sustainability

MDPI

Article

The Effect of Distance Intervals on Walking Likelihood in Different Trip Purposes

Elżbieta Macioszek [1,*], Ali Karami [2], Iman Farzin [3], Mohammadhossein Abbasi [3], Amir Reza Mamdoohi [3] and Cristiana Piccioni [4]

1 Department of Transport Systems, Traffic Engineering and Logistics, Faculty of Transport and Aviation Engineering, Silesian University of Technology, Krasińskiego 8 Street, 40-019 Katowice, Poland
2 Faculty of Civil Engineering, K.N. Toosi University of Technology, Tehran 19967, Iran; ali.karami@email.kntu.ac.ir
3 Faculty of Civil & Environmental Engineering, Transportation Planning Department, Tarbiat Modares University, Tehran 14117, Iran; iman.farzin@modares.ac.ir (I.F.); a_mohammadhossein@modares.ac.ir (M.A.); armamdoohi@modares.ac.ir (A.R.M.)
4 Faculty of Civil, Building and Environmental Engineering, Sapienza University of Rome, 00184 Rome, Italy; cristiana.piccioni@uniroma1.it
* Correspondence: elzbieta.macioszek@polsl.pl; Tel.: +48-32-603-41-50

Citation: Macioszek, E.; Karami, A.; Farzin, I.; Abbasi, M.; Mamdoohi, A.R.; Piccioni, C. The Effect of Distance Intervals on Walking Likelihood in Different Trip Purposes. *Sustainability* **2022**, *14*, 3406. https://doi.org/10.3390/su14063406

Academic Editors: Gabriella Mazzulla and Carmen Forciniti

Received: 16 February 2022
Accepted: 11 March 2022
Published: 14 March 2022

Abstract: Increasing private car ownership and car dependency has led to a low share of walking as an active mode as well as congestion, air pollution, and health problems in developing countries. This paper aims to identify and compare the impacts of a selection of socio-economic, travel-related, and built environment variables on walking likelihood and respondents' sensitivity to the walking distance, both for discretionary and mandatory trips. The analysis drew its origin from 14,463 responses acquired through an extensive travel survey conducted in the city of Qazvin, Iran. The estimated binary logit coefficients show people's heterogeneity in the walking behavior for discretionary and mandatory trips. The results report a higher likelihood of walking on mandatory trips at almost all distances than the discretionary ones. Furthermore, investigating individual heterogeneity in different trip distances reveals that people aged less than 14 are more likely to choose walking on mandatory trips longer than 2400 m. Besides, those aged 25–44 years old or above 65 have less tendency to choose walking on mandatory trips with distances of 2000–2400 m and 800–1200 m, respectively. These findings are almost different on discretionary trips; compared to other age groups, people aged 15–24 years are less likely to choose walking on discretionary trips with a distance of 800–1200 m. Moreover, in trip distances of 1200–1600 m, the elderlies have a greater tendency to choose walking compared to other age groups. Some implications for more sustainable mobility in human-oriented urban environments are also presented and critically discussed.

Keywords: transportation; walking distance; mandatory trips; discretionary trips; built environment; binary logit model

1. Introduction

The increasing urban sprawl, car ownership, dependency, and the mechanization of urban life have affected people's tendency to walk [1–4]. Low non-motorized share has resulted in various problems, including congestion, longer travel time, air, and noise pollution, overweight due to diminished physical activity, and staggering economic costs [5,6]. According to the most recent data from the World Health Organization, about 4.2 million people died because of air pollution and the resulting disease. Moreover, more than 1.9 billion adults, 18 years and older, were overweight which over 650 million were obese in the world. Based on this report, 25.8% of people are obese, and 27,000 people died because of air pollution in Iran [7,8]. This has gradually highlighted the necessity of encouraging people to choose active travel modes, such as cycling and walking. There are many reasons for preferring walking among people due to travel-related factors as well as mental, social and environmental health. Walking has many advantages over other transportation modes such as independence from motorized traffic congestion, lack of need for parking, lack of air and noise pollution, low/no monetary cost and improvement in mood and relieving stress [9]. In this regard, local authorities also attempt to increase the share of active travel modes to favor physical activity, improve air quality, reduce the accident rate, lift spirit and mood, and lower inevitable fatalities [9,10].

