# How pregnancy might change women's travel behavior

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**Abstract**

Understanding how to mitigate car dependency in cities has become increasingly important. Life events, such as childbirth, have been reported to influence parents' travel behavior, often leading to greater car dependency. While there is knowledge regarding changes in travel behavior among parents after childbirth, there is less knowledge about how pregnancy itself might change women's (mothers') travel behavior, who bear the primary burden of this event. The present study aims to explore (travel) behavioral responses of women to pregnancy. A latent class analysis was conducted using data from a survey of women (those who have recently experienced this event) in Tehran (n = 646). Employing a (retrospective) survey study, participants were asked about their daily travel behaviors, attitudes, and sociodemographic attributes before and during pregnancy. The results indicate that women show four transition patterns of their travel behavior in response to pregnancy: *increasingly car-dependents*, *consistent walkers*, *transit leavers*, and *continual car-independents*. Nearly half of respondents (*increasingly car-dependents*) utilized cars and walking for their trips prior to pregnancy; however, following pregnancy, there was a notable decrease in walking and an increase in car use. Quarter of respondents (*consistent walkers*) primarily use walking before pregnancy, and this travel behavior remains unchanged after this event. Factors such as attitudes towards travel modes, car ownership, economic level, educational attainment, and child order in household play role on respondents' transition patterns of travel behavior following pregnancy. Results show that those experiencing greater attitudinal changes being more likely to transition away from sustainable travel modes, while those with more stable attitudes showing greater resistance to such transitions.

**Keywords**: Travel behavior, Life events, Women, Pregnancy, Latent class analysis, Public health

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## 1. Introduction

Studies on changes in travel behavior has gained increasing attention, encompassing both day-to-day variability (Kang and Scott, 2010; Egu and Bonnel, 2020) and longer-term changes (de Haas et al., 2018; Scheiner, 2020). The mobility biography framework shows that specific life events can disrupt individuals' daily routines and subsequently change their travel behavior (Lanzendorf, 2010). One of these life events that might occurs in women's life is pregnancy. Studies have not specifically concentrated on the event of pregnancy to analyze its effects on women's travel behavior. Despite numerous investigations in the literature highlighting the significant impact of children on parents' travel behavior and activities, the specific phase of pregnancy remains underexplored. Women adjust their travel behavior in anticipation of pregnancy, unlike men who generally continue their jobs and respond gradually to the childbirth event (Lanzendorf, 2010). Thus, women's respond to this event differ from men.

In many developing countries, cultural norms and beliefs significantly shape women's experiences, particularly during pregnancy and traditional practices often dictate lifestyle choices, travel behaviors, and travel mode choice (Aynalem et al., 2023; Felisian et al., 2023). Additionally, societal pressures may discourage women from engaging in out-of-home activities deemed active or unsafe during pregnancy, impacting their mobility and overall well-being (Aynalem et al., 2023). In the Middle East, where religious practices are deeply established, women might encounter specific challenges during pregnancy that differ from those experienced globally (Hussein et al., 2020; Naja et al., 2021). For example, certain religious customs may restrict women's mobility or dictate their healthcare choices (Roudsari, 2015).

In Iran, traditional views surrounding pregnancy and women's roles contribute to a conservative approach to physical activity (Ahmadi et al., 2021). Women are often expected to adhere to cultural norms that prioritize caution and modesty, particularly during pregnancy. This cultural backdrop can be unsupportive for pregnant women engaging in active transport (e.g., walking and cycling), which is viewed as risky. Consequently, this might affect their level of active transport. While active transport can be beneficial for maintaining physical fitness and overall well-being during pregnancy (Skreden et al., 2016; Gascoigne et al., 2023), it is often discouraged in conservative societies specifically among old generations where traditional views prioritize caution and limit physical activity for pregnant women.

Our study contributes to the literature by investigating how pregnancy might change women's travel behavior in a context with specific cultural norms. Particularly, we aim to explore how women's modality style might change upon pregnancy as a life event among mothers of generation alpha children. Cultural views regarding women and their out-of-home activities even in such societies have been improved significantly these days. Therefore, our study can give updated knowledge surrounding travel behavior of women due to this life event. Also, our findings can help prevent shifts towards less sustainable travel modes and more car-dependency, before these behavioral changes become established. The occurrence of pregnancy affects all mothers (who constitute a significant portion of society), with current mothers who experienced this issue and potential mothers likely facing it in the future. Addressing this research question might reveal specific transition patterns of travel behavior among a large segment of society (mothers) following pregnancy and help mitigate tendencies towards unsustainable travel behavior and increased personal car use. Given mothers' significant role in daily travel patterns of their children after childbirth, the importance of this topic within the context of transportation becomes more important.

## 2. Literature review

To adequately assess how pregnancy might affect parents' travel behaviors, particularly for women, it is insightful to compare their travel behavior during pregnancy with their travel behavior prior to that period. However, past studies have not addressed this topic. Despite numerous studies in the literature emphasizing the significant effects of children on mothers' travel behavior and activities, studies have not specifically analyzed how pregnancy event might make potential shifts in modality/mobility patterns compared to before pregnancy period. A few studies have compared parents' travel behavior during pregnancy and after the childbirth. A study compared the travel behavior of parents in the year prior to become a parent with post-parenthood (McCarthy et al., 2019), although it was not specified whether this period included the pregnancy itself, and compared these travel behaviors to those after childbirth. Another study compared the travel behaviors of ten couples during pregnancy with their travel behaviors following childbirth (Zwerts et al., 2007) and in another one, interviews with 25 individuals (three of whom were pregnant) focused solely on before and post-birth travel behaviors without discussing pregnancy itself (McCarthy et al., 2021). Since childbirth can to some extent resemble the pregnancy event and there is a wealth of literature on childbirth, studies examining the impact of childbirth on parents' travel behavior have been reviewed.

Previous studies have examined the impact of childbirth on parents' travel behavior, generally indicating an increase in car use and a decrease in the use of sustainable travel modes and they found that this event can increase the likelihood of changes in household car ownership (Beige and Axhausen, 2012; Schoenduwe et al., 2015; de Haas et al., 2018; McCarthy et al., 2019; McCarthy et al., 2021). Most studies are conducted in developed countries. These studies show that travel behavior of women might be significantly different from men, for example, in Japan (Zhang et al., 2014), USA (Chakrabarti and Joh, 2019), Netherlands (Schwanen, 2011), Germany (Matthies et al., 2002), Sweden (Polk, 2004), Serbia (Basaric et al., 2016), Austria (Janke, 2021), Poland (Maciejewska and Miralles-Guasch, 2020), Spain (Sánchez and González, 2016), UK (Tilley and Houston, 2016), China (Hu et al., 2022). Therefore, some studies have focused on the differential effects of childbirth on mothers and fathers, revealing that childbirth has a more significant impact on mothers' travel behavior compared to fathers. In a study conducted by Beige and Axhausen, 2012, men showed more stable travel behaviors during life events than women, who appeared more flexible. This suggests that women adopt new changes and adjustments in their travel behavior following childbirth. Before childbirth, mothers typically undertook fewer daily trips than fathers; however, after childbirth, their travel frequency approached that of fathers (Zwerts et al., 2007). For men, this event might decrease their public transport and cycling use, with little effect on other travel modes; But conversely, for women, the event results in a significant increase in car use (as drivers) and walking and a notable decrease in cycling and car use (as passengers), along with some reduction in public transport use (Scheiner and Holz-Rau, 2013). The extent of change in travel behavior after childbirth (whether for the first child or subsequent ones) was more pronounced for mothers than for fathers (Scheiner, 2014). With the birth of a child, the likelihood of transitioning from "no access/shared access to a car" to "full access to a car" is greater for women than for men (Oakil, 2016). This event affects the use of other travel modes of parents as well. Gao et al., 2023 examined the impact of childbirth on parents travel behavior and observed that this event reduced women's cycling frequency, probably because of modifying their daily activities and travel behavior to meet the newborn baby's needs.

Some studies have more precisely examined the differences in individuals' responses to the childbirth and grouped them. Childbirth affects mothers differently. Generally, the patterns that mothers follow after the birth of their first child depend on their attitudes, economic factors, and whether they owned a car before childbirth

(Lanzendorf, 2010). In another study, new parents were grouped based on their travel patterns before and after childbirth. The findings revealed that after the birth of a child, individuals across all groups showed a high likelihood of transitioning to either "car-dependent individuals" or "mixed-mode users" (using both cars and walking). Overall, an increased dependency on cars was evident post-childbirth, attributed to the suitability of cars for traveling with children (de Haas et al., 2018). McCarthy et al., 2019 explored various travel patterns among new parents following childbirth. These new travel patterns ranged from a significant reduction in public transport use to stable travel behaviors compared to pre-parenthood. The results indicated that not all individuals adopted car-dependent travel behaviors after becoming parents, and each of the five groups showed unique characteristics and constraints in their travel behavior.

Travel behavior can be influenced by various factors, including attitudes toward travel modes, car ownership, economic level, and educational attainment. Attitudes toward different travel modes can influence individuals' travel behavior through the lens of theory of planned behavior (Ajzen, 1991). Favorable attitudes toward public transport (PT), for example, are associated with higher PT use, as individuals perceive this travel mode as more convenient, reliable, or cost-effective (Heinen & Chatterjee, 2015), whereas pro-car attitudes promote car dependency (Anable, 2005). Car ownership is another determinant of travel behavior. Households with higher car ownership levels indicate lower public transport use and higher car dependency due to the flexibility and time efficiency of private cars (Dargay, 2001). Additionally, increased car ownership is correlated with lower walking and cycling rates (Ewing & Cervero, 2010). Economic level can influence travel behavior by determining affordability and accessibility to different travel modes. Higher-income individuals are more likely to own private cars and rely on them for daily travel, prioritizing comfort and travel time over cost (Giuliano & Dargay, 2006). Individuals with higher educational levels tend to have greater awareness of the environmental impacts of transportation and may be more inclined to use sustainable travel modes such as cycling and public transport (Chatterjee et al., 2013). Therefore, we incorporate these variables as other variables (inactive covariates) of modal/mobility change of women upon pregnancy in our study.

