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Travel behavior changes due to life events: Longitudinal evidence from Dutch couple households

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ABSTRACT

Despite increasing interest in how travel behavior changes over time, few studies have investigated how life events alter travel behavior, especially from a household perspective. This study examined the extent to which life events influenced changes in travel mode frequencies at the household level. We applied structural equation modeling based on the Netherlands Mobility Panel data for 2014 and 2016. For both partners, acquiring a household car significantly increased car use, and disposing of household cars decreased car use frequency. The number of household cars was inversely related to men's train use. Childbirth in the household decreased both partners' cycling frequency. Men's job changes increased train use. These findings emphasize that life events can influence changes in travel behavior within household partners.

1. Introduction

Research on travel behavior changes has been receiving increasing attention, including both day-to-day variability (Egu and Bonnel, 2020; Heinen et al., 2011; Kang and Scott, 2010) and longer-term changes (Clark et al., 2016; de Haas et al., 2018; Scheiner, 2020). Most studies have attempted to explore the fundamental mechanisms of how travel behavior changes over time. The available evidence suggests that people adapt their travel behavior to changes in their social (Oakil et al., 2014) and spatial circumstances (Chatterjee et al., 2013; De Vos et al., 2021). Nevertheless, evidence regarding the underlying reasons for changes in travel behavior remains scarce.

As put forward by the mobility biography framework (Lanzendorf, 2003; Scheiner, 2018), specific life events may disrupt people's daily routines and alter travel behavior. In attempting to understand these changes, the mobility biographies approach comprises three domains of life events: household biographies (e.g., marriage, divorce, and childbirth) (Scheiner and Holz-Rau, 2012), employment biographies (e.g., getting a new job and other changes in employment) (Oakil et al., 2011; Scheiner, 2020; Wang et al., 2020), and changes in residential location (De Vos et al., 2021; Gao et al., 2019; Guan and Wang, 2019b).

Studies have shown that individual and household events differentially impact men and women (Lanzendorf, 2010; Scheiner, 2014, 2020). For instance, women tend to reduce their car use after giving birth, and their travel patterns are further affected by child-rearing tasks, including increased and reduced car use by women and men, respectively (Scheiner and Holz-Rau, 2012). This is because

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mothers usually perform most household work and childrearing tasks, including trips to accompany children (He, 2013).On the other hand, employment-related biographies were more likely to affect men's travel mode choices than women's (Scheiner, 2014, 2016). For example, female-dominated occupations tend to be more evenly distributed geographically than men who work in male-dominated occupations (Sandow, 2008), which leads to women having shorter commutes. These findings suggest that in partnered households, although couple members experience similar or the same individual life events, (e.g., changing jobs and childbirth in the family, respectively), and travel-related events (e.g., purchasing or selling a car), couple members' travel behavior may change differently. As individuals living in the same household share resources and familial tasks with their partners, such differences in behavioral response are likely a result of intra-household influences between partners (Ho and Mulley, 2015; Rau and Sattlegger, 2018). However, the existing literature has primarily focused on individuals and overlooked the varied effects of life events within a household. An exception is a study by Scheiner (2020), who assessed the influences of individual and household-level life events on changing car use from an intra-family perspective. Although life events affect travel mode usage differently, empirical evidence in this area remains limited.

Our study contributes conceptually to the literature in multiple ways. First, previous studies have investigated the effects of life events on travel behavior and attitudes at the individual level (Kalter et al., 2021; Oakil et al., 2011; Scheiner, 2014; Scheiner and Holz-Rau, 2013). In reality, the effects of life events on travel are gendered between couples. For example, having dependent children decreased men's but increased women's car use (Scheiner and Holz-Rau, 2012). By employing the household–level perspective on the life events–travel link, this study aims to extend extant literature and provide in-depth insights into the underlying mechanism of why travel behavior changes over time.

Second, most studies have investigated the direct impacts of life events on travel behavior (Clark et al., 2016; Wang et al., 2020; Yamamoto, 2008). These studies make no distinction between life and travel-related events (e.g., car acquisition) and usually consider changes in household car ownership in the same manner as other life events (e.g., changing jobs). However, travel-related events can directly or indirectly affect individuals' travel mode choices (Rau and Sattlegger, 2018). In addition, life events and travel-related events usually co-occur. Life events may indirectly affect travel behavior by changing the number of household cars (Schäfer et al., 2012). For example, purchasing a car is more likely after starting a new career or the birth of a child. After childbirth, household resources, tasks, and activities between partners usually have to be redistributed, resulting in a more pronounced effect on mothers' car use (Schwanen, 2011). Therefore, it is necessary to discriminate between life and travel-related events (Rau and Manton, 2016).

A third contribution concerns the role of travel-related attitudes in moderating the associations between life events and travel behavior changes. For example, giving birth may lead to car dependence, resulting in changes in mode-specific attitudes. Although some studies have looked at the associations between travel mode attitudes and changes in travel behavior (De Vos et al., 2021; Kalter et al., 2020; Wee et al., 2019), how life and travel-related events affect changes in travel mode frequency, and attitudes are relatively unexplored.

To address these gaps in knowledge, we used two-wave panel data from the Netherlands Mobility Panel to examine whether and how life and travel-related events are associated with changes in travel mode frequency and travel-related attitudes among household couples.

2. Gender differences in travel behavior

Significant gender differences were observed in travel behavior across Europe (e.g., Germany (Matthies et al., 2002), Sweden (Polk, 2004), Austria (Janke, 2021), and the Netherlands (Maat and Timmermans, 2009; Schwanen, 2011)), the USA (Cao et al., 2006), and Asian countries (e.g., China (Guan and Wang, 2019a, b; Hu et al., 2022) and Japan (Zhang et al., 2014)). Regarding gender differences in access to transport resources, for example, men typically use the family car in some European countries compared to women (Janke, 2021; Matthies et al., 2002; Schwanen, 2011). However, other studies showed that women had a stronger position in negotiating than men regarding car use. In the Chinese context, Guan and Wang (2019a) found that women may play a more dominant role in car use than their male partners.

Gender-specific personalities and socialization could also contribute to gender differences in travel-related attitudes and residential preferences. For instance, women showed more environmental and safety concerns regarding travel mode choice (Mitra and Nash, 2019; Mokhtarian et al., 2010). In addition, the gender division of labor and activities explains gender differences in travel behavior. The gender difference in travel behavior is expected to be more pronounced among household structures involving family constructs, such as spouses or partners, parenthood, and a male breadwinner, compared to nonfamily, and single households. However, the findings appear to be inconsistent. For example, spouse/partner presence and being parents significantly affected gender differences in travel behavior (Preston et al., 1993; Silveira Neto et al., 2015), whereas a few studies found null effects of such household structures (Elliott and Joyce, 2004; Zolnik, 2010). Regarding breadwinner status, men are more inclined to use cars than their partners (Scheiner and Holz-Rau, 2012).