Identifying factors affecting sustainable transportation modes is essential to increase walking and thus benefit from its potential advantages. This would lead to proper planning and policymaking to achieve the goals and perspectives in encouraging people towards walking [11,12]. Among the critical factors in walking likelihood, most studies have acknowledged distance as a key element. Still, contradictory findings have been seen for different trip purposes, age groups, and environmental contexts [13–15]. For example, Larrañaga et al. [16] found that with an increase in trip distance, the probability of choosing walking in work, educational, and recreational trips reduced in Brazil. Hatamzadeh et al. [13] investigated walking likelihood across genders in school trips to study the effect of different distance intervals (increasing by 0.25 miles) on walking likelihood in Rasht, Iran. They found that with an increase in trip distance, the probability of choosing walking reduced, and boys are more sensitive to walking distance than girls. In terms of first/last mile of trips, Paydar et al. concluded that the average preferred walking distance between origin and metro stations is 336 m in Shiraz, Iran [17]. Tsunoda et al. [18] explored the accepted walking and cycling thresholds of Japanese elderlies and found 1 and 2 km as the acceptable distance for walking and cycling, respectively. Besides, Piccioni et al. [19] identified a range of 500 m (0.31 miles) as an acceptable walking distance in an urban environment, intended as the maximum average distance people are willing to travel to reach their destination for both mandatory and discretionary trips. Agrawal and Schimek [20] investigated the effect of socio-economic characteristics and BE variables on the duration and length of walking trips in the USA. They found that the average distance of recreational walking trips is twice as large as that for work trips (1 mile vs. 0.5 miles).

Further, the lowest and highest recreational walking distance belonged to children and adults (30–64 years, 1.25 miles). Hatamzadeh et al. [21] explored the probability of choosing walking for working and shopping trips across genders in Rasht, Iran. They found that, on working trips, the effect of trip distance on the walking likelihood of women was more than men, while on shopping trips, the relationship was vice versa. In addition to the trip distance, many contradictory findings have been reported in the literature about the impact of travelers' age on walking distance and likelihood. For example, Pucher and Dijkstra [22] found that as people get older, the number of walking trips would reduce in the Netherlands and Germany. Moreover, elderlies (aged above 65 years old) walk 25% less than the average number of mandatory walking trips while they walk 39% more than this amount for recreational and exercise trips. Meanwhile, Teshome [23] reported a direct relationship between the probability of walking and age in work trips in Ethiopia, while Rodriguez and Joo [24] reported an inverse relationship in the USA. Larrañaga et al. [16] found that as an individual gets older, the probability of choosing walking decreases on work, educational, and recreational trips in Porto Alegre, Brazil.

According to the above-mentioned research, it can be found that most studies used distance as a continuous variable and did not categorize it into smaller intervals for a more accurate analysis. In addition, the effect of trip distance on walking likelihood in different trip purposes has been studied only for specific groups such as men and women, elderlies or students, limiting the applicability of the proposed model. Further, there are also quite contradictory results regarding travelers' age. Given the different nature of such kinds of trips, in terms of spatial and temporal characteristics, walking behaviors and thus model specifications seem likely to be completely different. Mandatory trips (i.e., work and educational activities) occur at specific places and times.

In contrast, discretionary trips (i.e., shopping and leisure activities) are more flexible and could be even avoided or shifted to off-peak hours in the neighborhood of travelers' residing location by implementing appropriate policies. Therefore, in this study, we deeply focus on the impact of these two important factors, their interaction effects, and other influential variables on walking likelihood in different trip purposes using a binary logit model. Hence, this paper aims to identify the main factors affecting walking likelihood, emphasizing the role of trip distance and age both on discretionary and mandatory trips. To achieve the mentioned objectives, socio-economic (SE) and trip characteristics, as well as built environment (BE) variables, are examined. Besides, the age and trip distance interaction variables are explored to identify the people's heterogeneity in walking behavior. According to the aforementioned gaps and limitations of previous studies, the original contributions of this paper are (1) concerning the differences in responses by people in the face of different situations, this paper uses trip distance and age interaction variables to explore the extent of people's preference for walking. To the best of our knowledge, limited studies have considered the interaction effect of age and trip distance to explore the heterogeneity preference in walking behavior across different trip purposes; (2) most previous studies have focused only on a limited number of trip purposes or a particular people group (e.g., elderly, gender-specific, and students) [13,18,21,25,26] while this paper proposed two separate for discretionary and mandatory trips to determine strong predictors and compare of their significant impacts more precisely.