The current research aims to evaluate how women's travel behaviors change after becoming pregnant in a developing country with specific cultural norms. Some studies have indicated that the retrospective approach is appropriate for collecting data on significant life events (Beige and Axhausen, 2012). It has been shown that individuals remember changes in their travel behavior more accurately when linked to significant life events (Behrens and Mistro, 2010). Several studies recommend relating data to important life events to enhance reliability (Beige and Axhausen, 2008; Oakil et al., 2014). The approach used in this study for data collection is retrospective, with the questionnaire designed based on this premise. Our study identifies differences in the transition patterns of travel behavior following pregnancy. In other words, various groups of women will be categorized based on their behavioral responses to pregnancy. Additionally, other variables (inactive covariates), e.g., attitudes and sociodemographic, contributing to differences among these groups in response to pregnancy will be profiled. This approach will provide insights into how pregnancy influences women's travel behaviors and inform targeted policies that address their specific needs during this critical transition.

**3. Method**

*3.1. The study context and sample*

The current study was conducted in Tehran, a metropolitan area with a good public transport system compared to other cities in Iran. Tehran, the capital of the country, has a population exceeding 9 million and boasts a public transport network that includes metro, BRT, buses, and line-taxis. The data used in this research was obtained through a questionnaire distributed in May 2022 in the city of Tehran. All respondents were mothers

of 6 or 7-year-old children, and the questionnaires were delivered to them through their children's school. This approach was taken because the questionnaires were designed based on this age group. Schools were asked to have first-grade and preschool teachers distributed the questionnaires to their students and request that the mothers complete them and return them to the teacher. Before distributing the questionnaires, teachers were informed about the nature of the questions and the reason for their distribution to ensure they were aware of the process. Given the size of Tehran, the city was divided into various districts, and stratified sampling was conducted based on the population of each district. In total, 1,834 questionnaires were distributed, with 1,223 questionnaires returned. After reviewing the questionnaires and excluding incomplete or missed responses, 731 questionnaires remained. Respondents who were not present in either before pregnancy or during pregnancy periods, or both, in Tehran were excluded from the analysis. This exclusion was necessary to ensure that respondents had been present in the same city during both periods to enhance analytical accuracy. Ultimately, the sample size for the analysis was reduced to 646.

The selection of the sample for this research was indeed intended to be from pregnant women or those who had recently given birth, as this would facilitate easier recall for the respondents. However, in a context like Iran, due to religious and cultural issues, it was quite challenging to approach women at this stage. Therefore, the only feasible way we felt could be used to reach them was somewhat delayed. It was decided to contact them through their children in schools. It is not recommended in Iran's educational system to do survey studies in the kindergartens. Thus, to minimize the time gap between the inquiry and the occurrence of pregnancy, only preschool and first-grade students were selected for distributing the questionnaires among their mothers, while students from higher grades were not considered.

*3.2. Measures*

To assess how pregnancy might affect women's travel behaviors, questionnaire asked their travel behavior and other characteristics based on two stages: (i) stage 1: one year (12 months) before childbirth (named before pregnancy), and (ii) stage 2: sixth month of pregnancy (named during pregnancy). More specifically, respondents were asked to recall these two specified stages and then recall their travel behaviors and other characteristics in these two periods. Since mothers are typically aware of the exact year and month of their child's birth, the stages in questionnaire were selected based on the childbirth event to facilitate easier recollection for the mothers. Therefore, for inquiries regarding the before pregnancy stage, "one year before childbirth" was asked, and for the during pregnancy stage, the "sixth month of pregnancy" was queried, which corresponds to approximately three months before the childbirth.

The questionnaire comprises six sections: travel behavior, attitudes toward travel modes, socio-economic characteristics, ownership and access to travel modes, accident experiences, and life events. Before the questions began, information was gathered on the mother's age, the type of school the child attends, the district of the child's school, and the child's birth order.

In the first section, the transition patterns of travel behavior from before pregnancy to during pregnancy was assessed through two specific questions. In the first question, respondents indicated how many days per an average week they used various travel modes for non-essential trips in one year before childbirth. Non-essential trips refer to urban trips for purposes other than work or study, for example, shopping, visiting, and recreation; this clarification was provided in the questionnaire. The questions covered four travel modes: household car,

public transport (subway, BRT, bus, line-taxi[2]), walking, and telephone-taxi[3]/ride-hailing. Respondents selected from eight options, with answer scale from (0) no use in the week, to (7) everyday use in the week. Notably, due to low bicycle use in Iran (especially among women), this travel mode was excluded. The next question addressed the same question (travel behavior) repeated for the sixth month of pregnancy. Respondents indicated how many days per an average week they used various travel modes for non-essential trips in the sixth month of pregnancy. This study focused on non-essential trips, because many women may not be employed before and during pregnancy. Therefore, asking about all trips or work-related trips would not be logical. However, all women (both employed and non-employed) have opportunities for non-essential trips, making this a valid basis for comparing individual travel behavior.

As for attitudes toward travel modes, the second section asked how respondents evaluate each of the following aspects/needs (i.e., comfort, safety, health, environmental compatibility, and affordability) of transport when they use a travel mode. For cars, for example, these questions include 'Travelling by car is comfortable.', 'Travelling by car is safe.', 'Travelling by car is healthy.', 'Travelling by car is environmentally friendly.', and 'Travelling by car is affordable'. This instrument measuring attitudes towards travel modes have been tested in past research (Kroesen and Chorus, 2020; Karami et al., 2023). A five-point Likert scale from (1) totally disagree, to (5) totally agree was used to measure these items. The same questions asked for other travel modes (i.e., public transport, walking, and telephone-taxi /ride-hailing). The questions were also asked for both periods (one year before childbirth and the sixth month of pregnancy).

The third section queried socioeconomic characteristics for one year before childbirth and the sixth month of pregnancy, including the mother's employment status, and education level. We also measured ownership and access to travel modes during both time periods, addressing holding of a driver's license, number of household cars, and the condition of pedestrian facilities in the residential area. In another section, respondents reported their accident experiences while using their household car from one year before childbirth until the sixth month of pregnancy. This question was repeated for public transport, walking, and telephone-taxi/ride-hailing. The final section addressed other life events occurring from one year before childbirth until the sixth month of pregnancy, including relocation within the city, leaving the labor market, and university graduation.

*3.3. Analysis method*

The objective of the study is to identify different groups of women based on their transition pattern of travel behavior following pregnancy. To achieve this, a Latent Class Analysis (LCA) was conducted using Latent Gold software (Vermunt and Magidson, 2005). LCA, a type of finite mixture model, probabilistically assigns individuals to classes, unlike traditional cluster-based techniques (Vermunt, 2002).

It is the principal objective of latent class analysis to identify the model that captures most effectively the relationships among the indicators by having the fewest latent classes (Kroesen, 2019). The Bayesian Information Criterion (BIC) is used to assess and compare models with different numbers of classes (Vermunt and Magidson, 2013). When comparing different solutions, the one with the lowest BIC is preferred (Vermunt and Magidson, 2013). Therefore, the BIC is the primary criterion to consider, followed by other factors such as the smallest class size (Mehdizadeh and Klockner, 2024). To ensure the preferred solution does not include a

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[2] Line-taxi is a form of public transport that operate along a fixed and predetermined route between two points within the city, with a fixed fare. Unlike private hire taxis, line-taxis do not depart until they reach full capacity, and passengers are required to disembark along the route.

[3] Telephone-taxi is an urban transportation service in which passengers request a vehicle with a driver for exclusive use by making a phone call. The vehicle is sent directly to the address of the requester. This service is typically provided by private companies.

class with a very small size, we assumed that a class with approximately 8 % of the sample is reliable (Ton et al., 2020; Mehdizadeh et al., 2024).

The modeling framework of this study is shown in Fig. 1. This study conducted two LCAs for each period: before pregnancy and during pregnancy. For before pregnancy period, a LCA was conducted utilizing the following indicator variables: household car use, public transport use, walking, and telephone-taxi/ride-hailing use in one year before childbirth. To identify the optimal model, supplementary models were computed, ranging from one to ten latent classes. According to BIC statistics and the smallest class size, the 2-class model emerges as the most optimal model (Table 1). The classes for this period are designated as Class $C_{I, pre}$ (comprising 75% of the data) and Class $C_{II, pre}$ (comprising 25% of the data). For during pregnancy period, another LCA was conducted utilizing the following indicator variables: household car use, public transport use, walking, and telephone-taxi/ride-hailing use in the sixth month of pregnancy. Again, to identify the optimal model, supplementary models were computed, ranging from one to ten latent classes. According to BIC statistics and the smallest class size, the 2-class model emerges as the most optimal model (Table 2). The classes for this period are labeled as Class $C_{I, post}$ (comprising 53% of the data) and Class $C_{II, post}$ (comprising 47% of the data). The estimation results for the latent class analysis model (measurement component) in both stages are presented in Table A.1 and Table A.2 in Appendix A.

