Transportation Research Part D 77 (2019) 243–251

Contents lists available at ScienceDirect

Transportation Research Part D

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

Longitudinal changes in transport-related and recreational walking: The role of life events

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ARTICLE INFO

Keywords:
Longitudinal data
Walking
Residential relocation
Life event
The Netherlands

ABSTRACT

Walking is a common form of physical activity and has a considerable impact on public health. Walking behavior may change over time due to life events, including residential relocation. Only a few studies based on longitudinal data have examined the impacts of life events on walking behavior. The present study investigated the extent to which life events lead to changes in transport-related and recreational walking duration, by analyzing longitudinal panel data from the Netherlands Mobility Panel (MPN) for the years 2013 and 2015. In total, 1185 respondents aged 18 or older who completed both survey waves were included in our sample. Multilevel mixed-effects Tobit regression models were fitted and showed that both childbirth and relocation to less urbanized areas were related to an increase in transport-related walking over time. No significant associations of life events with recreational walking were observed. Findings suggest that transport-related walking is more likely to be influenced by changes in the household composition and residential relocation than recreational walking. Further longitudinal research is needed to verify our findings and gain insight into the mechanisms underlying these relationships.

1. Introduction

Walking is considered one of several forms of physical activity (Bentley et al., 2018; Christian et al., 2017). A change in travel behavior toward walking is beneficial for population health (Scheiner and Holz-Rau, 2013b) as well as the environment, given that walking is carbon-neutral and a nonpolluting travel mode (Sallis et al., 2016). Increases in walking behavior can be promoted by specific interventions (e.g., the creation of walking groups in residential neighborhoods or improvements in walking infrastructure) (Bentley et al., 2018; Giles-Corti et al., 2013; Knuiman et al., 2014), but changes may also occur as a response to life events, such as childbirth (Lanzendorf, 2010).

Since many aspects of travel behavior are largely habitual until daily events or changes in living conditions disrupt the routine, life events may have a substantial effect on people's travel (Bamberg et al., 2003; Schäfer et al., 2012; Scheiner and Holz-Rau, 2013a; Zhang, 2017). This thinking, which is rooted in the mobility biography framework, addresses temporal stability and changes in people's travel behavior by acknowledging their routines (Müggenburg et al., 2015; Scheiner, 2007). Two main elements characterize

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https://doi.org/10.1016/j.trd.2019.11.006

Available online 14 November 2019

travel behavior from a longer term perspective: (1) People's routine travel behavior over time, until something disrupts the routine, and (2) key events that trigger a reconsideration of an individual's behavior, probably resulting in behavior change, probably resulting in behavior change (Scheiner, 2007). Three domains of life events are centered upon in this framework, namely households and family biographies (e.g., childbirth and divorce) (Lanzendorf, 2010), employment biographies, comprising job or education changes (Busch-Geertsema and Lanzendorf, 2017; Oakil et al., 2011), and residential biographies, including residential relocation (Lin et al., 2018; Prillwitz et al., 2007; Wells and Yang, 2008).

Several studies have addressed everyday travel behavior as a routine activity that may be affected by changes in these three life domains (Clark et al., 2016; Janke and Handy, 2019; Scheiner and Holz-Rau, 2013b; Van der Waerden et al., 2003). With respect to household and family events, childbirth may lead to changes in household maintenance tasks (Lanzendorf, 2010). After childbirth, parents may increase their walking behavior, as they may walk with a stroller rather than cycle. Regarding the second domain of life events, changing jobs may lead to an increase or decrease in commute distance, which may affect travel mode choice (Oakil et al., 2011; Van der Waerden et al., 2003). Additionally, retirement may disrupt daily routines and social networks, leading to rearrangements of lifestyle choices. These shifts in routines may change walking behavior (Jones et al., 2018), resulting in a new activity pattern until another life event happens (Lanzendorf, 2003).