Nevertheless, most studies to date examined gender differences between heterosexual couples. The division of labor and travel between same-sex couples also differs, but the differences are less pronounced (Smart et al., 2017). In addition, no significant difference in commuting duration was observed between same-sex men and women partners (Rapino* and Cooke, 2011).

Regarding mobility, gender should not be restricted to the traditional binary of men and women (Law, 1999). Instead, gender should be analyzed as a social category in transport studies with more complexity and nuance. Building on this perspective, Hanson (2010) delved into two aspects of gender and mobility. The first aspect explores the roles of gender in mobility, while the second investigates how mobility shapes gender by highlighting the power dynamics embedded in mobility. However, previous research has only focused on one of perspectives without exploring the connection between the two (Ravensbergen et al., 2019). To gain a deeper

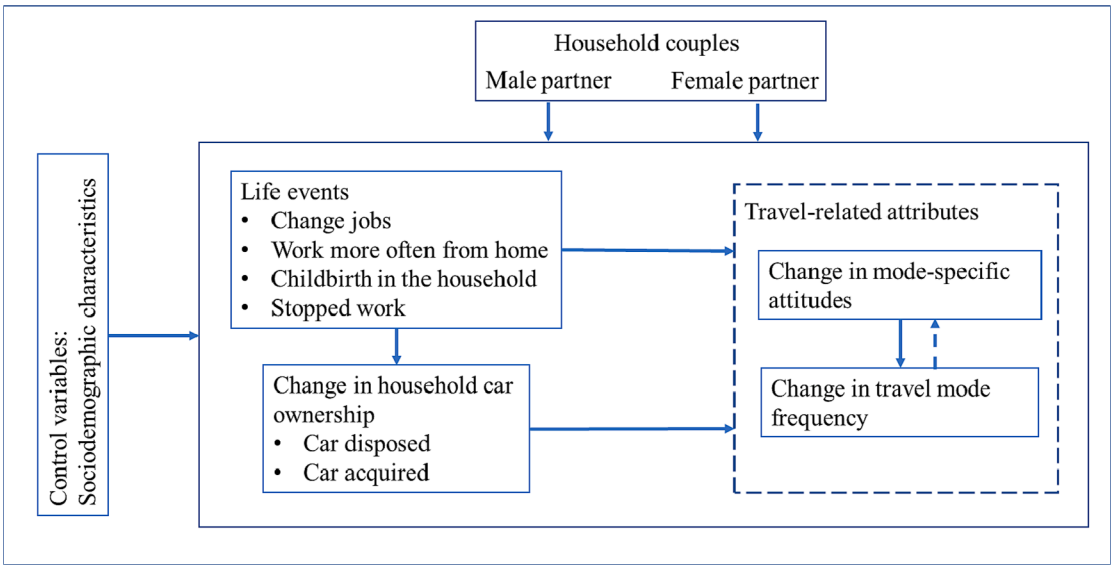

Fig. 1. Conceptual framework.

understanding of the relationship between gender and mobility, we need to integrate these two perspectives.

Regarding life events, childbirth in the household and changing jobs had pronounced effects between men and women (Scheiner, 2014). After childbirth, women were more sensitive to residential location choices for commuting trips than men (Sermons and Koppelman, 2001). Moreover, childbirth may induce mode choice changes to public transportation use or cycling (Lanzendorf, 2010). Residential relocation and changing jobs significantly affected car accessibility among women (Oakil, 2016; Schwanen, 2011). These findings indicate possible arrangements between heterosexual couples when triggered by life events.

3. Conceptual framework

Fig. 1 depicts our conceptual framework for explaining the changes in travel mode frequency and mode-specific attitudes triggered by life and travel-related events (i.e., car number changes in the household). For example, car ownership may change owing to life events (Kroesen, 2019; Scheiner, 2020), leading to changes in travel modes and attitudes. Therefore, we hypothesize that life events directly influence travel mode frequency and attitudes, as well as have an indirect effect via car number changes in the household. Similarly, household car number changes may directly affect travel behavior and attitudes. In addition, some researchers have investigated the bidirectional or reverse links between attitude and behavior using cross-sectional (Bagley and Mokhtarian, 2002; Bohte et al., 2009; Handy et al., 2005) and panel data (Kroesen, 2019; Thøgersen, 2006). These studies have revealed that people's travel-related attitudes may determine their preferred modes and vice versa (i.e., actual behavior influences attitudes) (Wee et al., 2019). However, other studies have reported that travel attitudes are more influenced by travel behavior than vice versa (Kroesen et al., 2017). For instance, direct experience with public transport could change initial travel attitudes toward public transportation use (Fujii and Kitamura, 2003).

The theory of planned behavior (Ajzen, 1991) assumes that travel-related attitudes substantially influence behavior intention, and attitudes are thought to be constant, suggesting that the effects of attitudes and travel behavior coincide. In contrast, the theory of cognitive dissonance (Festinger, 1957) states that individuals may also change their travel-related attitudes to comply with travel behavior, especially those with a mismatch between travel mode attitudes and travel behavior. A bidirectional relationship may exist between changes in travel-related attitudes and behavior. Moreover, couples who experience the same life events (e.g., childbirth) are likely to have different changes in travel-related attitudes, leading to varying changes in travel behavior (Heider, 2013). For example, couples with diverse daily activities and mobility needs tend to have different mode-specific attitudes (Ji et al., 2018). Individuals' travel behavior would probably be confounded by their partners' travel attitudes and life events, suggesting interpersonal interactions within couples (Scheiner, 2020).

As discussed above, we hypothesized that life events and changes in household car ownership would affect couples' travel behavior and attitudes differently based on their different roles within the household. During this process, gender power relations may also play a role in couples' travel mode choices. For example, women may take on a larger share of family responsibilities than their partners (Schwanen, 2011). As such, we hypothesized that women would adjust their travel demands considering their partners' travel behavior. It is necessary to investigate the underlying mechanism at the household level and distinguish between the effects of various life events and household car number changes. Finally, we expected that sociodemographic characteristics would affect life events, car ownership, change in travel mode frequency, and travel-related attitudes, as indicated by multiple reviews (Bohte et al., 2009; Müggenburg et al., 2015; Van Acker et al., 2010; van Wee and Cao, 2020). Therefore, we examined whether and to what extent

different life events and household car number changes would simultaneously affect both household partners' travel behavior and attitudes.