**Table 1**

Fit statistics for the LCA before pregnancy

| N of Classes | Log-Likelihood | BIC(LL) | Smallest class size |
|---|---|---|---|
| 1-Class | -4549 | 9280 | Accepted* |
| **2-Class** | **-4483** | **9180** | **Accepted** |
| 3- Class | -4467 | 9191 | Accepted |
| 4- Class | -4456 | 9199 | Rejected |
| 5- Class | -4448 | 9208 | Rejected |
| 6- Class | -4445 | 9234 | Rejected |
| 7- Class | -4436 | 9248 | Rejected |
| 8- Class | -4434 | 9277 | Rejected |
| 9- Class | -4429 | 9299 | Rejected |
| 10- Class | -4424 | 9322 | Rejected |

Accepted: the smallest class size is ≥ 8%.


**Table 2**

Fit statistics for the LCA during pregnancy

| N of Classes | Log-Likelihood | BIC(LL) | Smallest class size |
|---|---|---|---|
| 1- Class | -4356 | 8895 | Accepted* |
| **2- Class** | **-4310** | **8826** | **Accepted** |
| 3- Class | -4290 | 8834 | Rejected |
| 4- Class | -4281 | 8842 | Rejected |
| 5- Class | -4270 | 8850 | Rejected |
| 6- Class | -4257 | 8858 | Rejected |
| 7- Class | -4255 | 8886 | Rejected |
| 8- Class | -4249 | 8907 | Rejected |
| 9- Class | -4241 | 8922 | Rejected |
| 10- Class | -4243 | 8959 | Rejected |

Accepted: the smallest class size is ≥ 8%.

As observed in Fig. 1, for before pregnancy, respondents are either in Class $C_{I,\,pre}$ or Class $C_{II,\,pre}$; and for during pregnancy, respondents are either in Class $C_{I,\,post}$ or Class $C_{II,\,post}$. Thus, to determine the transition patterns of travel behavior from before pregnancy to during pregnancy, respondents could be divided into four groups:

1. Those who were in Class $C_{I,\,pre}$ in before pregnancy and in Class $C_{I,\,post}$ in during pregnancy (Group A).
2. Those who were in Class $C_{I,\,pre}$ in before pregnancy and in Class $C_{II,\,post}$ in during pregnancy (Group B).
3. Those who were in Class $C_{II,\,pre}$ in before pregnancy and in Class $C_{I,\,post}$ in during pregnancy (Group C).
4. Those who were in Class $C_{II,\,pre}$ in before pregnancy and in Class $C_{II,\,post}$ in during pregnancy (Group D).

To capture the distinct behavioral contexts and underlying class structure at each stage, we opted to estimate two separate LCA models: one for Stage 1 and one for Stage 2. This approach allows for more accurate identification of behavioral types and their transitions over time, without imposing potentially invalid assumptions of temporal invariance. From these two LCA models, we derived latent classes for each stage (two classes for each stage). However, our intention was not to estimate the relationship between the other variables (inactive covariates) and the classes derived from the measurement model (Class$_{CI,\,pre}$, Class$_{CII,\,pre}$, Class$_{CI,\,post}$, and Class$_{CII,\,post}$), but rather to profile the transition patterns of classes based on other variables (inactive covariates). As mentioned by Kim and Mokhtarian, 2023, simultaneous modeling means that the specifications of the measurement and structural models will affect each other, and if the analyst does not want this situation (e.g., if it helps reduce the chance of having estimation issues), a two-step approach may be beneficial. Therefore, we decided to follow a two-step approach, as illustrated in Fig. 1. In the first step, we determined travel behavior transitions from Stage 1 to Stage 2 (four groups) directly based on observation, and in the second step, we computed group-specific averages post-estimation to estimate the relationship between the groups and other variables (inactive covariates). Typically, latent class models estimate both measurement and structural models simultaneously, and the two-step approach may not be fully efficient or may have an inferior goodness-of-ft (Kim and Mokhtarian, 2023).

The inactive covariates chosen for the analysis include respondents' attitudes towards travel modes, sociodemographic attributes, ownership and access to travel modes in both before and during pregnancy periods, as well as accident experiences and life events between these two periods. The transition groups were profiled across different inactive covariates (measured for both pre and post pregnancy) to see how these variables (e.g., attitudes towards different travel modes, car ownership) explain behavioral change (modality change).
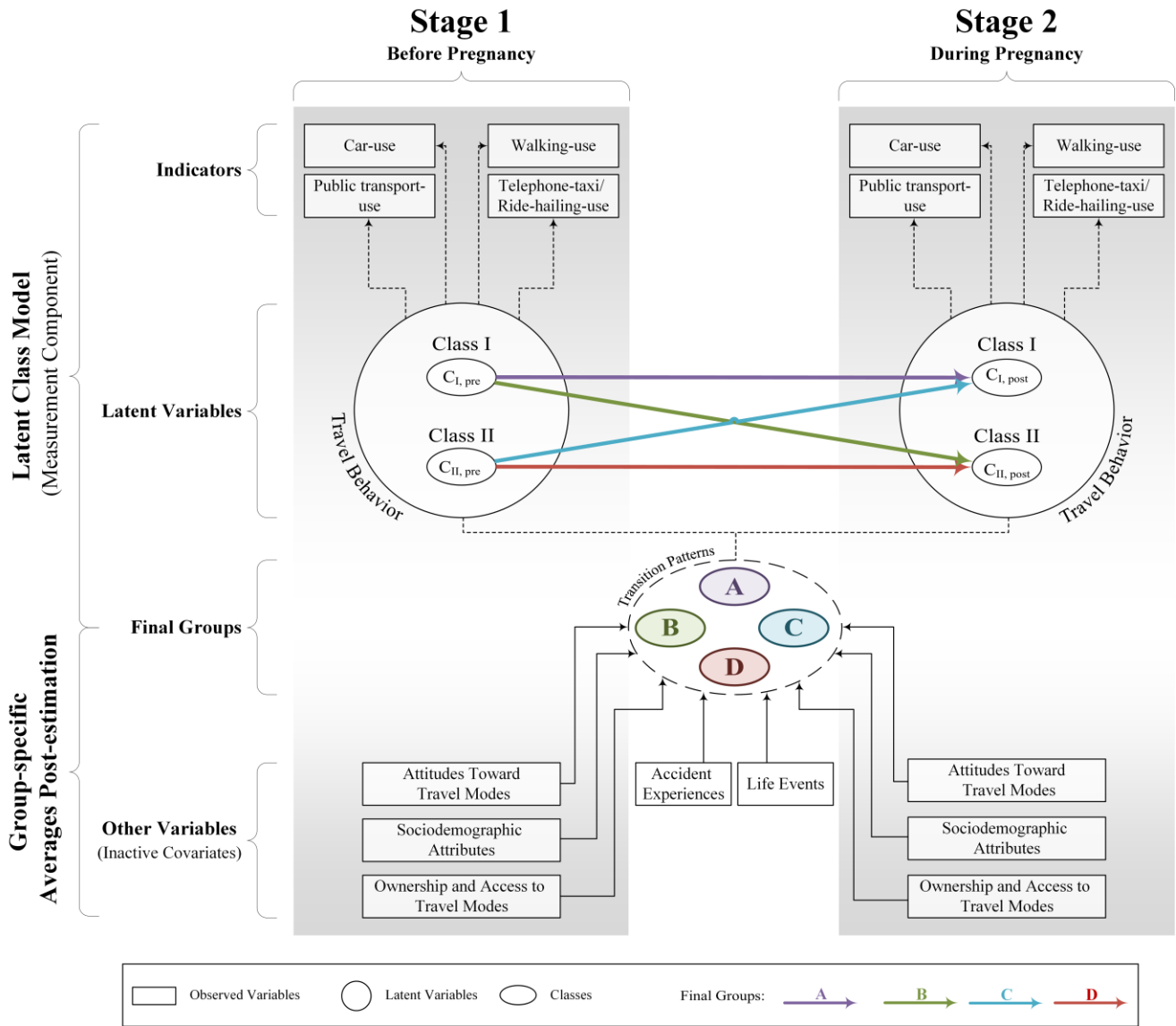
**Fig. 1.** The conceptual modeling framework

## 4. Results

### 4.1. Descriptives

Descriptive statistics for travel mode use and attitudes toward travel modes are shown in Fig. 2. As shown in Fig. 2(a), before pregnancy, mothers use walking more frequently and telephone-taxi/ride-hailing less than other travel modes. However, during pregnancy, both walking and car are the most frequently used travel modes, while public transport becomes significantly less desirable in response to pregnancy, making it the least frequently used travel mode during this period. As shown in Fig. 2(b), attitudes toward travel modes for the sample are presented in five aspects: comfort, safety, health benefits, environmental compatibility, and affordability. Considering attitudes toward cars in both before and during pregnancy, comfort and safety are stronger than other aspects, while environmental compatibility is the weakest. Regarding attitudes toward public transport in both before and during pregnancy, environmental compatibility and affordability are stronger than other aspects, whereas comfort, health benefits, and safety are the weakest. For attitudes toward walking, before pregnancy, health benefits, environmental compatibility, affordability, and comfort are

stronger aspects, while safety is the weakest. During pregnancy, health benefits, environmental compatibility, and affordability remain stronger aspects.

Descriptive statistics for sociodemographic attributes, ownership and access to travel modes, accident experiences, and life events are presented in Table A.3 and Table A.4 in Appendix A. As shown in Table A.3 and Table A.4, 8% of mothers were 29 years old or younger, 63% were 30-39 years old, and 29% were 40 years or older. Additionally, 56% of mothers were pregnant with their first child, while 44% were pregnant with a subsequent child. Regarding employment status, before pregnancy, 20% of mothers were employed full-time, 16% part-time, 60% unemployed, and 4% students. However, in post pregnancy, 13% were employed full-time, 10% part-time, 74% unemployed, and 3% students. Before pregnancy, 57.7% of mothers held a driver's license, increasing to 58.8% in during pregnancy, and household car ownership was 0.84 in this period, rising to 0.87 in during pregnancy. From before to during pregnancy period, 27.4% of mothers relocated within the city, 12.8% left the labor market, and 3.3% graduated from university. Some variables (inactive covariates), such as education, holding of a driver's license, and the condition of pedestrian facilities in the living area, remained relatively stable across both periods.