The paper is articulated as follows: a literature review is presented in the research background section. Data and methods are discussed in the methodology section. The main findings, along with a critical discussion and policy implications, are presented in the results and discussion section; the concluding remarks and recommendations for future studies are provided in the conclusions section.

2. Research Background

This section categorized the inflectional factors on walking likelihood in discretionary and mandatory trips into three groups: individual/household characteristics, Trip characteristics, and built environment variables.

2.1. Individual/Household Characteristics

Individual and household characteristics have frequently been examined in different studies, though inconsistent walking results were reported. Concerning gender, Agrawal and Schimek [20] found that men were 13% less likely to choose walking for recreational, exercise, and access to transit trips than women in the USA. However, there is no significant difference in tendency to walk for work trips and average trip distance across genders. Furthermore, they found that when the income exceeded $30 per day, the extent of walking diminished by 40% for mandatory trips. On the other hand, when the income is higher than $30, the extent of walking for recreational and sports trips grew continuously. In contrast, Larrañaga et al. [16] and Zavareh et al. [27] found that with an increase in income, the likelihood of walking reduced in trips with work, educational, and recreational purposes, while Ton et al. [28] report a negative relationship for high-income households in the Netherlands. In the case of household car ownership, it was found that the number of walking trips for households without a private car was 3.5 times higher than those with at least one [29]. Besides, they found a significant positive relationship between the level of education and the number of discretionary and mandatory walking trips in Portland. In a further study, Khan et al. [30] concluded that as the household size increased, the probability of walking trips increased in Seattle, while Ton et al. [28] reported a negative relationship in the Netherlands. Sehatzadeh et al. [31] found that car ownership is lower in regions with greater walking potentials in New Jersey. They concluded that households were less likely to choose walking with an increase in the number of vehicles. Kaplan et al. [32] concluded that with an increase in household car ownership, the probability of choosing walking reduced. On the other hand, some other studies observed that the number of vehicles per person with a driving license in the household had no significant impacts on choosing walking for students' educational trips in Austin, Texas [33]. Further, higher car ownership had a negative impact on choosing walking for work and shopping trips [34].

2.2. Trip Characteristics and Built Environment (BE) Variables

The trip-related factors such as trip distance, trip starting and ending time, cost, and trip purpose are other influential factors affecting walking likelihood.

The impacts of distance on walking likelihood were thoroughly discussed in the introduction section [35]. Concerning the departure time of walking trips, Hatamzadeh et al. [13] found that the time of day had a different impact on walking likelihood in educational trips across genders in Rasht, Iran; they concluded that this variable had no significant impacts on girls, while it had a significant positive impact on boys (in the afternoon). Hatamzadeh et al. [21] observed that women were more likely to choose walking in the morning for their working trips than men. Further, on shopping trips, men and women had a greater tendency to walk at 7–8 a.m. or 5–7 p.m. in Rasht, Iran. In another study, Kaplan et al. [32] concluded that walking likelihood is greater at the weekends in Germany.

Many studies have examined the effect of BE variables on walking behavior. To this end, Reid and Cervero [36] proposed the BE variables affecting walking as the following six *Ds* variables: density, diversity, design, distance to transit, destination accessibility, and demand management. According to the studies, people living in high-density urban regions walk more from/to public transportation stations [37]. Furthermore, better network connectivity is associated with an increased number of walking trips [31]. Concerning design variables, T-shaped or three-leg intersections result in poor network connectivity and are considered a barrier to walking.

On the other hand, other junctions (e.g., four-leg intersections) increase network connectivity, thereby providing a greater variety of potential paths for people [31]. Mixed land-use and network connectivity improve accessibility in neighborhoods [38]. Moreover, mixed land use (entropy) is one of the most influential and important variables affecting walking trip behavior [21,39].

3. Materials and Methods

The case study is the city of Qazvin, one of the central cities of Iran, with a population of about 400,000 inhabitants living in 13 municipality districts covering a total area of 65 square kilometers. Similar to many urban settings both in developed and developing countries, air pollution is one of the key issues affecting this city due to the increasing share of private motorized mobility over time. In such a context, the high rate of vehicle ownership, the low cost of fuel, and the relatively poor transit service quality have encouraged the massive use of private cars in daily trips.