4. Materials and methods

4.1. Panel data

We used the 2014 and 2016 waves of the Netherlands Mobility Panel data (MPN). Both waves were considered due to the required variables' availability to realize our research aim. Since 2013, this annual web-based household panel has included approximately 2,000 households distributed across the Netherlands. Each year, family members over the age of 12 are invited to complete individual- and household-related questionnaires and a three-day travel diary from September to November. The respondents are randomly selected and recruited from an online access panel. The attrition rate between the waves fluctuates between 18% and 28% (La Paix Puello et al., 2017). Each wave refreshes the sample to retain a representative sample of the Dutch population. An in-depth description of the data protocol can be found elsewhere (Hoogendoorn-Lanser et al., 2015).

This study was conducted as follows. First, we merged the two survey waves ($N = 12{,}027$). Second, we excluded the data of respondents with no opinion on travel-related attitudes ($N = 2{,}548$), missing socio-demographics ($N = 276$), and missing life events ($N = 1{,}945$). Third, based on the role in the household (i.e., only "main income earner" and "partner of main income earner in a household"), we only retained household couples who had participated in both waves ($N = 2{,}295$). Fourth, we removed one-person households ($N = 1{,}117$) and respondents from same-sex couples. The latter was necessary because of their low frequency ($N = 36$). The final analytical sample included, in total, 1,142 individuals from 571 households. A figure illustrating the detailed data selection process is displayed in the supplemental materials.

4.2. Travel mode frequency

While travel diaries comprise multiple days, diary fatigue often occurs after a few days, leading to underreporting of trips (Stopher et al., 2008). As the MPN records people's mobility only for three days, the trip diary cannot capture the general travel behavior. The results might be biased if using the 3-day trip diary data. For example, in 2014, 54 out of 227 people (23.79%) self-rated as regularly traveled by car (i.e., 1 to 3 days per week), whereas travel diaries observed zero car trips during the three survey days. Therefore, we used weekly travel frequency of mode use as done elsewhere (de Haas et al., 2018; Kalter et al., 2021).

Travel mode frequency was measured based on the respondents' answers about daily travel mode usage (i.e., bicycle, car, bus/tram/metro [BTM], and train), which were recorded on a seven-point Likert scale ranging from "Never" to "Four or more days per week." Changes in travel mode frequency were assessed separately for female and male partners by value differences in mode-specific frequencies between the two waves. The change value for each of the four modes was a variable including five categories ranging from "far less frequent" (-2) to "far more frequent" (+2).

4.3. Life events

The respondents were asked if they had encountered any life events in the previous 24 months: getting a new job, starting work, starting to work more/less often from home, stopping work, and childbirth in the household. Response categories included "0–12 months ago," "13–24 months ago," "I do not know," "event did not occur," "not asked: person younger than 16 years old," "not asked: person younger than 12 years old," and "person did not complete the questionnaire." Owning to the low share of job-related life events, "getting a new job" and "starting work" were grouped as a combined dummy variable named "changes in the job situation" (yes vs. no). Other life events (i.e., stopping work) were not considered because of their low frequency.

Concerning travel-related events, changes in household car ownership were included with two dummy variables: car disposed of or others (including no change and car acquired) and car acquired or others (including no change and car disposed of). Unfortunately, respondents' residential postal codes were unavailable because of privacy constraints, and we were thus unable to identify the households that changed their residential location.

4.4. Travel mode attitudes

We measured attitudes for each travel mode (i.e., bicycle, car, BTM, and train) using 24 items (e.g., I find traveling by car pleasurable/comfortable/flexible/relaxing/safe/time-saving). Each item was rated on a five-point Likert scale ranging from "strongly disagree" to "strongly agree." Differences in the scores of each item across the two waves reflected changes in mode-specific attitudes. The values included five categories ranging from "far more negative" to "far more positive.".

4.5. Statistical analyses

We conducted structural equation modeling (SEM) (Bollen and Long, 1993) to examine the effects of life events and changes in household car ownership on travel behavior changes for each travel mode among female and male partners within households. Compared to multivariate regressions, the advantage of SEM is that it enables the measurement of multiple links among a set of dependent variables. Within SEM, we specified a factor model as a latent construct based on mode-specific attitude items derived from

Table 1
Sample characteristics and life events on the person-level and household-level.

	Total sample (N = 1,142)	Male (N = 571)	Female (N = 571)	p-values[a]
Personal life events (between 2014 and 2016 waves)				
Job changing	10.4%	7.9%	13%	0.003
Getting a new job	7.9%	7.0%	8.8%	0.251
Start working	2.5%	0.9%	4.2%	0.102
Stopped work	5.4%	4.7%	6.1%	0.258
Work from home more often	6.6%	6.0%	7.2%	0.088
Changes in educational program	2.9%	2.1%	3.7%	0.090
Household life events (between 2014 and 2016 waves)				
Childbirth in the household	6.0%			
Changes in household car ownership				
Car disposed of	20.3%			
No change	70.4%			
Car acquired	9.3%			
Individual characteristics at baseline (2014)				
Age				0.000
18–39	30.3%	28.0%	32.7%	
40–59	52.6%	52.0%	53.2%	
60+	17.0%	20.0%	14.0%	
Education				0.141
No college degree	54.2%	51.3%	57.1%	
With college degree	45.8%	48.7%	42.9%	
Employment status				0.000
Employed	73.9%	80.4%	67.3%	
Retired and other unemployed	26.1%	19.6%	32.7%	
Household characteristics at baseline (2014)				
Gross household income				
< €38,800	55.2%			
> €38,800	30.6%			
Unknown[1]	14.2%			
Children aged<12 years				
No	70.2%			
Yes	29.3%			
Residential location				
Urban area (1,000 or more inhabitants/km2)	57.1%			
Suburban/rural area (<1,000 inhabitants/km2)	42.9%			

[a] Based on Wilcoxon tests comparing male and female partners, $p < 0.05$ was considered significant.
[1] Income data with 'unknown' refers to respondents who do not want to public revenue. Considering the moderate sample size, we keep observations coded as 'unknown' like done elsewhere (Faber et al., 2021).

a principal component analysis based on positive loadings for all items. Furthermore, in contrast to a single regression equation, SEM enables the simultaneous measurement of direct and indirect effects among exogenous and endogenous variables (Bollen and Long, 1993). We used a weighted least square mean and variance-adjusted estimator in the software package Mplus 7.4 to account for categorical endogenous variables and multivariate non-normally distributed data (Muthén and Muthén, 2017). Data with a ratio between sample size and the number of observed variables larger than 15 (Stevens, 2012) or with a sample size larger than 500 could be considered a large sample. Our study's sample size is 571, and the ratio is 27.2 (i.e., clearly above the recommended ratio of 15).