*4.2. Transition patterns*

As illustrated in Fig. 3, each group has a different transition pattern of travel behavior in response to pregnancy. For each group, the average share of travel modes is shown for both before and during pregnancy periods and the change in the share of travel modes between these two periods is described. According to Fig. 3 (the last column), the overall transition pattern of travel behavior of the sample in response to this event is characterized by an increase in the car and telephone-taxi/ride-hailing use, alongside a decrease in the public transport and walking use. Notably before pregnancy, the primary travel mode of women is walking. In this period, on average, women walk for 40% of their trips and make 30% of their trips with car, which ranks second. However, in response to pregnancy, as walking decreases and car use increases, the level of use between these two travel modes becomes equal (both of them reached to 35%). Additionally, before pregnancy, women, on average, utilize public transport for 20% of their trips and make 10% of their trips with telephone-taxi/ride-hailing, which ranks last. However, in response to pregnancy, with a reduction in public transport use and an increase in telephone-taxi/ride-hailing use, public transport loses its position to telephone-taxi/ride-hailing and falls to the last position (both of them reached to nearly 15%).
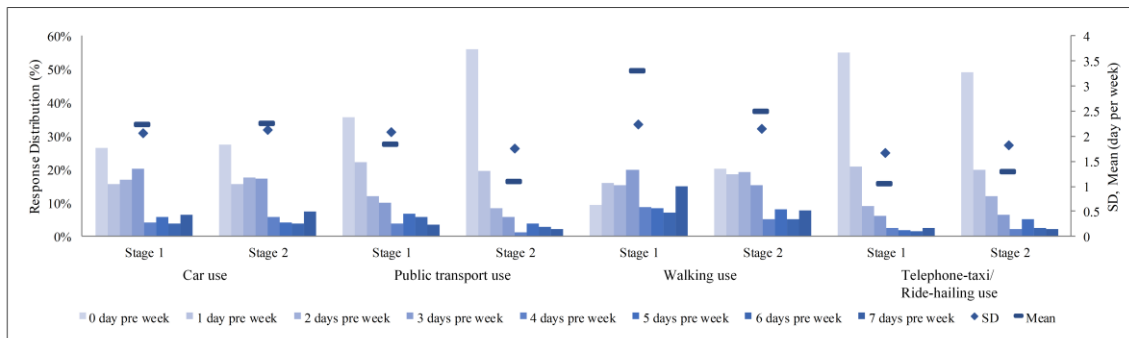
a) Travel modes use in Stage 1 and Stage 2
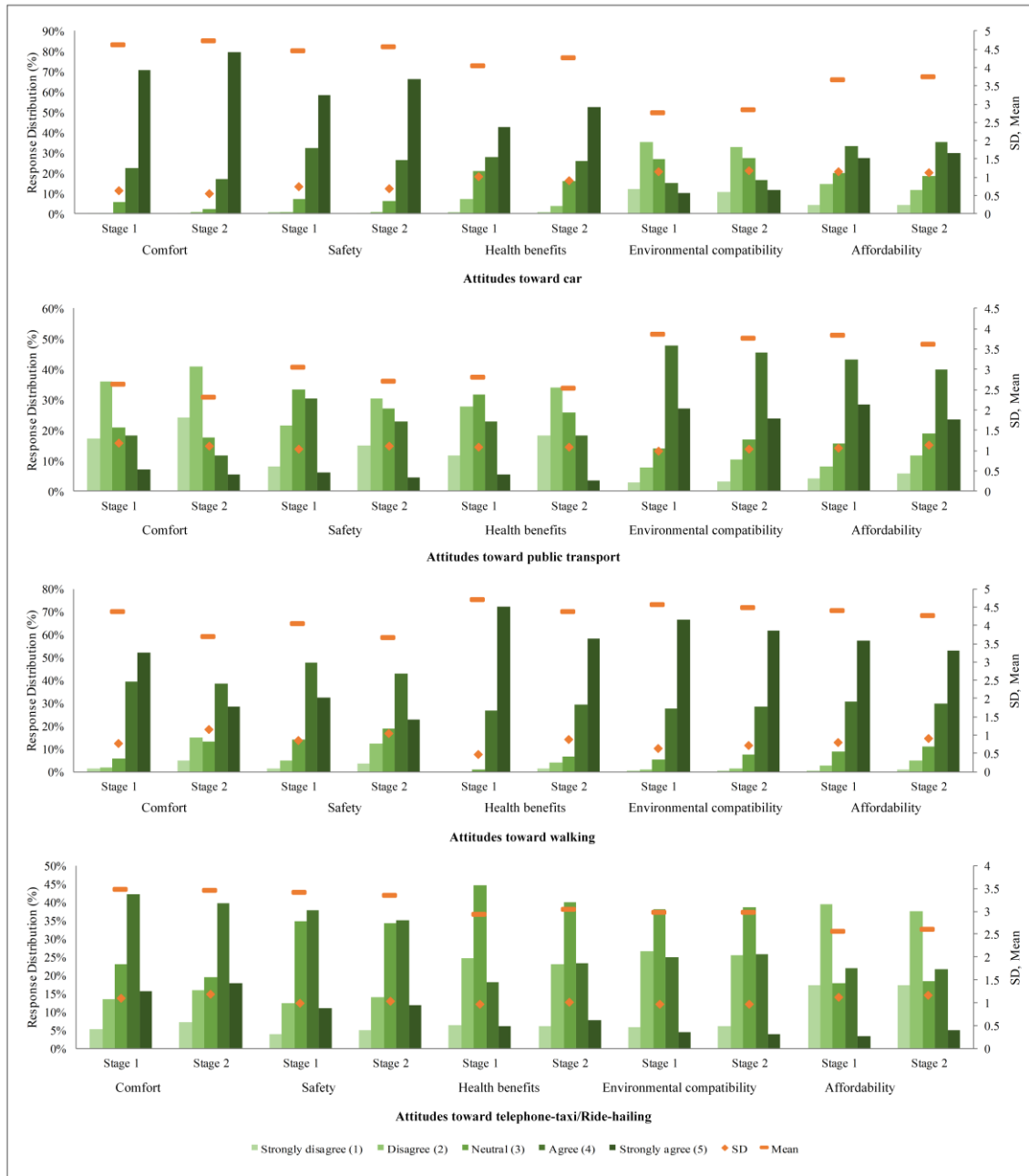


b) Attitudes toward travel modes in Stage 1 and Stage 2

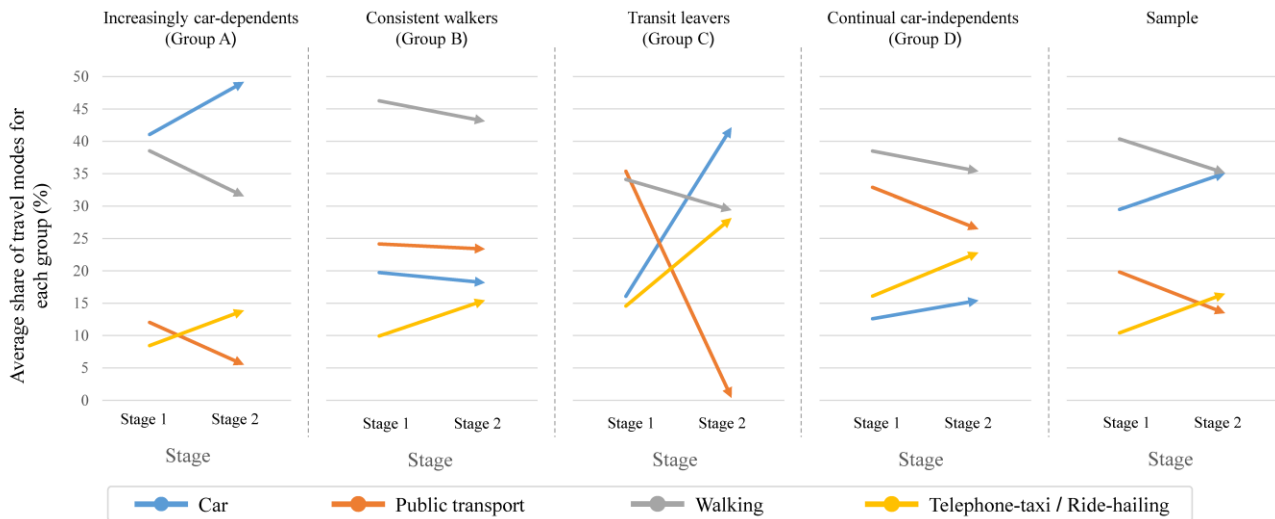**Fig. 2.** Travel mode use and attitudes toward travel modes

Fig. 3. The transition patterns of travel behavior in response to pregnancy for each group

As shown in Fig. 3, the four groups show completely different transition patterns of travel behavior in response to pregnancy, with some of these transition patterns not aligning with the responses of the whole sample. This indicates that grouping individuals might have more accurate understanding of their travel behaviors. These four groups are labeled as follows: *increasingly car-dependents* (Group A), *consistent walkers* (Group B), *transit leavers* (Group C), and *continual car-independents* (Group D). The indicators and other variables (inactive covariates) of the model for each of these groups can be seen in Table 3. Moreover, Fig. 4 presents the attitudes toward travel modes in response to pregnancy for each group. For the interpretation of results, the degree of favorability in these attitudes is expressed in relative terms. For instance, regarding the attitudes toward the safety of telephone-taxi or ride-hailing, the score for this attitude in Group A is approximately 3.3, which is above the neutral point. However, when compared to the scores of other groups, this value is relatively unfavorable. The characteristics of each of these groups can be described as follows.