Previous studies have focused on the impact of life events on changes in travel mode, including car, public transportation, and bicycle (Chatterjee et al., 2013; Clark et al., 2016; Klein and Smart, 2019; Oakil et al., 2011; Scheiner and Holz-Rau, 2013b). Oakil et al. (2016) found that job changes increased the likelihood of cycling commuting, while childbirth reduced it. With respect to other travel modes, changes in income, changes in the household structure, childbirth, etc. are related to changes in car ownership (Klein and Smart, 2019; Oakil et al., 2018; Wang et al., 2018; Zhang et al., 2014). Regarding cycling behavior, life events, such as residential relocation, job changes, and changes in household structure, have an important impact on such behavior (Chatterjee et al., 2013; Janke and Handy, 2019; Jones, 2013; Oakil et al., 2016). However, the impact of life events on walking, especially for different purposes, remains largely unexplored.

Changes in the third life domain (i.e., those caused by residential relocation) may also lead to changes in travel behavior (Müggenburg et al., 2015). When moving to a different place, the available transportation options, the accessibility of shops and facilities, and the neighborhood "walkability" may differ between the old and the new residential neighborhood, which may lead to changes in people's walking behavior (Giles-Corti et al., 2013). People who moved from urban to suburban and rural areas showed an increase in travel distance and time (Næss, 2005; Prillwitz et al., 2007; Scheiner and Holz-Rau, 2013a). Scheiner and Holz-Rau (2013a) found that suburbanization increased car use and decreased the use of other travel modes (i.e., public transportation, walking, and cycling).

In addition, existing knowledge about walking behavior is mainly based on cross-sectional studies, thus failing to address causal relations. Only longitudinal study designs can incorporate the temporal order and the examination of changes within the individual due to the influence of life events (including residential relocation) on walking behavior. Within-person relationships cannot adequately account for time-constant factors (e.g., gender) and other confounders (e.g., self-selection factors) (Fitzmaurice et al., 2012). The longitudinal effects of life events on walking have received minor attention (Jones et al., 2014). Giles-Corti et al. (2013) showed significant longitudinal associations between changes in built environment after relocation and walking for transportation and recreation, however, without considering other life events (e.g., childbirth, job changes, and retirement).

To address these knowledge gaps, the present study gathered longitudinal evidence regarding the effects of life events (i.e., regarding household composition, employment, and residential relocation) on transport-related and recreational walking behavior by using longitudinal panel data from 2013 and 2015.

2. Materials and methods

2.1. Research design and study population

Data were obtained from the Netherlands Mobility Panel (MPN) (Hoogendoorn-Lanser et al., 2015)—a longitudinal household panel of approximately 2500 households that has been followed up annually since 2013. Each year, household members aged 12 years or older record their travel behavior using a travel diary for three successive days in the period September to November. Respondents also report their demographics and socioeconomic characteristics.

The 2013 and 2015 waves were used for this analysis. These waves were chosen because they included all variables of interest. Our sample included participants aged at least 18 years (i.e., the age at which a person may drive unsupervised in the Netherlands) who had recorded travel data (N = 1673). Participants who did not complete the whole questionnaire (N = 427) and those who provided no data on transport-related and recreational walking across the waves (N = 61) were excluded. In total, our data include 1185 respondents, residing in 922 households nested in 87 Dutch municipalities. The mean number of respondents per municipality was 27 (SD = 17).

2.2. Data

2.2.1. Walking duration

The participants had recorded their trips and travel-related characteristics (i.e., mode, distance, travel time, and purpose) on each survey day. Because walking for transportation (i.e., walking to a bus stop, a car park, work, or to get from place to place) differs from recreational walking (i.e., walking for pleasure or with a dog) in terms of flexibility and discretionary nature, the two purposes were considered separately (Heinen et al., 2011; Mirzaei et al., 2018). Our outcome variables were the average transport-related and recreational walking duration on weekdays and weekends, measured per person per day in minutes.

2.2.2. Life events and residential relocation

The occurrence of life events is tracked through the annual survey. Along with the mobility biographies (Lanzendorf, 2003), respondents in 2015 were asked whether in the previous 24 months they had experienced (1) childbirth in their household, (2) getting a job, (3) starting work, or (4) stopping work (1 = Yes; 0 = No). Due to the low frequency of getting a job and starting work, the two life events were grouped together as "Changes in the job situation" and represented by a dummy variable. Moving status in the 2013 and 2015 waves was determined by means of changes in the residential address within the Netherlands. By combining data on residential postcode with the level of address density (CBS, 2014, 2015a), this variable was coded into two dummy variables: Someone moved to a more urbanized area or to a less urbanized area, with no change in population density as reference group. Additionally, we incorporated changes in the number of cars in the household by means of two dummy variables (i.e., car disposal and car acquisition). Due to a low proportion of income changes, we did not test effects of income change.