We developed a separate SEM for each travel mode frequency change to ensure model parsimony and interpretability. In addition, we assessed 1) the direct effects of life events and changes in household car ownership on travel mode frequency changes, 2) the links between life events and changes in car ownership, and 3) the effects of sociodemographic characteristics and residential location (urban vs. suburban/rural) on changes in travel mode frequency and changes in mode-specific attitudes.

The control variables were measured in 2014. We included age (grouped into 18–39, 40–59, or 60 + years), employment status (employed, retired, or other), education (with or without a college degree), household income (low income [≤€38,800], high income [≥€38,800], or unknown), and presence of children aged<12 years (yes or no). In addition, residential locations were grouped into urban (1,000 or more inhabitants/km^2) and suburban/rural (<1,000 inhabitants/km^2) based on address density data (CBS, 2014).

5. Results

5.1. Descriptive statistics

Table 1 depicts the descriptive statistics of individual and household characteristics stratified into men and women partners. Among the sample, 54.2% of the participants had a college degree, and 73.9% were employed. Men were more often employed than women (80.4% vs. 67.3%). In addition, 29.3% of households had dependent children at the household level, and most resided in urban areas (57.1%). About 20.3% of households had reduced car ownership between the two waves, whereas 9.3% had acquired one car, and regarding personal life events, changing jobs significantly differed between male and female partners.

Table 2
Changes in travel mode frequency from 2014 to 2016 (in %).

Change in mode frequency	Far less frequent		Less frequent		No change		More frequent		Far more frequent		*p*-values[a]
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
Car use	1.8	2.5	9.6	13.1	75.0	71.6	12.6	10.5	1.2	2.3	0.131
Train use	3.0	1.8	10.9	11.0	71.8	72.0	11.9	12.6	2.5	2.6	0.346
Bus/Tram/Metro use (BTM)	3.3	2.6	13.5	17.3	68.3	64.4	12.4	13.5	2.5	2.1	0.596
Bicycle use	3.3	2.8	14.5	20.1	61.6	60.9	15.6	11.9	4.9	4.2	0.024**

[a] Based on paired sample *t*-tests comparing male and female partners; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table 3
Factor loadings of changes in mode-specific attitudes.

Factor	Statement item	Factor loading	
		Men	Women
Car attitude	I find travelling by car to be comfortable.	0.711	0.711
M: α = 0.766;	I find travelling by car to be relaxing.	0.525	0.617
F: α = 0.778.	Travelling by car saves me time.	0.517	0.503
	Travelling by car is safe.	0.6	0.53
	I find travelling by car to be flexible.	0.593	0.571
	Travelling by car is pleasurable.	0.647	0.741
Bus/tram/metro attitude	I find travelling by bus, tram or metro to be comfortable.	0.744	0.673
M: α = 0.788;	I find travelling by bus, tram or metro to be relaxing.	0.699	0.728
F: α = 0.772.	Travelling by bus, tram or metro saves me time.	0.554	0.449
	Travelling by bus, tram or metro is safe.	0.425	0.394
	I find travelling by bus, tram or metro to be flexible.	0.466	0.487
	Travelling by bus, tram or metro is pleasurable.	0.796	0.794
Cycling attitude	I find cycling to be comfortable.	0.681	0.635
M: α = 0.684;	I find cycling to be relaxing.	0.46	0.639
F: α = 0.756.	Cycling saves me time.	0.418	0.415
	Cycling is safe.	0.417	0.556
	I find cycling to be flexible.	0.486	0.613
	Cycling is pleasurable.	0.707	0.654
Train attitude	I find travelling by train to be comfortable.	0.673	0.703
M: α = 0.694;	I find travelling by train to be relaxing.	0.615	0.562
F: α = 0.694.	Travelling by train saves me time.	0.376	0.323
	Travelling by train is safe.	0.377	0.418
	I find travelling by train to be flexible.	0.445	0.367
	Travelling by train is pleasurable.	0.69	0.731

Table 2 shows changes in travel mode frequency from 2014 to 2016. Although many respondents reported similar travel patterns, more women changed their travel mode frequencies than their male partners. Significant gender differences in changing travel-related attributes were found for cycling. Male partners cycled more frequently compared to their female counterparts (15.6% men vs. 11.9% women). Car and BTM usage followed closely, with no significant differences observed between genders.

5.2. SEM results

5.2.1. Latent factor of changes in mode-specific attitudes

Latent variables in the SEM were measured by using the items for each travel mode. Four factors representing mode-specific attitude were constructed. All factor loadings are greater than 0.4, suggesting acceptable indicator reliability (Hair et al., 2009). Each latent variable has an acceptable Cronbach's alpha value (Table 3).

5.2.2. Life events, car number changes, travel-related attitudes, and behavior

Due to the complexity of our model, the figures here only show significant paths and variables. Nevertheless, the full model results (including both significant and insignificant paths and variables) could be found in the supplement material. Figs. 2–5 display four full-sample SEMs, each with a separate dependent variable for travel mode frequency changes and travel-related attitudes accordingly. All models fit the data well. The root mean square error of approximation (RMSEA) was below the critical level of 0.05, both the comparative fit index (CFI) and the tucker lewis index (TLI) values were above 0.90, and the weighted root mean square residual (WRMR) values were below 1 (Fan et al., 2016; Hu and Bentler, 1999). Table 4 presents the significant pathways from life events and changes in the number of car ownership to changes in travel mode frequency and attitudes. Detailed estimated SEM results are shown in the supplemental materials (see Table 1A).