**Table 3**

Distribution of inactive covariates on Groups (transition patterns of travel behavior)

| Group | | A | B | C | D | Sample |
|---|---|---|---|---|---|---|
| | Group size | 52% | 26% | 5% | 17% | |
| Travel mode use before pregnancy (day pre week) [mean] | Car | 2.49 | 1.74 | 2.61 | 2.15 | 2.24 |
| | Public transport | 0.69 | 1.72 | 4.87 | 4.81 | 1.85 |
| | Walking | 2.3 | 3.54 | 4.84 | 5.69 | 3.31 |
| | Telephone-taxi/Ride-hailing | 0.58 | 0.76 | 2.26 | 2.66 | 1.05 |
| Travel mode use in during pregnancy (day pre week) [mean] | Car | 2.4 | 1.71 | 3.52 | 2.26 | 2.25 |
| | Public transport | 0.14 | 1.75 | 0.03 | 3.43 | 1.11 |
| | Walking | 1.35 | 3.53 | 2.16 | 4.56 | 2.5 |
| | Telephone-taxi/Ride-hailing | 0.66 | 1.3 | 2.23 | 3.06 | 1.3 |
| Economic level of child' school region | Rich | 0.14 | 0.08 | 0.26 | 0.06 | 0.12 |
| | Upper-middle | 0.24 | 0.16 | 0.23 | 0.28 | 0.22 |
| | Lower-middle | 0.35 | 0.39 | 0.29 | 0.4 | 0.36 |
| | Low | 0.28 | 0.38 | 0.23 | 0.26 | 0.3 |
| Type of child' school | Public | 0.87 | 0.95 | 0.97 | 0.97 | 0.91 |
| | Private | 0.13 | 0.05 | 0.03 | 0.03 | 0.09 |
| Child order in household | First child | 0.54 | 0.52 | 0.84 | 0.57 | 0.56 |
| | Subsequent child | 0.46 | 0.48 | 0.16 | 0.43 | 0.44 |
| Mother's age group | 29 years or younger | 0.07 | 0.12 | 0.06 | 0.08 | 0.08 |
| | 30-39 years | 0.62 | 0.62 | 0.77 | 0.63 | 0.63 |
| | 40 years or older | 0.31 | 0.26 | 0.16 | 0.29 | 0.29 |
| Mother's age group during pregnancy | 24 years or younger | 0.21 | 0.23 | 0.23 | 0.22 | 0.22 |
| | 25-34 years | 0.67 | 0.66 | 0.74 | 0.65 | 0.67 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 35 years or older | 0.12 | 0.11 | 0.03 | 0.13 | 0.11 |
| Employment status (before pregnancy) | Full-time | 0.19 | 0.15 | 0.29 | 0.28 | 0.2 |
| | Part-time | 0.15 | 0.15 | 0.32 | 0.14 | 0.16 |
| | Unemployed | 0.62 | 0.68 | 0.35 | 0.51 | 0.6 |
| | Student | 0.04 | 0.02 | 0.03 | 0.07 | 0.04 |
| Employment status (during pregnancy) | Full-time | 0.12 | 0.12 | 0.1 | 0.16 | 0.13 |
| | Part-time | 0.08 | 0.1 | 0.13 | 0.14 | 0.1 |
| | Unemployed | 0.76 | 0.76 | 0.77 | 0.67 | 0.74 |
| | Student | 0.04 | 0.01 | 0 | 0.04 | 0.03 |
| Education (before pregnancy) | Under diploma | 0.12 | 0.22 | 0.13 | 0.18 | 0.16 |
| | Diploma or associate degree | 0.45 | 0.45 | 0.35 | 0.4 | 0.44 |
| | Bachelor's degree | 0.31 | 0.29 | 0.39 | 0.33 | 0.31 |
| | Master's degree | 0.1 | 0.02 | 0.13 | 0.09 | 0.08 |
| | Doctorate or higher | 0.01 | 0.01 | 0 | 0 | 0.01 |
| Education (during pregnancy) | Under diploma | 0.12 | 0.22 | 0.13 | 0.18 | 0.16 |
| | Diploma or associate degree | 0.45 | 0.44 | 0.29 | 0.37 | 0.42 |
| | Bachelor's degree | 0.32 | 0.3 | 0.42 | 0.33 | 0.32 |
| | Master's degree | 0.11 | 0.03 | 0.16 | 0.12 | 0.09 |
| | Doctorate or higher | 0.01 | 0.01 | 0 | 0 | 0.01 |
| Holding of a driver's license (before pregnancy) (mean) | | 0.63 | 0.47 | 0.61 | 0.56 | 0.58 |
| Holding of a driver's license (during pregnancy) (mean) | | 0.64 | 0.49 | 0.61 | 0.58 | 0.59 |
| Household car ownership (before pregnancy) (mean) | | 0.97 | 0.71 | 0.81 | 0.68 | 0.84 |
| Household car ownership (during pregnancy) (mean) | | 0.99 | 0.74 | 0.9 | 0.7 | 0.87 |
| Attitude toward car [Mean – A scale of 1 (totally disagree) to 5 (totally agree)] | Comfort (before pregnancy) | 4.68 | 4.55 | 4.61 | 4.6 | 4.63 |
| | Comfort (during pregnancy) | 4.8 | 4.71 | 4.87 | 4.66 | 4.75 |
| | Safety (before pregnancy) | 4.53 | 4.39 | 4.48 | 4.4 | 4.47 |
| | Safety (during pregnancy) | 4.64 | 4.44 | 4.71 | 4.52 | 4.57 |
| | Health benefits (before pregnancy) | 4.08 | 3.95 | 4.16 | 4.05 | 4.04 |
| | Health benefits (during pregnancy) | 4.31 | 4.09 | 4.55 | 4.32 | 4.26 |
| | Environmental compatibility (before pregnancy) | 2.8 | 2.79 | 2.39 | 2.71 | 2.76 |
| | Environmental compatibility (during pregnancy) | 2.88 | 2.89 | 2.52 | 2.86 | 2.86 |
| | Affordability (before pregnancy) | 3.68 | 3.65 | 3.65 | 3.61 | 3.66 |
| | Affordability (during pregnancy) | 3.76 | 3.72 | 3.81 | 3.76 | 3.75 |
| Attitude toward public transport [Mean – A scale of 1 (totally disagree) to 5 (totally agree)] | Comfort (before pregnancy) | 2.41 | 2.92 | 2.39 | 2.9 | 2.63 |
| | Comfort (during pregnancy) | 2.17 | 2.67 | 2.06 | 2.37 | 2.33 |
| | Safety (before pregnancy) | 2.93 | 3.28 | 2.9 | 3.1 | 3.05 |
| | Safety (during pregnancy) | 2.6 | 2.94 | 2.58 | 2.78 | 2.72 |
| | Health benefits (before pregnancy) | 2.68 | 3.02 | 2.84 | 2.95 | 2.82 |
| | Health benefits (during pregnancy) | 2.43 | 2.79 | 2.35 | 2.62 | 2.55 |
| | Environmental compatibility (before pregnancy) | 3.88 | 3.85 | 4 | 3.93 | 3.88 |
| | Environmental compatibility (during pregnancy) | 3.78 | 3.66 | 3.87 | 3.87 | 3.77 |
| | Affordability (before pregnancy) | 3.71 | 3.99 | 3.97 | 3.94 | 3.84 |
| | Affordability (during pregnancy) | 3.49 | 3.86 | 3.68 | 3.7 | 3.63 |
| Attitude toward walking [Mean – A scale of 1 (totally disagree) to 5 (totally agree)] | Comfort (before pregnancy) | 4.3 | 4.44 | 4.65 | 4.5 | 4.39 |
| | Comfort (during pregnancy) | 3.48 | 4.02 | 3.58 | 3.94 | 3.7 |
| | Safety (before pregnancy) | 3.99 | 4.06 | 4.23 | 4.15 | 4.05 |
| | Safety (during pregnancy) | 3.54 | 3.85 | 3.87 | 3.85 | 3.69 |