2.2.3. Control variables

Numerous covariates at an individual and a household level were selected according to previous studies (de Haas et al., 2018; Gao et al., 2018). Specifically, we considered age with six categories (i.e., 18–29, 30–39, 40–49, 50–59, 60–69, and ≥70 years). Educational level and gross annual household income were grouped into low, middle, and high (CBS, 2016). Employment status was incorporated as employed, and retired or other unemployed. Other control variables were gender, number of children (aged ≤12 years) per household, number of working hours, driver's license, and number of cars in household. All these covariates were measured in 2013.

Informed by the literature (Handy et al., 2002; Wong et al., 2011) but constrained by data availability, the following variables describe the residential environment at the four-digit postal code level (PC4 level) for 2013 and 2015 (CBS, 2015b, 2013). Address density means the total number of addresses per km^2. Distances (in km) from the center of each postal code area to the nearest train station, supermarket, and major transfer station were determined. To preserve the respondents' privacy, the data owner (Netherlands Institute for Transport Policy Analysis) blurred the environmental variables by adding a 1% random noise.

2.3. Statistical analyses

Repeated walking duration was recorded by our participants. We therefore examined the longitudinal associations between life events and residential relocation on changes in both transport-related and recreational walking duration in 2013 and 2015, by means of two-level mixed-effects regression models. The two-level regression design was necessary because we expected within-subject correlations and correlations for people within the same household. A significant proportion of the participants did not report walking in 2013 and 2015, resulting in positively skewed outcome variables. Because the response was further censored to zero, multilevel mixed-effects Tobit regressions were fitted, which can deal with the absence of negative values in the dependent variable and excess of zero (Greene, 2003). Further, multilevel regression models with only a random intercept were used, due to the small size of the average cluster (an average of 1.29 people were nested in each household) (Snijders, 2005).

Two models for each walking purpose were estimated. Our base model (Model 1) included only sociodemographic and residential environmental variables, whereas Model 2 also included life events and residential relocation. All modes were adjusted for time in years, and the time-vary control variables (Table 1). Goodness-of-fit across the models was assessed through the chi-square statistics, log likelihood ratio test, and the deviance statistic. As the estimated parameters do not directly quantify the absolute differences in minutes of walking compared to a reference group, the average marginal effects were determined for easy interpretation. For a continuous variable, the average marginal effect refers to an additional minute of walking if the continuous variable increased by one unit. For a categorical variable, the average marginal effect is the estimated average change in walking duration for each level of the categorical variables and the first category was used as the reference category. The analyses were performed with Stata SE 15.1 (StataCorp, College Station, TX).

3. Results

Table 1 presents the descriptive statistics. About 31% and 26% of the participants in 2013 and 2015, respectively, engaged in any transport-related walking over the three successive days during which they kept a travel diary, while 22.5% (2013) and 20.5% (2015) reported any walking for recreation. The mean daily transport-related walking duration was 2.8 min in 2013 and 2.3 min in 2015. Recreational walking decreased from 3.3 min (2013) to 2.8 min (2015). The participants were aged 18 years or older and 53.9% were females. The frequency of life events was low, ranging from changed jobs (9.8%) to stopped work (3%) and childbirth (3.7%). Approximately 3.7% of respondents had relocated to less urbanized areas, and 7% had moved to more urbanized areas. Of the participants, 5.9% had disposed of a car and 5.5% had acquired a car. Life events co-occurred only rarely. For instance, childbirth co-occurred with moving to a less urban area in only 0.3% of cases.

The regression results are summarized in Table 2. Chi-square tests indicate that Model 2 significantly exceeds Model 1 ($p < 0.05$). Therefore, we focus on Model 2, where the average marginal effect of walking for transportation decreased on average by 0.25 min/day ($p = 0.009$). Childbirth was significantly related with transport-related walking: on average, the marginal effect increased by 1.54 min/day ($p = 0.041$). Moving to less urbanized areas was positively associated with transport-related walking: The

Table 1
Sociodemographic and behavioral characteristics of participants for 2013 and 2015.