As shown in Fig. 2, regarding changes in car use frequency, changes in the number of household cars played a significant role. For both couple members, acquiring a household car significantly increased car use, whereas disposing of household cars negatively

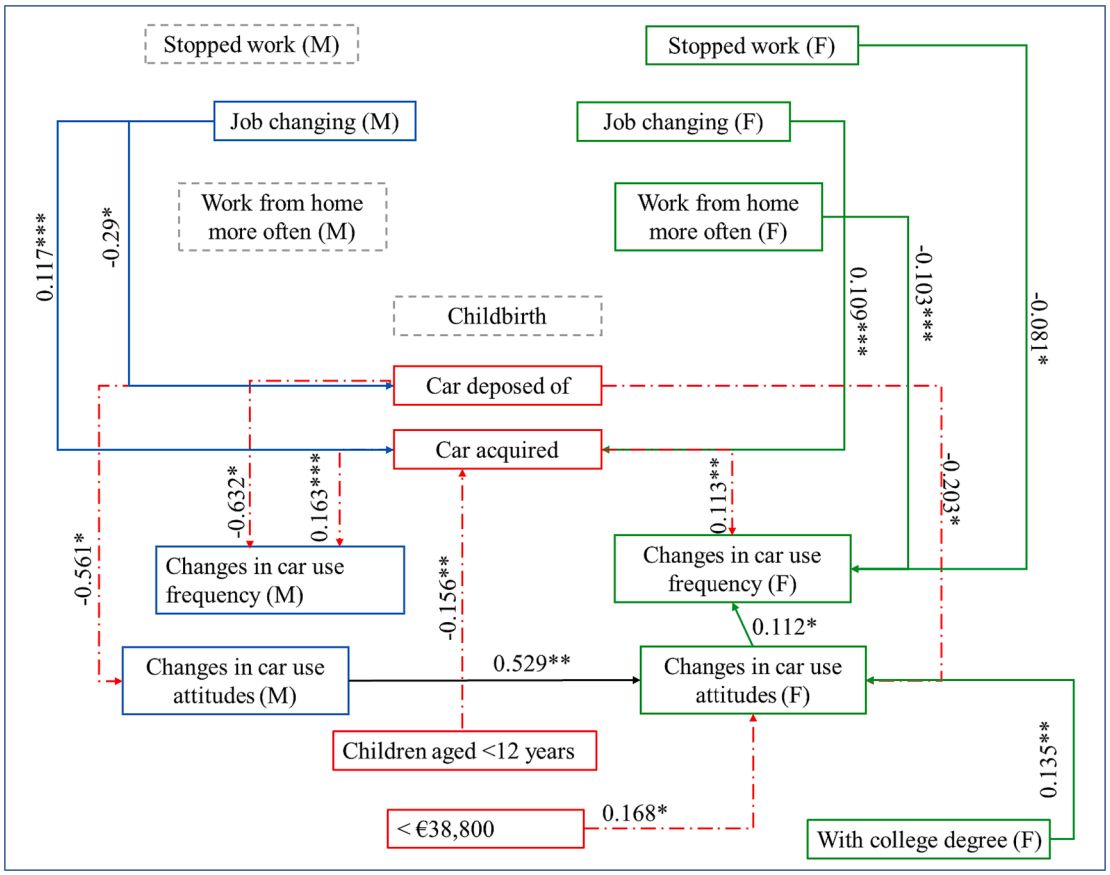

Fig. 2. Results of the final SEM model for change in car use (coefficients are standardized). Coefficients not significant at the 0.1 level are not shown. Blue dashed paths refer to the male respondents, green paths to the female partner, red line-dotted paths are based on the household level, and black lines represent the correlation between variables. *p < 0.1, **p < 0.05, ***p < 0.01. Model fit: RMSEA/CFI/TLI/WRMR: 0.019/0.961/0.942/0.766. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

influenced only male partners' car use frequency. In addition, retired women and women who worked from home more often decreased their car use frequency, whereas no significant effect was observed for their partners.

Regarding cycling (in Fig. 3), increasing the number of household cars decreased men's cycling frequency, whereas childbirth in the household decreased both partners' cycling frequency. Retired men showed an increased cycling frequency. For public transportation (Figs. 4 and 5), men's attitudes toward BTM use positively influenced those of their female partners but not vice versa. Acquiring a household car decreased men's BTM use and BTM use attitudes. In addition, acquiring a household car decreased men's train use. Men's job changes increased train use, whereas this was not the case for their partners.

In addition, as shown in Table 4, men's job changes negatively and indirectly affected their public transportation use (i.e., BTM and train use) via the increased number of household cars. Childbirth in the household had a positive indirect effect on women's car use (via the increased number of household cars). The results also showed associations between life events and changes in car ownership per household. Job changes for both men and women exerted a significantly positive impact on the number of household cars, whereas women's retirement negatively affected the number of household cars.

5.2.3. Bidirectional effects between changes in travel mode use and attitudes within household couples

We examined the bidirectional effects between travel mode frequency and attitudes within household partners simultaneously (see Figs. 2–5). For car use, men's attitudes toward car use were positively related to their female partners' car use attitudes. However, no significant effects were observed in the opposite direction. Men's BTM attitudes positively influenced those of their partners, whereas no significant effects were found in the opposite direction. Bidirectional effects revealed that men's attitudes toward bicycle use negatively influenced those of their female partners, whereas women's attitudes toward bicycle use positively affected those of their male partners. Men's train use attitudes improved those of their female partners, whereas women's train use attitudes negatively affected their male partners' train use attitudes. In contrast, men's train use increased that of their female partners, whereas no similar significant effects were identified in the opposite direction.