The current research draws its origin from data gained through comprehensive transportation studies (CTS) as an extensive travel survey conducted in Qazvin. It should be noted that CTS is usually conducted every 10 years in metropolises in Iran, but due to COVID-19, it has not yet been updated. Thus, our data is the most recent available data at such a level of detail. It is noteworthy that in the OD of CTS, questionnaires are distributed among school students of age (12–15) who are asked to have them filled by their parents for all household members above 6 years of age. To prevent bias, students are also asked to give the questionnaire to two of their neighbors to be filled out in the same manner. As regards the questionnaire administered to the interviewees, it was made up of the three following sections. The first section introduced the research objectives and survey anonymity and confidentiality terms. The second section asked for the socio-economic characteristics of each household member, including age, gender, occupation, household size, possession of a driving license, education level, household car ownership status, and residence location. In the third section, each household member was asked to state the details of their trip on a typical day (including the departure time, travel modes, the origin and destination, and purpose), using a revealed preference (RP) approach, thus dealing with the actual choice of respondents under the real conditions. It is noteworthy to say that due to the dependence of children's (under 15 years) mobility behavior on their parent's transportation mode, the third section of children aged lower than 15 is filled by their parents.

The collected information contains 9938 households consisting of 29,840 individuals residing in 113 traffic analysis zones (TAZs). After data manipulations and cleanings, such as omitting the outlier and missing data, 14,463 observations (including 10,000 for mandatory trips and 4463 for discretionary trips) were considered for modeling purposes. It is noteworthy that the likelihood of pedestrian trips is higher for mandatory trips (10,000) as compared to discretionary trips (4463), which can be ascribed to different reasons, including more reliable timing, independence from motorized traffic congestion, commute nature due to daily repetition enabling planning with certainty and identical destination. To prevent any possible bias in our findings, we tried to use a representative sample of respondents in terms of age and gender. In other words, we tried to minimize the differences between age and gender proportions in our sample and the population. According to the census data of the Statistical Center of Iran, the gender proportion is equal to 52% male and 48% female. Hence, we tried to keep this ratio in our sample, too. According to the features of the selected sample (Table 1), it can be found that 8645 (59%) responses were obtained from male respondents, and 5818 (41%) were from female respondents.

Table 1. Descriptive analysis of variables by trip purpose.

Variables	Values	Total		Mandatory Trips		Discretionary Trips	
		Count	**Frequency (%)**	**Count**	**Frequency (%)**	**Count**	**Frequency (%)**
Gender	Male	8645	59	7041	70.4	1604	35.9
	Female	5818	41	2959	29.6	2859	64.1
	Sum	14,463	100	10,000	100	4463	100
Driving License Status	With License	6160	42.6	4230	42.3	1930	43.2
	Without License	8303	57.4	5770	57.7	2533	56.8
	Sum	14,463	100	10,000	100	4463	100
Household Size	1	171	1.1	85	0.9	86	1.9
	2	834	5.8	438	4.4	396	8.9
	3	2858	19.8	1824	18.2	1034	23.2
	4	6725	46.5	4850	48.5	1875	42.0
	5+	3875	26.8	2803	28.0	1072	24.0
	Sum	14,463	100	10,000	100	4463	100
Age	<14	2243	15.5	2002	20.0	241	5.4
	(15–24)	3656	25.2	2988	29.9	668	15.0
	(25–44)	5457	37.8	3272	32.7	2185	49.0
	(45–64)	2680	18.5	1536	15.4	1144	25.6
	>65	427	3	202	2.0	225	5.0
	Sum	14,463	100	10,000	100	4463	100
Education Levels	Illiterate	414	2.8	238	2.4	176	3.9
	Up to high school diploma	10,948	75.7	7406	74.1	3542	79.4
	Associate Degree and Bachelors	2815	19.5	2124	21.2	691	15.5
	Masters and above	286	2	232	2.3	54	1.2
	Sum	14,463	100	10,000	100	4463	100
Departure time	Peak	8420	65.6	6875	81.5	1545	35.2
	Afternoon	3142	24.5	1226	14.5	1916	43.6
	Night	1267	9.9	338	4	929	21.2
	Sum	12,829	100	8439	100	4390	100
Trip mode	Walking	3618	25	2200	22	1418	31.7
	Other	10,845	75	7800	78	3045	68.3
	Sum	14,463	100	10,000	69.1	4463	30.9