Indicators	2013 (N = 1185)	2015 (N = 1185)
Dependent variables		
Mean transportation walking (min.) (SD)	2.8 (6.69)	2.5 (6.19)
Mean recreational walking (min.) (SD)	3.3 (8.79)	2.8 (7.86)
Life events:		
Changed jobs		9.8%
Stopped work		3.0%
Childbirth in the household		3.7%
Car change in the household		
Car disposed of		5.9%
Car acquired		5.5%
Residential relocation		
Move to less urban areas		3.7%
Move to more urban areas		7%
Control variables:		
Age (years)		
18–29	14.8%	
30–39	18.5%	
40–49	18.6%	
50–59	18.2%	
60–69	18.2%	
≥70	11.6%	
Gender		
Male	46.1%	
Female	53.9%	
Education		
Low	22.2%	
Medium	39.4%	
High	38.4%	
Gross household income		
< €26,000	20.8%	
€26,000–65,000	48.9%	
> €65,000	17.4%	
Unknown	12.9%	
Driver's license		
No	11.5%	
Yes	88.5%	
Employment status		
Employed	63.5%	
Retired and other unemployed	36.5%	
Working hours		
< 12 h	6.9%	
12–35 h	21.6%	
35+ hours	30.0%	
Unemployed	41.4%	
Children ≤12 years		
No	84.1%	
Yes	15.9%	
Number of cars in the household		
0	17.9%	
1	49.8%	
2 or more	32.3%	
Residential environment variables:		
Address density (1000 addresses per km^2)	1.66(1.63)	1.68(1.61)
Distance to nearest train station (km)	4.50(4.93)	4.65(4.99)
Distance to major transfer station (km)	9.73(8.25)	9.97(8.26)
Distance to nearest supermarket (km)	1.03(0.69)	1.06(0.71)

average marginal effect increased by 1.64 min/day ($p = 0.061$). Moving from less to more urbanized areas was insignificant. The increase in transportation walking duration was significantly larger for residents of areas with shorter distances to both a supermarket and a major transfer station.

For recreational walking, similar models were fitted. As no significant associations appeared between life events and recreational walking, the results are reported only in the appendix (Table A1). Nonetheless, the average marginal effect of recreational walking decreased by 0.20 min/day ($p = 0.071$) (Model 1) after taking life events and residential relocation into account (Model 2; 0.32 min/day ($p = 0.042$)).

Table 2
Results for transport-related walking duration.