| | | A | B | C | D | |
|---|---|---|---|---|---|---|
| | Health benefits (before pregnancy) | 4.7 | 4.69 | 4.87 | 4.72 | 4.71 |
| | Health benefits (during pregnancy) | 4.32 | 4.48 | 4.29 | 4.53 | 4.39 |
| | Environmental compatibility (before pregnancy) | 4.59 | 4.56 | 4.68 | 4.58 | 4.59 |
| | Environmental compatibility (during pregnancy) | 4.51 | 4.48 | 4.61 | 4.45 | 4.5 |
| | Affordability (before pregnancy) | 4.34 | 4.48 | 4.55 | 4.53 | 4.42 |
| | Affordability (during pregnancy) | 4.22 | 4.36 | 4.26 | 4.36 | 4.28 |
| Attitude toward telephone-taxi/ride-hailing [Mean – A scale of 1 totally disagree) to 5 (totally agree)] | Comfort (before pregnancy) | 3.39 | 3.49 | 3.65 | 3.73 | 3.48 |
| | Comfort (during pregnancy) | 3.31 | 3.49 | 3.61 | 3.76 | 3.45 |
| | Safety (before pregnancy) | 3.3 | 3.49 | 3.61 | 3.51 | 3.4 |
| | Safety (during pregnancy) | 3.24 | 3.44 | 3.42 | 3.52 | 3.35 |
| | Health benefits (before pregnancy) | 2.79 | 3.06 | 3.1 | 3.11 | 2.93 |
| | Health benefits (during pregnancy) | 2.9 | 3.12 | 3.23 | 3.27 | 3.03 |
| | Environmental compatibility (before pregnancy) | 2.9 | 2.99 | 2.74 | 3.13 | 2.96 |
| | Environmental compatibility (during pregnancy) | 2.9 | 3.02 | 2.77 | 3.1 | 2.96 |
| | Affordability (before pregnancy) | 2.53 | 2.52 | 2.32 | 2.71 | 2.55 |
| | Affordability (during pregnancy) | 2.55 | 2.59 | 2.52 | 2.77 | 2.6 |
| Condition of pedestrian facilities in the living area (before pregnancy) Mean – A scale of 1 (very low) to 5 (very [high] | | 2.88 | 2.99 | 2.94 | 3.18 | 2.96 |
| Condition of pedestrian facilities in the living area (during pregnancy) Mean – A scale of 1 (very low) to 5 (very [high] | | 2.87 | 3.02 | 2.97 | 3.13 | 2.96 |
| The % of accident experienced while using car (before pregnancy to during pregnancy) | | 10.1 | 6.5 | 9.7 | 8.3 | 8.8 |
| The % of accident experienced while using public transport (before pregnancy to during pregnancy) | | 2.1 | 1.8 | 3.2 | 11.1 | 3.6 |
| The % of accident experienced while walking (before pregnancy to during pregnancy) | | 3.9 | 2.4 | 0 | 7.4 | 3.9 |
| The % of accident experienced while using telephone-taxi/ride-hailing (before pregnancy to during pregnancy) | | 1.2 | 1.8 | 12.9 | 4.6 | 2.5 |
| The % of life event experienced (before pregnancy to during pregnancy) | Relocation within the city | 23.7 | 33.5 | 22.6 | 30.6 | 27.4 |
| | Leaving the labor market | 12.8 | 8.2 | 38.7 | 13 | 12.8 |
| | Graduation from university | 2.4 | 2.4 | 9.7 | 0.9 | 2.5 |

1 Note**:** A: increasingly car-dependents; B: consistent walkers; C: transit leavers; D: continual car-independents

2

3 *4.2.1. Increasingly car-dependents*

4 The largest group of respondents, representing 52%, consists of women who have become more car-
5 dependent, a trend viewed as undesirable for sustainable transport. As illustrated in Group A in Fig. 3, before
6 pregnancy, this group primarily utilized cars - substantially higher than other groups- and walking for their trips
7 (share of car and walking in their trips was respectively 41% and 39%); however, following pregnancy, there
8 was a notable decrease in walking and an increase in car use (share of car in their trips became 49% and it
9 turned to 31% for walking). Share of public transport also declined significantly (from 12% to 5%), dropping

1     from third to last place. Share of ride-hailing services in their trips changed from 8% to 14%. As indicated in

2     Table 3, this group has the highest percentage of children attending private schools (13%) and the highest level

3     of car ownership. As shown in Fig. 4, before pregnancy, this group had relatively the most favorable attitude

4     towards cars and the most unfavorable attitudes about public transport across all other groups. In both periods,

5     this group maintains the most unfavorable attitude towards walking among all groups.



Legend: ----●---- Increasingly car-dependents (Group A)    ---●--- Consistent walkers (Group B)    --●-- Transit leavers (Group C)    ···●··· Continual car-independents (Group D)
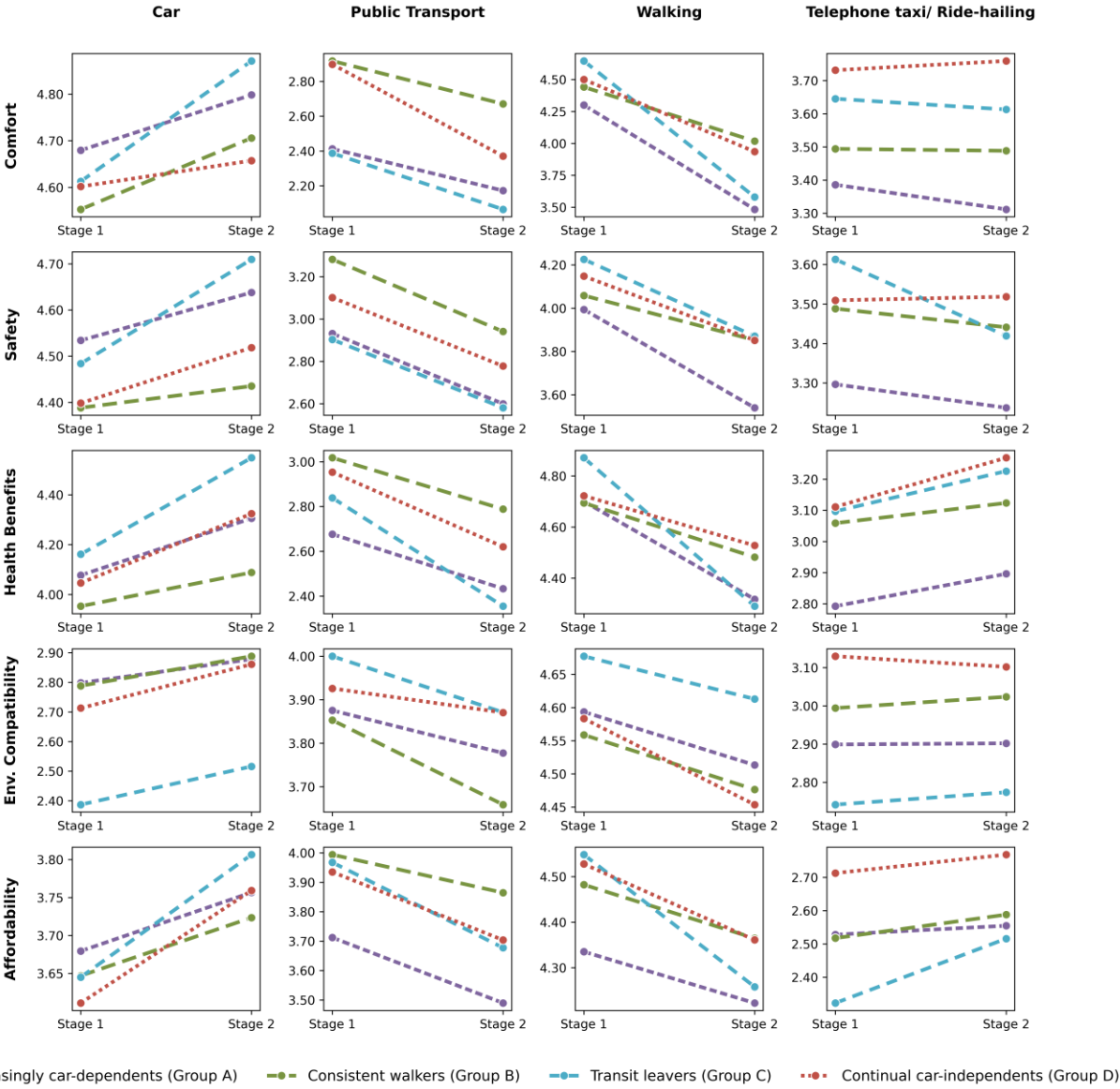
**Fig. 4.** Attitudes toward travel modes in response to pregnancy for each transition group [Mean - A scale of 1 (totally disagree) to 5 (totally agree)]

### 4.2.2. Consistent walkers

11 A quarter of respondents belong to the *consistent walkers*, whose travel behavior is considered highly desirable

12 for sustainable transport. As illustrated in Group B in Fig. 3, these individuals primarily use walking for their

13 trips, and this pattern remains unchanged during pregnancy period (share of walking in their trips was nearly

14 45% in both periods). In both periods, their levels of car, public transport, and ride-hailing use are significantly

15 lower than walking. Before pregnancy, share of public transport and car in their trips was respectively nearly

25% and 20%, and these shares remained unchanged during pregnancy period. Before pregnancy, share of ride-hailing was nearly 10% and this share increase to 15% during pregnancy. As noted in Table 3, a majority of mothers in this group have children attending schools in lower-middle-income areas (76%), and they have the lowest educational attainment among all groups. This group also has the lowest levels of car ownership and holding of a driver's license, similar to *continual car-independents*. As indicated in Fig. 4, in both periods, this group maintained relatively more unfavorable attitude towards cars, and relatively more favorable attitude towards public transport among all groups. Overall, this group showed the least change in attitudes in response to pregnancy compared to other groups, highlighting their consistent preference for walking as a travel mode.

### 4.2.3. Transit leavers

*Transit leavers*, comprising only 5% of respondents, have travel behaviors that are considered highly undesirable for sustainable transport. As illustrated in Group C of Fig. 3, pregnancy significantly impacts the travel behavior. Before pregnancy, they primarily relied on public transport and walking (share of both public transport and walking was 35%), with much lower use of cars and ride-hailing services (share of both cars and ride-hailing was 15%). However, following pregnancy, public transport use drops to zero, while car use increases dramatically to become their primary travel mode of travel (42%). Walking also decreases (30%), and the use of ride-hailing rises considerably (30%), highlighting the challenges this group faces in maintaining sustainable transport practices following pregnancy. As shown in Table 3, nearly half of the individuals in this group have children attending schools in affluent areas (26% in rich areas and 23% in upper-middle-income areas). This group also has the highest educational attainment among all groups. Also, a majority experienced their first pregnancy (84%). Additionally, they experience a significant increase in car ownership, rising by 12% in response to pregnancy. As shown in Fig. 4, in response to pregnancy, their attitude towards cars became more favorable, with a more significant increase compared to other groups. Furthermore, their attitude towards public transport and walking became less favorable like other groups; however, this decline was more pronounced than in other groups. Overall, this group showed the most significant changes in attitudes compared to other groups, emphasizing the significant impact of this life event on their travel behavior.