Regarding age comparison between the selected sample and census data, interestingly, the average and standard deviation of age in our selected sample are 30.8 and 15.8, respectively. On the other hand, according to the recent census data of Qazvin residents, the average and standard deviation of age are 30.9 and 18.7, respectively. Comparing two means (*p*-value: 0.524) indicates that the difference in age between the selected sample and population is not significant at a 95% confidence interval. Concerning respondents' driving license status, 42.6% have a driving license, and the remaining (57.4%) have not. The gathered information about respondents' age shows that 15.5% are less than 14 years old, respondents who aged between 15 and 24 account for 25.2%, 37.8% of respondents aged 25 to 44 years old, 18.5% of respondents aged 45 to 64 years old, and 3% of respondents aged more than 65 years old. With regard to household size, 46.5% of the respondents live in a 4-person household. About the education level, 2.8% of respondents were illiterate, 75.7% had up to a high school diploma. Concerning the respondents' trip departure time, 65.6% of trips were taken at peak hours (6–8 and 17–19). Finally, 3618 (25%) of trips were taken by walking. The results of the descriptive analysis of the data related to both trip types show that, in both discretionary and mandatory trips, those without driving license, 4-member households, people aged 25–44 years, besides those with at most high school diplomas, have the most significant walking trip frequency. In mandatory trips taken by men, trips conducted during peak hours, and in the case of discretionary trips, women, and trips conducted in the afternoon (13–17) have the highest frequencies. Analysis of travel time for different transportation modes shows that the average and standard deviation (S.D.) of 15.51 and 5.10 min for private cars, 34.73 and 15.23 min for transit, and 45.15 and 31.05 min for pedestrians, respectively.

Based on individuals' socio-economic characteristics, it can be observed (Figure 1) that women and men choose walking in discretionary trips more than in mandatory ones. Individuals without a driving license (compared to those with) have a greater tendency to choose walking on both trip types. Regardless of household size, respondents prefer walking in their discretionary trips rather than mandatory trips. People aged less than 15 choose walking both on mandatory and discretionary trips more than other age groups. With an increase in education, the tendency to prefer walking in discretionary trips diminishes. Moreover, people like to walk more during peak hours (compared to other hours) to accomplish their trips, regardless of their purpose.

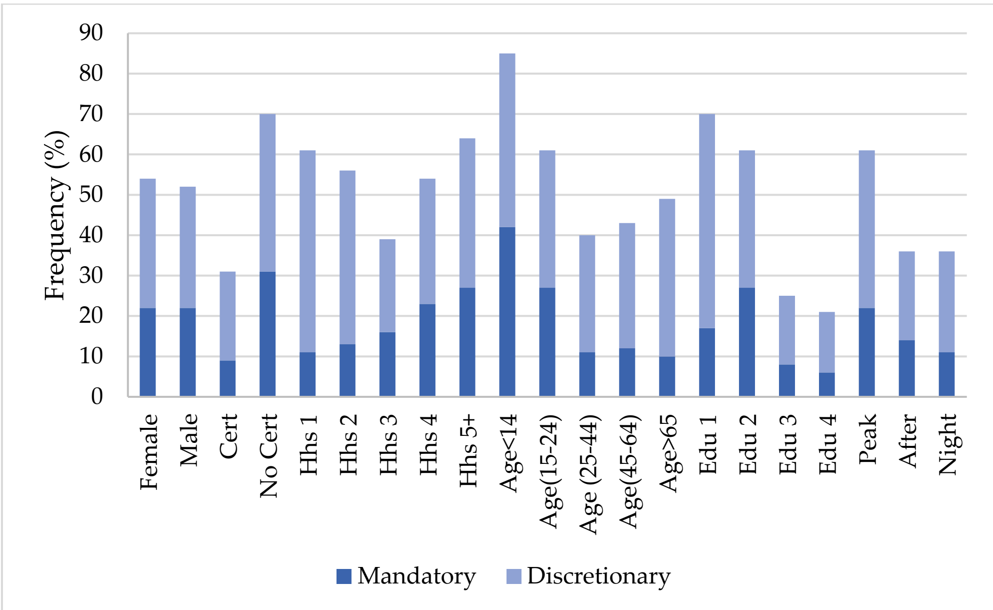

Figure 1. Share of walking by trip purposes and socio-economic/trip characteristics.