Variables	Model 1 Coef.	Std. err.	Model 2 Coef.	Std. err.	Average margins effects (Model 2)	Delta-method Std. err.
Constant	−7.140**	3.237	−7.053**	3.263		
Time (0 = 2013)	−0.768**	0.337	−0.980***	0.374	−0.249***	0.095
Life events:						
Changed job			−0.247	1.818	−0.063	0.462
Stopped work			1.150	3.160	0.293	0.804
Childbirth in the household			6.040**	2.960	1.536**	0.753
Car changes in the household						
Car acquisition			0.971	2.314	0.252	0.610
Car disposal			−4.420	2.658	−1.035	0.572
Residential relocation:						
Move to less urban areas			5.773**	2.785	1.644*	0.884
Move to more urban areas			−3.039	2.325	−0.731	0.528
Sociodemographic variables:						
Age 18–29 (ref.)						
30–39	3.127*	1.726	2.912*	1.731	0.699*	0.411
40–49	1.371	1.750	1.661	1.757	0.389	0.408
50–59	1.732	1.803	1.949	1.816	0.459	0.424
60–69	4.930**	1.996	5.053**	2.013	1.267**	0.499
≥70	5.193**	2.261	5.330**	2.282	1.345**	0.582
Gender Male (ref.)						
Female	3.780***	0.884	3.717***	0.881	0.936***	0.220
Education Low (ref.)						
Medium	1.281	1.208	1.290	1.206	0.318	0.295
High	2.509*	1.302	2.388*	1.304	0.602*	0.325
Gross household income						
< €26,000 (ref.)						
€26,000–65,000	−0.404	1.237	−0.489	1.239	−0.126	0.320
> €65,000	−0.540	1.675	−0.681	1.682	−0.174	0.430
Unknown	−1.481	1.685	−1.535	1.689	−0.387	0.422
Employment status						
Employed (ref.)						
Retired and other unemployed	−0.364	2.404	−0.083	2.409	−0.021	0.612
Working hours						
< 12 h (ref.)						
12–35 h	−0.068	1.980	0.068	1.982	0.017	0.498
35+ hours	−2.105	1.928	−2.051	1.929	−0.495	0.477
Unemployed	1.955	2.712	1.881	2.716	0.491	0.702
Children ≤12 years No (ref.)						
Yes	0.672	1.604	0.487	1.612	0.125	0.416
Driver's license No (ref.)						
Yes	−2.570*	1.356	−2.491*	1.355	−0.658	0.372
Number of cars in household						
No car (ref.)						
1 car	−2.092**	1.023	−1.842*	1.022	−0.488*	0.276
2 or more cars	−4.120***	1.181	−3.570***	1.198	−0.915***	0.311
Residential environment:						
Address density	0.572	0.354	0.593*	0.356	0.151*	0.091
Distance to nearest train station	0.006	0.134	0.015	0.134	0.004	0.034
Distance to nearest supermarket	−2.004**	0.970	−2.324**	0.976	−0.591**	0.248
Distance to nearest major transfer station	−0.182**	0.080	−0.185**	0.080	−0.047**	0.020
Between-individual variance	91.163	11.229	93.038	11.352		
Within individual variance	135.894	9.714	132.651	9.503		
Model fit						
Log-likelihood	−3449.46		−3442.35			
Wald chi-square	(24) 131.66		(31) 143.00			
LR test	14.21**					

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
LR = Likelihood-ratio test.

4. Discussion

4.1. Key findings

This longitudinal study complements the largely cross-sectional knowledge base on the effects of life events on transport-related and recreational walking duration. We found that childbirth positively affected transport-related walking over time, which is

Table A1
Results for recreational walking duration.

Variables	Model 1 Coef.	Std. err.	Model 2 Coef.	Std. err.	Average margins effects (model 2)	Delta-method Std. Err.
Constant	–22.24***	−5.77	–22.27***	−5.82		
Time (0 = 2013)	−1.07*	−0.60	−0.89*	−0.67	−0.20*	0.15
Life events						
Changed jobs			−1.65	−3.44	−0.37	0.77
Stopped work			1.87	−5.56	0.42	1.24
Childbirth in the household			0.45	−6.02	0.10	1.35
Car changing in the household						
Car acquisition			0.37	−4.19	0.08	0.94
Car disposal			1.89	−4.24	0.43	0.99
Residential relocation						
Move to less urban areas			2.97	−5.12	0.69	1.22
Move to more urban areas			−4.16	−4.26	−0.89	0.87
Sociodemographic variables						
Age 18–29 (ref.)						
30–39	−1.83	−3.14	−1.88	−3.15	−0.39	0.66
40–49	−0.11	−3.14	−0.13	−3.16	−0.03	0.68
50–59	4.46	−3.10	4.39	−3.12	0.99	0.69
60–69	4.97	−3.54	4.82	−3.57	1.09	0.80
≥70	2.51	−4.06	2.39	−4.09	0.53	0.90
Gender Male (ref.)						
Female	0.06	−1.57	0.05	−1.57	0.01	0.35
Education Low (ref.)						
Medium	2.63	−2.16	2.61	−2.16	0.55	0.45
High	7.04***	−2.31	7.07***	−2.32	1.57***	0.51
Gross household income						
< €26,000 (ref.)						
€26,000–65,000	0.45	−2.26	0.51	−2.26	0.12	0.52
> €65,000	−2.69	−3.03	−2.75	−3.04	−0.61	0.67
Unknown	−3.91	−3.11	−3.83	−3.12	−0.83	0.67
Employment status						
Employed (ref.)						
Retired and other unemployed	−0.36	−4.38	−0.33	−4.40	−0.07	0.98
Working hours						
< 12 h (ref.)						
12–35 h	0.03	−3.46	0.15	−3.47	0.03	0.79
35+ hours	−4.12	−3.34	−4.06	−3.34	−0.89	0.75
Unemployed	0.29	−4.84	0.39	−4.85	0.09	1.11
Children < 12 years No (ref.)						
Yes	−6.18**	−2.99	−6.23**	−3.00	−1.32**	0.60
Driver's license No (ref.)						
Yes	−4.03	−2.46	−4.00	−2.47	−0.93	0.59
Number of cars in the household						
No car (ref.)						
1 car	1.50	−1.92	1.47	−1.92	0.33	0.42
2 and more cars	1.85	−2.13	1.76	−2.17	0.39	0.48
Residential environment						
Address density	0.78	−0.64	0.80	−0.65	0.18	0.14
Distance to nearest train station	0.28	−0.22	0.28	−0.22	0.06	0.05
Distance to nearest supermarket	0.15	−1.55	0.02	−1.56	0.00	0.35
Distance to nearest major transfer station	−0.06	−0.14	−0.07	−0.14	−0.01	0.03
Between-individual variance	2511.061		2512.072			
Within individual variance	3306.042		3304.395			
Model fit						
Log-likelihood	−3567.935		−3566.96			
Wald Chi-square	(24) 45.90		(31) 47.54			
LR test	1.95					