### 4.2.4. Continual car-independents

Approximately 17% of respondents belong to a group that use cars less than all other groups in both before and during pregnancy, which is evaluated as desirable in terms of sustainable transport. As illustrated in Group D in Fig. 3, individuals in this group primarily used walking and public transport for their trips before pregnancy (respectively 38% and 33%), with significantly lower use of ride-hailing and cars (respectively 16% and 13%). This travel behavior is similar to that of *transit leavers* before pregnancy. However, unlike *transit leavers*, this group maintained their relatively sustainable travel behavior following pregnancy. Although there was a decrease in share of walking and public transport (respectively became 35% and 26%) alongside an increase in share of ride-hailing and car (respectively became 23% and 15%), walking and public transport remained the primary travel mode and car remained their last travel mode. This pattern indicates resilience in their sustainable travel behavior despite the changes associated with pregnancy. As indicated in Table 3, before pregnancy, this group had the lowest car ownership rates, similar to the *consistent walkers*. During the period from before to during pregnancy, 11% reported experiencing an accident while using public transport, marking the highest rate among all groups. As indicated in Fig. 4, in both before and during pregnancy, this group had the most favorable attitude towards ride-hailing compared to other groups. This group had the most favorable evaluation of the walkability of their living area compared to all other groups, both before and during pregnancy. Nevertheless, they are not as dependent on walking as *Consistent walkers*.

**5. Discussion**

In this section, the general characteristics of each group (*increasingly car-dependents*, *consistent walkers*, *transit leavers*, and *continual car-independents*) are outlined, and targeted policies aimed at promoting sustainable transport are proposed.

*Increasingly car-dependents* have the highest car ownership among all groups and show a favorable attitude towards cars. Before pregnancy, this group utilized cars substantially higher than others and following pregnancy, their car use increases even more. Considering their consistency to use car, including some pregnant-specific subsidies for car-sharing as an alternative to individual car use seems to be an appropriate policy. This group has the highest car ownership among all groups, and their attitude toward environmental compatibility of car is relatively high, indicating a lack of concern. Therefore, raising awareness about the environmental pollution caused by cars is crucial, particularly to encourage the transition from conventional vehicles to electric ones. Both before and during pregnancy, they perceived the comfort and safety of walking lower than other groups. Therefore, improving the quality of walking facilities for pregnancy needs (e.g., adding benches) could be an effective solution to counteract their walking use decline, as supported by Scheiner and Holz-Rau, 2013, who emphasize the role of infrastructure improvements in encouraging active travel. Moreover, this group holds an unfavorable attitude toward telephone-taxi/ride-hailing, especially regarding comfort, safety, and health benefits. An appropriate policy response would be the introduction or promotion of certified ride-hailing services specifically designed for women and mothers with infants, featuring background-checked drivers (preferably women), high cleanliness standards, and driver training focused on maternal needs.

Conversely, *consistent walkers* rely heavily on walking and maintains an unfavorable attitude towards cars both before and during pregnancy. Their attitudes towards public transport and walking are relatively favorable. For this group, policies could focus on maintaining current conditions. Given their lower economic status, it could be suggested that discounts for public transport use be offered specifically for pregnant women to enhance the appeal of sustainable transport options. Similar interventions have been proposed by Currie et al., 2010, who highlight the importance of financial incentives in promoting public transport use among lower-income populations, particularly for vulnerable groups such as pregnant women.

*Transit leavers* have indicated markedly different travel behavior compared to all other groups. Before pregnancy, this group primarily relied on public transport and walking. However, after becoming pregnant, they developed a significant decrease in walking and a complete cessation of public transport use. Following pregnancy, their unfavorable attitude towards public transport appears to be largely related to health concerns. Therefore, one proposed policy could be enhancing public transport services to better accommodate pregnant individuals. Key concerns could be the availability of empty seats and the absence of overcrowding, which are crucial for the health of both mother and child. This aligns with research by del Mistro and Behrens, 2015, which underscores the importance of seat availability and comfort in retaining public transport users during major life transitions. Reducing headway times between public transport vehicles and real-time arrival information to reduce waiting could alleviate overcrowding issues, as supported by studies like Mattson, 2017, which found that service frequency plays a significant role in public transport use. Additionally, accessibility to a travel mode is vital; the presence of stairs without escalators or elevators can pose significant barriers for pregnant individuals. To address these challenges, it might be recommended that municipalities issue cards connected to the public transport system for pregnant women, providing better access and priority seating throughout their pregnancy. Interestingly, although this group initially showed more favorable attitudes toward the health benefits of walking compared to other groups before pregnancy, their attitudes shifted to become the least

favorable following pregnancy. Policies aimed at educating pregnant individuals about the benefits of walking can promote more sustainable travel behaviors. Notably, 84% of individuals in this group experienced their first pregnancies, which can make them more sensitive to their decisions and more concerned about their health. This group's high rate of leaving the labor market and university gradation in response to pregnancy underscores these concerns. Providing pregnant women with targeted information that highlights how sustainable transport choices can enhance maternal health (e.g., by reducing stress and promoting physical activity) may help address these concerns. Moreover, the vast majority of this group, who are experiencing their first pregnancy, do not have another child before pregnancy and can use sustainable travel modes with fewer limitations prior to this event, whereas women who are pregnant with their subsequent child, have another child in the household prior to the current pregnancy. Therefore, the first pregnancy can have a greater impact on abandoning sustainable travel modes. Thus, an appropriate policy could involve familiarizing this group with the existing facilities and services in the public transport system that are specifically designed for individuals with children or those who are pregnant. As this is their first experience with pregnancy, they may be entirely unaware of such supportive features.

*Continual car-independents* have low car ownership, primarily utilizing walking for most trips. Before pregnancy, this group uses public transport as their second most frequent travel mode. Although public transport use declines following pregnancy, it remains their secondary travel mode. Given that this group reports the highest experience of accidents while using public transport, from before to during pregnancy, improvements to the safety of public transport (e.g., implementation of dedicated routes for public transport vehicles) might be warranted. Introducing dedicated public transport routes, with a very low likelihood of accidents, to pregnant women appears to be appropriate for enhancing their peace of mind while using these routes. Moreover, this group has favorable attitude towards ride-hailing services compared to other groups. Since women in this group generally do not have a high economic level, integrating subsidized ride-hailing credits for pregnant women seems to be an appropriate policy.

**6. Conclusion**

We find that pregnancy has a significant influence on women's travel behavior in the study area, often leading to increased car dependency. While some maintain sustainable travel behavior, many transition towards greater dependency on private cars. This transition is particularly evident among those with higher car ownership, greater economic level, higher educational attainment, greater attitudinal changes and those who experience first pregnancy. The change in attitude towards travel modes in response to the event of pregnancy varied significantly across groups. *Transit leavers* showed the most substantial change, as their attitudes towards cars became significantly more favorable while their attitudes toward public transport and walking declined more sharply than in other groups, leading to a complete abandonment of public transport use. In contrast, *consistent walkers* showed the least change in attitudes, maintaining their preference for walking and showing resilience against the broader trend of declining attitudes towards sustainable travel modes. These findings indicate that the extent of attitudinal change plays a significant role in determining whether women maintain or abandon sustainable transport travel behavior during pregnancy, with those experiencing greater attitudinal changes being more likely to transition away from sustainable travel modes, while those with more stable attitudes indicating greater resistance to such transitions. Women with higher education attainments show a greater tendency to shift from sustainable travel modes to car use, suggesting that interventions should focus on this group. However, efforts to promote active transport should also focus on low-income women, who are more dependent on walking and public transport, by enhancing the safety, comfort, and reliability of these modes.

This study has some limitations. As previously mentioned, data were collected using a retrospective survey, which constitutes a quasi-longitudinal method. To achieve more precise results, it would be preferable to gather data directly and contemporaneously during pregnancy using a longitudinal design. Another limitation is that, in order to assess respondents' travel behavior, only their travel mode use was surveyed. Our dataset does not include information on respondents' travel distances or activity ranges, and having access to such data could allow for a more thorough analysis of the determinants underlying group membership. Furthermore, given the traditional cultural norms and views surrounding pregnancy in the study area, the findings may not be fully generalizable to all contexts worldwide, especially Western societies, which are generally less conservative than Tehran and where religious criteria play a less significant role. However, cities with cultural norms similar to Tehran (for example, those in the Middle East and North Africa) may be able to apply our findings with fewer reservations compared to Western societies. Future research should explore the long-term impact of pregnancy and motherhood on travel behavior, particularly whether car-dependent behaviors persist as children grow. The direction and strength of attitude–behavior relationships could also be tested for such special life events using panel data. The relative impacts of different life events could be investigated, for example, by exploring which events have the greatest influence on short- and long-term travel behavior, such as pregnancy, childbirth, gaining employment, relocation, or changes in marital status.

1    **Appendix A.**

2    The estimation results for the latent class analysis (measurement component) in both stages are displayed in
3    Table A.1 and Table A.2. Moreover, Table A.3 shows the descriptive statistics for sociodemographic attributes
4    and table A.4 shows descriptive statistics for ownership and access to travel modes, accident experiences, and
5    life events.