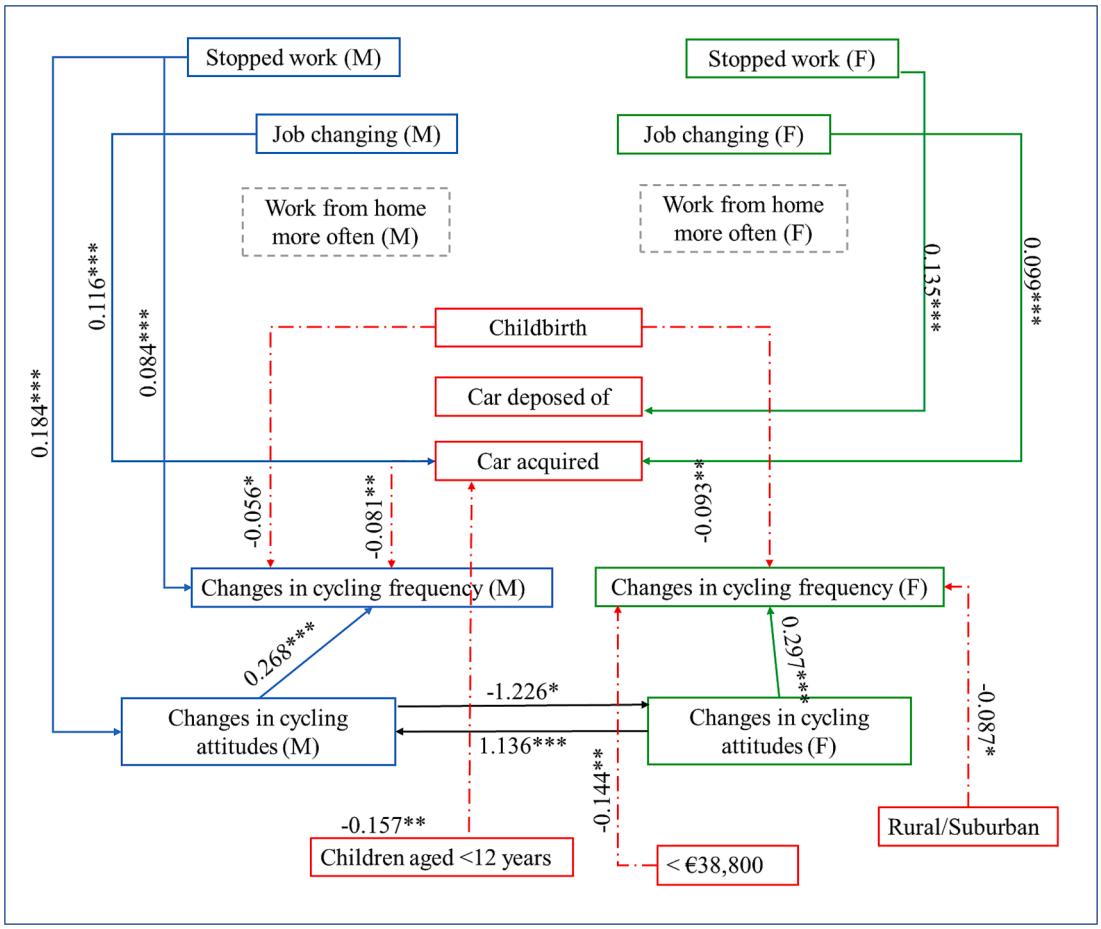

Fig. 3. Results of final SEM model for change in cycling use (coefficients are standardized). Coefficients not significant at the 0.1 level are not shown. Blue dashed paths refer to the male respondents, green paths to the female partner, red line-dotted paths are based on the household level, and black lines represent the correlation between variables. *p < 0.1, **p < 0.05, ***p < 0.01. Model fit: RMSEA/CFI/TLI/WRMR: 0.017/0.968/0.952/0.796. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

5.2.4. Social and spatial characteristics and changes in travel mode frequency and attitudes

The effects of sociodemographic characteristics on changes in travel mode frequency and attitudes were diverse (see Figs. 2–5). We found that highly educated women and women from low-income households had positive attitudes toward car use. Women from low-income households or suburban/rural areas decreased their cycling frequency. Women from both low-income and high-income households showed negative attitudes toward BTM and train use. Age seemed to improve train-use attitudes among women.

6. Discussion and conclusion

Life events, such as changing jobs and childbirth, interact with travel-related events, in our case, changes in car ownership per household. This is likely to lead to changes in long-term personal travel decisions, which are also influenced by intra-household factors (Guan and Wang, 2019a; Rau and Sattlegger, 2018). Therefore, it is imperative to investigate the impacts of life events and travel-related events on travel behavior from a household perspective (Scheiner, 2020) rather than only at the individual level (Kalter et al., 2021). This study adopted such an approach while simultaneously examining the interactive effects of life events and travel-related events on male–female couples' travel behaviors.

The SEM results showed that the influences of life events and household car number changes were related to changes in travel mode frequency and attitudes within partners in a household. We found, for example, that at the household level, changing jobs increased the possibility of acquiring a household car for both partners in a couple, which is in line with a previous study (Scheiner, 2014). In contrast, acquiring a household car negatively affected men's train use, whereas such significant effects were not observed for female partners. These findings imply that while couples in the same household experience similar life events, their mode-specific attitudes and travel behavior may change differently.

Contrary to previous studies (Scheiner, 2020; Scheiner and Holz-Rau, 2012), our study revealed that changing jobs was positively associated with acquiring a household car. This finding suggests that Dutch couples are more egalitarian and believe in equal rights to