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
LR = Likelihood-ratio test.

consistent with previous studies (Hirsch et al., 2014; Hou et al., 2010; Lanzendorf, 2010). Contrary to both our expectations and previous studies (Prillwitz et al., 2007; Scheiner and Holz-Rau, 2013a), we found that relocation to less urbanized areas was significantly related with increases in transport-related walking duration. Life events seem to influence transport-related walking to some extent, but no significant longitudinal relationship was observed between life events and recreational walking duration.

4.2. Explanation of key findings

The descriptive analyses showed that both transport-related and recreational walking duration slightly decreased over time. A low frequency of life events occurring simultaneously with residential relocation suggests that childbirth and residential relocation (i.e., to less urbanized areas) are positive and significant determinants of changes in transport-related walking duration. Consistent with previous studies (Lanzendorf, 2010; Scheiner, 2014), childbirth plays an important role in transport-related walking. One possible reason is that in the Netherlands, approximately 27% of short trips (< 5 km) are made by bike, and it is likely that a considerable share of these bike trips are replaced by walking, simply because it is not easy to take a baby on a bike. For example, newborn babies not only need a full-time caretaker, but also travel in a stroller for shopping or for child-related maintenances activities, such as visiting doctors. Thus, caretakers have to adjust their daily activities and schedules accordingly. Another partner-related reason is that if one parent needs to use the family car during working hours, the car is unavailable for the other parent.

However, other life events including job changes and stopping work showed no significant associations with changes in transport-related walking. The lack of significant effect may be due to the low frequency of life events. Additionally, changes in travel behavior can be delayed because of life events (Oakil et al., 2014). For instance, after they retire, people may need time to adapt to their "new" lifestyle, whereby they may walk or cycle more for transportation and/or recreation—rather than immediately changing their travel behavior—and only to a minor extent, even if circumstances in the environment change dramatically. Further, as previous studies mainly focused on the effect of life events on travel mode, the biographical life events may not have a significant impact on all travel behavior measures, such as walking durations (Scheiner and Holz-Rau, 2013b). The weak effects of life events also suggest that a considerable amount remains unknown about predicting walking duration. For instance, it is possible that changes in walking routes occurred during the study period that may have facilitated or inhibited transport-related walking duration, but were not captured in the survey.