6

7    **Table A.1**
8    Estimation results for the latent class analysis model (measurement component) in before pregnancy period

| Models for Indicators | | Class $C_{I, pre}$ | Class $C_{II, pre}$ | Wald | p-value | $R^2$ |
|---|---|---|---|---|---|---|
| Car use in before pregnancy (day pre week) | | 0.09 | -0.09 | 4.70 | 0.07 | 0.18 |
| Public transport use in before pregnancy (day pre week) | | -0.42 | 0.42 | 23.48 | 0.00 | 0.52 |
| Walking use in before pregnancy (day pre week) | | -0.28 | 0.28 | 29.60 | 0.00 | 0.36 |
| Telephone-taxi/Ride-hailing use in before pregnancy (day pre week) | | -0.28 | 0.28 | 36.18 | 0.00 | 0.32 |
| | | | | | | |
| Intercepts | | Overall | Wald | p-value | | |
| Car use in before pregnancy (day pre week) | | | 165.20 | 0.00 | | |
| | 0 | 1.01 | | | | |
| | 1 | 0.48 | | | | |
| | 2 | 0.56 | | | | |
| | 3 | 0.73 | | | | |
| | 4 | -0.82 | | | | |
| | 5 | -0.52 | | | | |
| | 6 | -0.98 | | | | |
| | 7 | -0.45 | | | | |
| Public transport use in before pregnancy (day pre week) | | | 33.92 | 0.00 | | |
| | 0 | 0.81 | | | | |
| | 1 | 0.70 | | | | |
| | 2 | 0.40 | | | | |
| | 3 | 0.44 | | | | |
| | 4 | -0.53 | | | | |
| | 5 | -0.05 | | | | |
| | 6 | -0.48 | | | | |
| | 7 | -1.30 | | | | |
| Walking use in before pregnancy (day pre week) | | | 81.01 | 0.00 | | |
| | 0 | -0.86 | | | | |
| | 1 | -0.09 | | | | |
| | 2 | 0.11 | | | | |
| | 3 | 0.56 | | | | |
| | 4 | -0.10 | | | | |
| | 5 | -0.02 | | | | |
| | 6 | -0.14 | | | | |
| | 7 | 0.54 | | | | |
| Telephone-taxi/Ride-hailing use in before pregnancy (day pre week) | | | 199.41 | 0.00 | | |
| | 0 | 2.06 | | | | |
| | 1 | 1.28 | | | | |
| | 2 | 0.55 | | | | |
| | 3 | 0.24 | | | | |
| | 4 | -0.69 | | | | |
| | 5 | -1.07 | | | | |
| | 6 | -1.30 | | | | |
| | 7 | -1.06 | | | | |
| | | | | | | |
| Model for Clusters | | | | | | |
| Intercept | | Class $C_{I, pre}$ | Class $C_{II, pre}$ | Wald | p-value | |
| | | 0.56 | -0.56 | 17.55 | 0.00 | |

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1 **Table A.2**

2 Estimation results for the latent class analysis model (measurement component) in during pregnancy period

| Models for Indicators | | Class $C_{I, post}$ | Class $C_{II, post}$ | Wald | p-value | $R^2$ |
|---|---|---|---|---|---|---|
| Car use in during pregnancy (day pre week) | | 0.15 | -0.15 | 9.86 | 0.04 | 0.24 |
| Public transport use in during pregnancy (day pre week) | | -0.81 | 0.81 | 12.17 | 0.00 | 0.42 |
| Walking use in during pregnancy (day pre week) | | -0.27 | 0.27 | 16.24 | 0.00 | 0.34 |
| Telephone-taxi/Ride-hailing use in during pregnancy (day pre week) | | -0.17 | 0.17 | 15.81 | 0.00 | 0.28 |
| | | | | | | |
| Intercepts | | Overall | Wald | p-value | | |
| Car use in during pregnancy (day pre week) | | | 184.56 | 0.00 | | |
| | 0 | 1.02 | | | | |
| | 1 | 0.47 | | | | |
| | 2 | 0.59 | | | | |
| | 3 | 0.56 | | | | |
| | 4 | -0.53 | | | | |
| | 5 | -0.84 | | | | |
| | 6 | -0.93 | | | | |
| | 7 | -0.33 | | | | |
| Public transport use in during pregnancy (day pre week) | | | 43.19 | 0.00 | | |
| | 0 | 3.81 | | | | |
| | 1 | 2.94 | | | | |
| | 2 | 1.68 | | | | |
| | 3 | 0.63 | | | | |
| | 4 | -1.60 | | | | |
| | 5 | -1.42 | | | | |
| | 6 | -2.46 | | | | |
| | 7 | -3.58 | | | | |
| Walking use in during pregnancy (day pre week) | | | 41.41 | 0.00 | | |
| | 0 | 0.58 | | | | |
| | 1 | 0.64 | | | | |
| | 2 | 0.75 | | | | |
| | 3 | 0.54 | | | | |
| | 4 | -0.60 | | | | |
| | 5 | -0.29 | | | | |
| | 6 | -0.92 | | | | |
| | 7 | -0.71 | | | | |
| Telephone-taxi/Ride-hailing use in during pregnancy (day pre week) | | 220.04 | 0.00 | | | |
| | 0 | 2.04 | | | | |
| | 1 | 1.17 | | | | |
| | 2 | 0.69 | | | | |
| | 3 | 0.01 | | | | |
| | 4 | -1.12 | | | | |
| | 5 | -0.32 | | | | |
| | 6 | -1.11 | | | | |
| | 7 | -1.35 | | | | |
| | | | | | | |
| Model for Clusters | | | | | | |
| Intercept | | Class $C_{I, post}$ | Class $C_{II, post}$ | Wald | p-value | |
| | | 0.06 | -0.06 | 0.13 | 0.72 | |

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**Table A.3**

Descriptive statistics for sociodemographic attributes

| | Categories | N$_{total}$ | N | Percent |
|---|---|---|---|---|
| Economic level of child' school region | | 646 | | |
| | Rich | | 75 | 12 |
| | Upper-middle | | 144 | 22 |
| | Lower-middle | | 235 | 36 |
| | Low | | 192 | 30 |
| Type of child' school | | 646 | | |
| | Public | | 591 | 91 |
| | Private | | 55 | 9 |
| Child order in household | | 646 | | |
| | First child | | 359 | 56 |
| | Subsequent child | | 287 | 44 |
| Mother's age group | | 646 | | |
| | 29 years or younger | | 54 | 8 |
| | 30-39 years | | 406 | 63 |
| | 40 years or older | | 186 | 29 |
| Mother's age group during pregnancy | | 646 | | |
| | 24 years or younger | | 141 | 22 |
| | 25-34 years | | 431 | 67 |
| | 35 years or older | | 74 | 11 |
| Employment status (before pregnancy) | | 646 | | |
| | Full-time | | 128 | 20 |
| | Part-time | | 102 | 16 |
| | Unemployed | | 389 | 60 |
| | Student | | 27 | 4 |
| Employment status (during pregnancy) | | 646 | | |
| | Full-time | | 83 | 13 |
| | Part-time | | 63 | 10 |
| | Unemployed | | 481 | 74 |
| | Student | | 19 | 3 |
| Education (before pregnancy) | | 646 | | |
| | Under diploma | | 103 | 16 |
| | Diploma or associate degree | | 284 | 44 |
| | Bachelor's degree | | 203 | 31 |
| | Master's degree | | 51 | 8 |
| | Doctorate or higher | | 5 | 1 |
| Education (during pregnancy) | | 646 | | |
| | Under diploma | | 101 | 16 |
| | Diploma or associate degree | | 274 | 42 |
| | Bachelor's degree | | 207 | 32 |
| | Master's degree | | 59 | 9 |
| | Doctorate or higher | | 5 | 1 |

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**Table A.4**

2   Descriptive statistics for ownership and access to travel modes, accident experiences, and life events

| | | N | Percent | Mean | SD |
|---|---|---|---|---|---|
| Holding of a driver's license (before pregnancy) | | | | 0.58 | 0.49 |
| | Yes | 373 | 57.7 | | |
| | No | 273 | 42.3 | | |
| Holding of a driver's license (during pregnancy) | | | | 0.59 | 0.49 |
| | Yes | 380 | 58.8 | | |
| | No | 266 | 41.2 | | |
| Household car ownership (before pregnancy) | | | | 0.84 | 0.52 |
| Household car ownership (during pregnancy) | | | | 0.87 | 0.51 |
| Condition of pedestrian facilities in the living area (before pregnancy) | | | | 2.96 | 0.91 |
| | Very low | 54 | 8.4 | | |
| | Low | 82 | 12.7 | | |
| | Neutral | 380 | 58.8 | | |
| | High | 93 | 14.4 | | |
| | Very high | 37 | 5.7 | | |
| Condition of pedestrian facilities in the living area (during pregnancy) | | | | 2.96 | 0.89 |
| | Very low | 51 | 7.9 | | |
| | Low | 85 | 13.2 | | |
| | Neutral | 383 | 59.3 | | |
| | High | 95 | 14.7 | | |
| | Very high | 32 | 5.0 | | |
| Having accident while using car (before pregnancy to during pregnancy) | | | | 0.09 | 0.32 |
| | Yes | 58 | 9.0 | | |
| | No | 588 | 91.0 | | |
| Having accident while using public transport (before pregnancy to during pregnancy) | | | | 0.04 | 0.24 |
| | Yes | 24 | 3.7 | | |
| | No | 622 | 96.3 | | |
| Having accident while walking (before pregnancy to during pregnancy) | | | | 0.04 | 0.27 |
| | Yes | 26 | 4.0 | | |
| | No | 620 | 96.0 | | |
| Having accident while using telephone-taxi/ride-hailing (before pregnancy to during pregnancy) | | | | 0.03 | 0.25 |
| | Yes | 17 | 2.6 | | |
| | No | 629 | 97.4 | | |
| Relocation within the city (before pregnancy to during pregnancy) | | | | 0.27 | 0.45 |
| | Yes | 177 | 27.4 | | |
| | No | 469 | 72.6 | | |
| Leaving the labor market (before pregnancy to during pregnancy) | | | | 0.13 | 0.33 |
| | Yes | 83 | 12.8 | | |
| | No | 563 | 87.2 | | |
| Graduation from university (before pregnancy to during pregnancy) | | | | 0.03 | 0.18 |
| | Yes | 21 | 3.3 | | |
| | No | 625 | 96.7 | | |

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