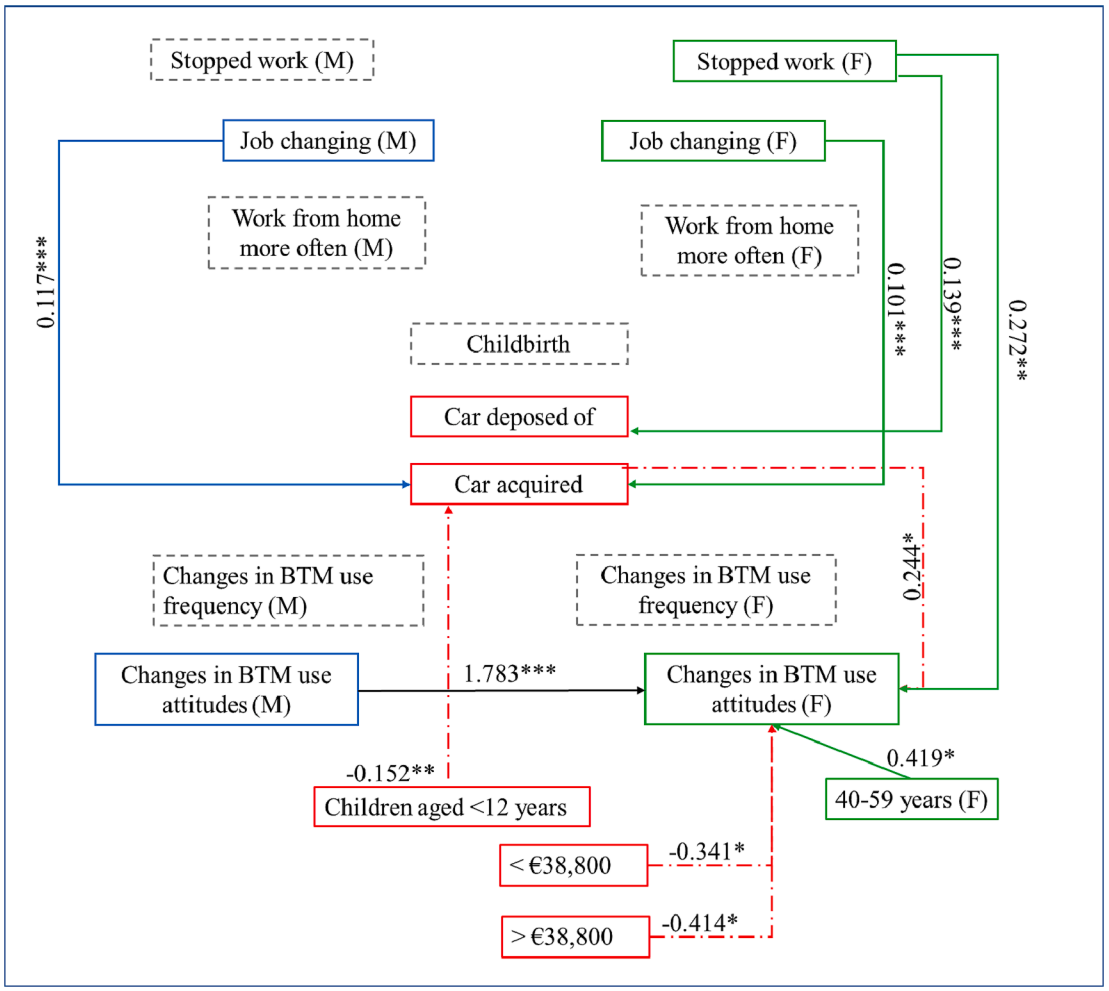

Fig. 4. Results of final SEM model for change in bus/tram/metro use (standardized coefficients). Coefficients not significant at the 0.1 level are not shown. Blue dashed paths refer to the male respondents, green paths to the female partner, red line-dotted paths are based on the household level, and black lines represent the correlation between variables. The grey one shows insignificant links. *p < 0.1, **p < 0.05, ***p < 0.01. Model fit: RMSEA/CFI/TLI/WRMR: 0.015/0.976/0.964/0.751. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

car use concerning changing jobs. One possible explanation is that despite dominant household car use among men (Oakil, 2016) when women start working or get a new job, their need for a car becomes comparable to that of their male partners. For example, women have shorter commutes but longer and more frequent maintenance trips (Gao et al., 2017), including more complex trip chains (e.g., they have to juggle employment and accompany their children (Schwanen et al., 2008)). Therefore, car use may simplify women's daily travel patterns (Chidambaram and Scheiner, 2021).

We also observed that childbirth reduced women's cycling frequency, implying that parents may modify their daily activities and travel behavior to meet the newborn baby's needs (Lanzendorf, 2010). In contrast, retired men showed a higher likelihood of engaging in cycling. For women, stopping work decreased the number of household cars used and positively affected attitudes toward BTM use. This is probably because people may change their travel behavior and attitudes after retirement to adapt to their "new" lifestyle.

In addition, we found adverse indirect effects of men's job changes on public transportation use and positive indirect effects of household childbirth on women's car use via acquiring a household car. These findings suggest that acquiring a household car significantly changed travel behavior. One possible explanation is that if people acquire a car, they may substitute car use for public transit in fulfilling their travel needs.

Sociodemographic characteristics (e.g., household income) were also differentially associated with couples' travel behavior. For example, women from both low-income and high-income households showed negative attitudes toward BTM and train use. In addition, women from low-income households decreased their cycling frequency. This finding suggests that high-income people engaged in more active travel (Fishman et al., 2015; Gao et al., 2017). Thus, higher socioeconomic groups in the Netherlands may be the most likely to be active and engage in more physical activity.

Furthermore, our study shed light on the interdependencies between couples' travel behavior within households. First, one

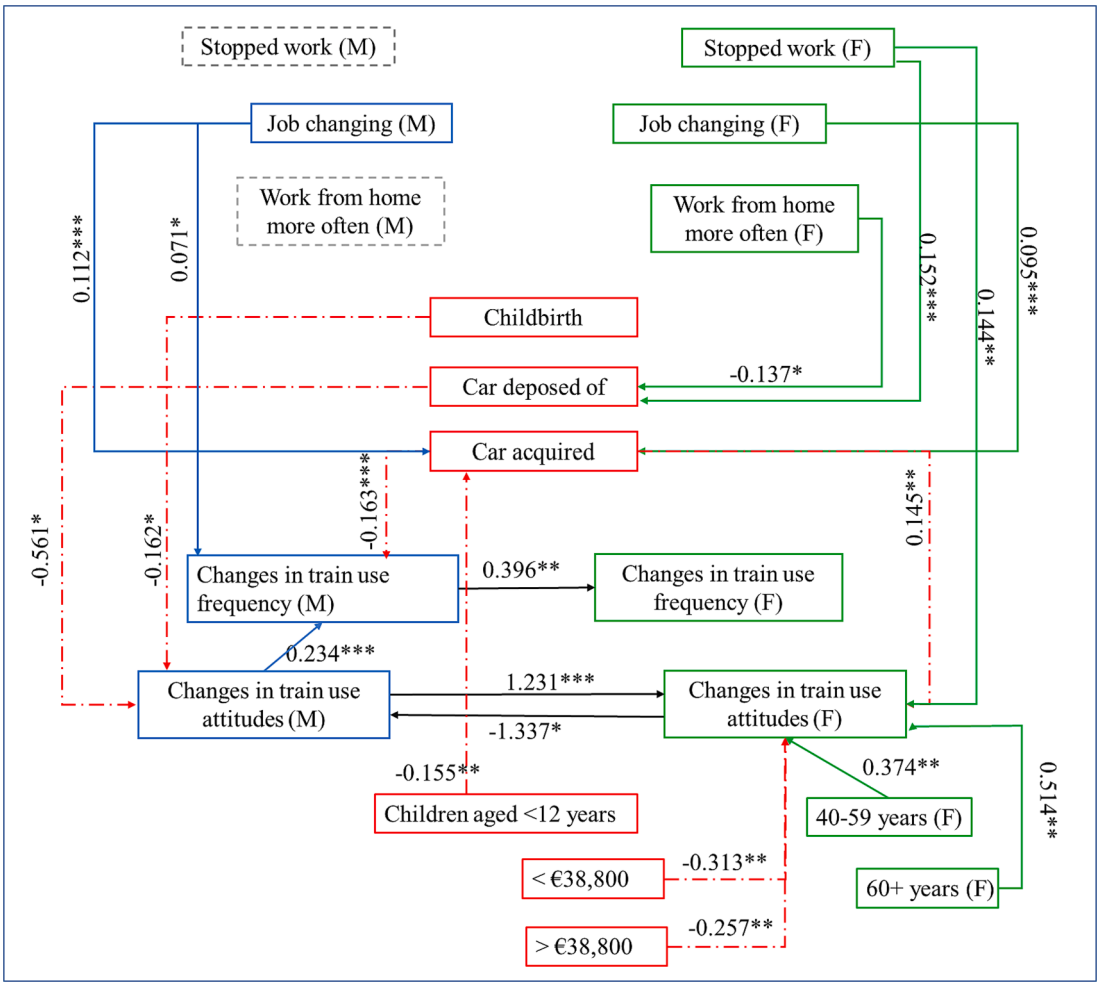

Fig. 5. Results of final SEM model for change in train use (coefficients are standardized). Coefficients not significant at the 0.1 level are not shown. Blue dashed paths refer to the male respondents, green paths to the female partner, red line-dotted paths are based on the household level, and black lines represent the correlation between variables. *p < 0.1, **p < 0.05, ***p < 0.01. Model fit: RMSEA/CFI/TLI/WRMR: 0.019/0.939/0.909/0.820. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

