare and playgroups. Many parents believe that the private car is a good solution for the travel needs of child-related activities. The presence of newborn children in a household may make parents more time constrained. Therefore, they may consider a car necessary to reduce the time spent commuting and access multiple destinations for their children's needs during one trip. We also found that if a household owns more than one car, this has a negative effect on sustainable transport mode usage, which aligns with a previous study by Scheiner and Holz-Rau [36]. In China, it is a common practice for an individual to buy a car at some point in their life as a signifier of their high quality of life and social status. This increases their interest in and desire to buy and use a car, which may lead them to abandon sustainable forms of travel.

TABLE 6: Logistic regression analysis results related to changes in private car users' travel behaviour.

Independent variables	Coeff	S.E.	Sig.
Constant	-1.633***	0.246	0.000
Variables entered			
Workplace is accessible by metro	1.625***	0.305	0.000
Attitudes towards travel	-1.793***	0.521	0.001
Changes in accessibility to metro stations (computed)	1.155***	0.350	0.001
Model fit			
Nagelkerke's R^2	0.278		

Note. * $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$.

Table 6 shows that, although the same twenty independent variables were initially considered in relation to changes in private car users' travel behaviour, only three of them were retained after the forward selection. Thus, it can be concluded that only a few factors can encourage car users to give up their car travel habits and adopt more sustainable modes of transport. In contrast to the results obtained from the model assessing sustainable transport users' behaviour, whether an individual's workplace is accessible by metro and having a preference for metro travel were both found to have a significant effect on reducing car users' intention to continue using unsustainable transport. Another valuable finding is that improving accessibility to metro stations has a significant effect on attracting car users to switch to sustainable modes of transport. This is perhaps unsurprising as it follows that, if travelling by metro is made more convenient and comfortable, it will improve the quality of the overall travel experience and thus increase the likelihood that car users will want to use this sustainable form of transport.

4. Conclusions

Using the data about residents in Hangzhou, we ran a series of logistic regressions to analyse how the sustainable transport mode choices of residents living in the TOD catchment areas are affected by significant life events. We also assessed the probability of individuals switching from sustainable modes of transport to cars and vice versa over time. This study extends the existing literature by providing new insights into the relationships between life events and travel behaviours among residents living in the TOD catchment areas.

The results demonstrated that new TOD stations are generally seen as more attractive to younger people. It was also found that if new TOD projects contain commercial areas, which are a feature of their mixed land use, this could create barriers for cyclists, so it is therefore recommended that a more comprehensive cycling network should be constructed when designing future TOD projects [53]. It was shown that private car drivers living close to the TOD stations are less likely to change their travel behaviours and switch to more sustainable travel modes as evidenced by the mode retention ratio of approximately 70%. The increased number of metro users in Hangzhou is largely comprised of individuals who had previously used other sustainable transport modes. Car drivers were least likely to be interested

in any public transport development once they get into the habit of travelling by car.

Moreover, this study revealed that age, monthly incomes, residential tenure, whether an individual's workplace is accessible by metro, convenient access to metro stations, attitudes towards travel, car ownership, and the number of children in a household are all factors that influence sustainable travel behaviours. The findings imply that only a high level of accessibility to metro stations could prevent sustainable travellers from turning to unsustainable modes of travel, and making minor improvements to accessibility may not be enough for this trend. The presence of newborn children in a household could result in parents deciding to reduce their commuting time and increase the need for a car so that they can access multiple destinations during one trip. Our research study shows that there are only a few factors that could encourage car users to give up driving and switch to more sustainable transport modes, working somewhere that is accessible by metro, changing attitudes towards travel, and making metro stations more accessible.

Our findings may help provide insights that could be used to inform policies designed to encourage sustainable travel behaviours. Local governments should provide more rental housing around metro connections as renters are more likely to use metro services. In addition, our study showed evidence that residents living in the TOD catchment areas are more concerned with the accessibility of metro stations. Providing better access to metro stations would have a threefold positive effect, encouraging sustainable travel mode choices, promoting and maintaining sustainable travel habits, and prompting residents to switch from car travel to more sustainable modes of travel. Thus, policy-makers and planners should focus on improving the accessibility of metro stations. For example, regular upgrades can be implemented to improve the accessibility of metro stations, such as redesigning internal pathways and neighbourhood entrances. Moreover, public transit agencies, along with shared mobility operators, can increase the density of shared mobility services within the metro catchment areas [54]. Also, building a mobility-as-a-service platform may promote metro use, on which intermodal travel plans and fare concessions related to metro-integrated usage can be accessed.

However, our study has several limitations which should be addressed in future research studies. First, we considered only the subjective aspects of the built environment but overlooked its objective characteristics, despite these playing

a part in influencing travel behaviours (e.g., density and land use mixture) [55–57]. Second, this study did not control for the effects of residential relocation on changes in travel behaviours. Future research studies could extend this study by exploring the relationship between residential relocation and changes in sustainable travel behaviours [31, 47, 58]. Third, it appears that there may be a causal association between life events and changes in travel behaviour [23, 59–61]. Therefore, future studies could explore a causal association between life events and changes in travel behaviour. Fourth, the COVID-19 impacts on residents' travel behaviours are not discussed in this research study. Although the pandemic was contained in China at that time (July 2020), it still had a certain impact on residents' travel behaviours. Thus, the COVID-19 impacts should be further analysed in future research studies.

Data Availability

The data used to support the findings of the study can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This research was funded by the Research Foundation-Flanders (FWO) (Grant no. 1257022N) and the Fundamental Research Funds for the Central Universities.

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