Regarding residential relocation, the effect of moving to a lower density area did not meet our expectations and our results are contrary to those of previous studies (Giles-Corti et al., 2013; Handy et al., 2008; Hirsch et al., 2014; Scheiner and Holz-Rau, 2013a). While these studies were conducted in countries with lower population density, such as the USA and Australia, the Netherlands is among the world's most densely populated countries, so individuals relocating to less urbanized areas could still be within an acceptable walking distance to daily utilitarian destinations and bus stops. In a study in Germany, relocation to suburban areas had a stronger influence on car and public transportation use than on bicycle use and walking (Scheiner and Holz-Rau, 2013a). However, the study mainly focused on the influence of residential relocation on car ownership, rather than walking behavior. Additionally, our findings suggest that moving to inner-city neighborhoods may not have the anticipated positive impact on transport-related walking duration. This finding is congruent with a previous study (Prillwitz et al., 2006), where relocation from one regional main area to another had a strong effect on car acquisition. To encourage walking in more urbanized areas, pedestrian conditions—such as clean pavements, street lighting, and connectivity—should be improved (Kelly et al., 2011).

The lack of associations between life events and recreational walking confirms both cross-sectional studies (Lee and Moudon, 2006; Lovasi et al., 2008; Pikora et al., 2006) and a longitudinal study (Hirsch et al., 2014), suggesting that transport-related and recreational walking are different behaviors (Kang et al., 2017). This indicates that life events can influence routines and mandatory activities, such as work and school, more strongly than discretionary activities. Also, compared to recreational walking, transport-related walking has higher participation rates and frequency. Another possible reason is that the present study omitted factors that may encourage recreational walking (e.g., aesthetic quality, sidewalks, and street lighting). Different relationships of residential environment characteristics with transport-related and recreational walking highlight that it is important to incorporate different environmental features of different travel behaviors (Hirsch et al., 2014; Lee and Moudon, 2006). It is also possible that recreational walking is influenced by attributes beyond the built environment, such as safety or social features, which could still be the characteristics of residential areas.

4.3. Strengths and limitations

A key strength of this study is the longitudinal study design. In addition, it is based on a national sample that includes both movers and non-movers to avoid unobserved preferences regarding both choice of residential relocation and travel behavior.

Our study also has some limitations. First, the low frequency of life events is due to the sample being constrained by two waves with limited sample size. The low frequency of life events did not allow us to add lag effects to our model, or to examine combined or independent effects of different life events when two or more occur at the same time. Additional data are needed to analyze the effects of life events in depth. Additionally, to enhance our understanding of how individuals adjust their walking behavior when they move into new life stage, it would be of great value to have information on short-term changes (i.e., changes within weeks or months) following life events, instead of being limited to annual or biannual reports. We were also not able to incorporate different travel characteristics between weekdays and weekends due to limited sample size. Second, while we considered built environmental characteristics at the postal code level, "micro" characteristics known to be important for walking (e.g., aesthetics, presence of walking trails) were not included. Third, our outcome measure of minutes spent walking for transportation and recreational purposes was self-reported and thus may be prone to recall bias (Bentley et al., 2018; Turrell et al., 2014). For example, the large proportion of non-walkers observed is probably due to the underreporting of short daily walks, including fetching the mail or going to the grocery store. This restriction may also bias the estimated relationship between life events, such as residential relocation, and walking for transportation and recreation. Tracking people through a global positioning system seems promising to objectively collect data on walking behavior. Finally, other life events (e.g., accidents, health issues) may also influence walking behavior but were not available for this study.

5. Conclusion

This study provided longitudinal evidence of the effect of life events on changes in walking over time. Our study adds to the literature by showing that changes in transport-related walking behavior are positively associated with childbirth and moving to less urbanized areas. Life events, however, were not associated with recreational walking, whereas travel-related walking was more likely to be influenced by changes in household composition and residential relocation. For policymaking, our findings highlight the importance of residential relocation for changes in transport-related walking. The findings suggest that it is necessary to provide specific information for households that are considering relocation, concerning their travel costs and options related to household composition (e.g., families with young children). Paying attention to specific life events (e.g., residential relocation) may help urban planners and policymakers to evaluate whether walking changes are caused by changes in living circumstances. Further, although we investigated direct links between life events and walking duration, these links may also be moderated by changes in activity patterns, destination choice, associated distances, and other variables. Further longitudinal research is needed to verify our findings and gain insight into the underlying mechanisms explaining these relationships.

Declaration of Competing Interest

None.

Acknowledgment

We thank the Chinese Scholarship Council (CSC) (201506560001) for providing the PhD funding that supported this research.

Appendix A

Table A1

Appendix B. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trd.2019.11.006.

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