household member's travel decisions were influenced by other household members' attitudes and travel behaviors, which is in line with a previous study (Guan and Wang, 2019a). Second, supporting our hypothesis, women were found to adjust their travel behaviors upon considering the travel patterns of their partners. This means that social roles and accessible resources can explain the interrelationships between couples' travel behaviors and attitudes. For instance, bearing household responsibilities (e.g., childcare and utilitarian household tasks) likely increases women's car use (Schwanen, 2004). In contrast, women's mode-specific attitudes were influenced by those of their male partners, suggesting that patriarchal power relations and gender-specific socialization matter.

This study makes three key contributions to the literature. First, our study emphasizes the significance of investigating how life events affect travel behavior from the perspective of partner households. While a few studies have investigated the links between life events and travel behavior, most of them have been limited to the individual level (Kalter et al., 2021; Oakil et al., 2011; Scheiner, 2014). Therefore, we provide a more comprehensive picture by focusing on the simultaneous effects of individual- and household-level life events on couples' travel behavior. Second, we complement the existing literature by considering household partner interactions on travel behavior changes. For example, men's driving behavior is determined by their female partners and the number of household cars, suggesting that women dominate the interrelationships between couples' travel behaviors (Guan and Wang, 2019a). Moreover, women usually deal with more family activities. Increasing car use is beneficial for women in balancing the time-budget constraints imposed by non-work responsibilities. Third, life events usually coincide; for example, becoming a parent may increase car use over time, whereas cycling is less popular among women after childbirth because of childcare responsibilities.

There are some limitations to this study. First, owing to data limitations, we could not specify the details of the life events we studied, such as whether childbirth events pertained to the couples' first child and whether their jobs were full-time or part-time. Future studies are encouraged to examine the links between these life events and travel behavior longitudinally. The collection of multi-wave data is therefore recommended. In addition, "travel-related events" as a construct only contained one item: "change in the

Table 4
Standardized direct, indirect, and total effect of life events and changes in the number of car ownership on changes in travel mode frequency and attitudes.

Pathways				Gender	Direct effect	Indirect effect	Total effect
Car							
Car acquired	→	Changes in car use frequency		Men	0.163***	–	0.163***
				Women	0.113**	–	0.113**
Car deposed of	→	Changes in car use frequency		Men	−0.632*	–	−0.632*
				Women	–	–	–
Car deposed of	→	Changes in car use attitudes		Men	−0.561*	–	−0.561*
				Women	−0.203*	–	−0.203*
Job changing	→	Car acquired→	Changes in car use frequency	Men	–	0.019**	0.019**
				Women	–	0.012*	0.012*
Train							
Job changing	→	Changes in train use frequency		Men	0.071*	−0.024**	0.047**
				Women	–	–	–
Car acquired	→	Changes in train use attitudes		Men	–	–	–
				Women	0.145**	–	0.145**
Stopped work	→	Changes in train use attitudes		Men	–	–	–
				Women	0.144**	–	0.144**
Childbirth	→	Changes in train use attitudes		Men	−0.162*	–	−0.162*
				Women	–	–	–
Car acquired	→	Changes in train use frequency		Men	−0.163***	–	−0.163***
				Women	–	–	–
Job changing	→	Car acquired→	Changes in train use frequency	Men	–	−0.018***	−0.018***
				Women	–	–	–
Bus/Tram/Metro							
Car acquired	→	Changes in BTM use attitudes		Men	–	–	–
				Women	0.244*	–	0.244*
Stopped work	→	Changes in BTM use attitudes		Men	–	–	–
				Women	0.272**	–	0.272**
Cycling							
Childbirth	→	Changes in cycling frequency		Men	−0.093	–	−0.093
				Women	–	–	–
Work from home	→	Changes in cycling frequency		Men	–	–	–
				Women	−0.103	–	−0.103
Stopped work	→	Changes in cycling frequency		Men	0.084***	–	–
				Women	–	–	−0.081
Car acquired	→	Changes in cycling frequency		Men	−0.081**	–	−0.081
				Women	–	–	–
Stopped work	→	Changes in cycling frequency		Men	0.084***	–	0.084***
				Women	–	–	–
Childbirth	→	Changes in cycling frequency		Men	−0.056*	–	−0.056*
				Women	−0.093**	–	−0.093**
Stopped work	→	Changes in cycling attitudes		Men	0.184***	–	0.184***
				Women	–	–	–
Changes jobs	→	Car acquired→	Changes in cycling frequency	Men	–	−0.009*	−0.009*
				Women	–	–	–

Note: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

number of cars." Another potential item could be "changes in the local public transportation system." Second, we examined the weekly mode use frequency (which did not categorize travel purpose) instead of the self-reported three-day travel diaries. Thus, the specific purposes of weekly mode use frequency require further attention in the future. Moreover, it is worth noting that when Type I errors are controlled in present study, approximately half of all tests may produce falsely significant results (Cribbie, 2007). Nonetheless, there has been little research into the issue of appropriate multiplicity control when testing multiple parameters in SEM. Without proper control, the risk of false-positive results increases, and the accuracy of the results is compromised. Further research into this issue is urgently needed. Finally, besides household couples, other family members, such as older adults and dependent children, could also largely shape family travel mode decisions, an aspect that requires further analysis.

For policy implications, our findings suggest that policymaking should consider interpersonal influences between partners, particularly in response to life events. People may change their travel mode decisions by considering their partners' travel demands and family obligations. For example, changing jobs and childbirth could be potential time points for household car purchases, resulting in different effects on couple members' travel behavior. Additionally, our findings reveal that policies aiming to decrease car use and encourage sustainable travel patterns may influence female and male partners within households differently. As women's travel mode choices are more easily influenced by time and space constraints than those of their male partners, related policies should try to incorporate women's specific needs. Therefore, planners should consider the gender-differentiated influence of life events in response to changes in travel behavior among partners.

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CRediT authorship contribution statement

Jie Gao: Data curation, Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft, Funding acquisition. **Sylvia Y. He:** Writing – review & editing. **Dick Ettema:** Writing – review & editing. **Marco Helbich:** Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tra.2023.103765.

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