The shortest path distance between the TAZ centroids of origin and destination of each trip was used to assess the influence of travel distance [13,21]. Seven categories were defined for trip distance (increased by 0.25-miles (~400 m)) and considering trips less than 0.25 miles as the reference level [13,38,40]. Table 2 presents the number of respondents in each travel distance category stratified by trip purposes. Distance analysis of mandatory walking trips (Figure 2) indicates that the share of such trips by women is higher than men in those shorter than 0.25 (~400) and 0.25–0.5 miles (400–800 m). Meanwhile, the portion of mandatory walking trips is greater in those with a driving license for distances shorter than 0.25, 0.25–0.5, and 0.75–1 mile (1200–1600 m) compared to people without a driving license.

Table 2. Categorization of respondents based on travel distance in their mandatory and discretionary trips.

Travel Distance	Mandatory Trips		Discretionary Trips	
	Count	Frequency (%)	Count	Frequency (%)
Dis < 0.25	865	8.7	609	13.6
Dis (0.25–0.5)	280	2.8	171	3.8
Dis (0.5–0.75)	569	5.7	287	6.4
Dis (0.75–1)	780	7.8	370	8.3
Dis (1–1.25)	1584	15.8	662	14.8
Dis (1.25–1.5)	1363	13.6	579	13.0
Dis > 1.5	4559	45.6	1785	40.0
Sum	10,000	100	4463	100

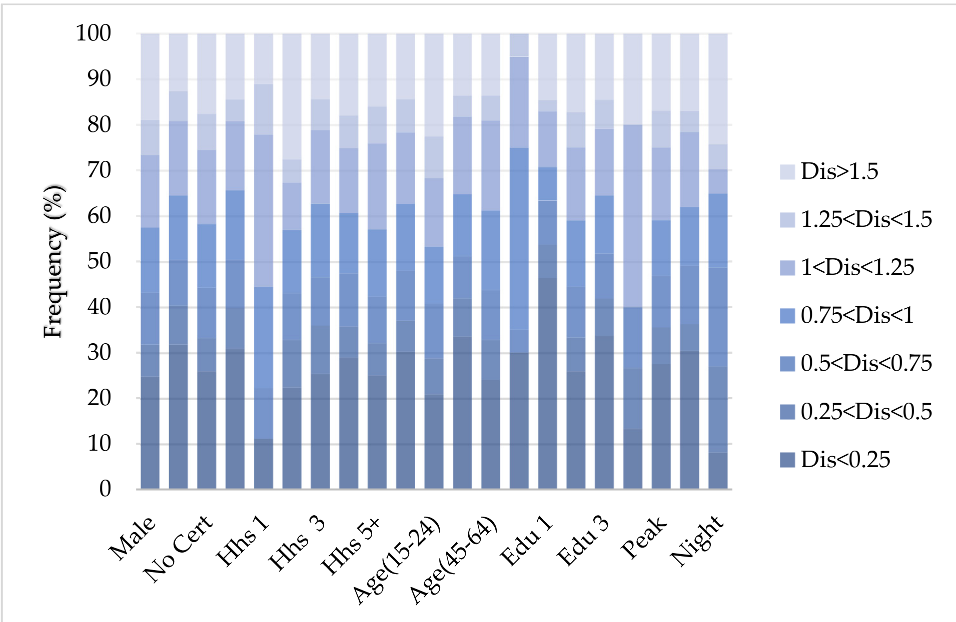

Figure 2. Analysis of the mandatory walking trip distance in terms of socio-economic/trip characteristics.

The largest share of walking trips in three, four-, and five-person households belong to distances shorter than 0.25 (400 m) miles. On the other hand, the greatest share for two-person households is mandatory walking trips longer than 1.5 miles (2400 m). Further, individuals aged 25–44 years old account for a large portion of the mandatory walking trips shorter than 0.25 miles (~400 m). Among different age groups, the elderly (above 65 years) has no mandatory walking trip longer than 1.5 miles (2400 m), while they account for the highest share of trips with the length of 0.75–1 mile (1200–1600 m). Individuals with high school diplomas and higher education levels claim the highest share in mandatory walking trips shorter than 0.25 and 1–1.25 miles (1600–2000 m), respectively. Compared to afternoon and peak hours, it is also observed that people walk more during the night if the destination is respectively located at 0.25–0.5 (400–800 m), 0.5–0.75 (800–1200 m), 0.75–1 (1200–1600 m), and more than 1.5 (2400 m) miles away. In the afternoon, the tendency to walk for mandatory trips is greater at distances shorter than 0.25 miles (400 m) than peak hours and nights.

Results of distance analysis of discretionary trips (Figure 3) indicate that most men's and women's walking trips are shorter than 0.25 miles (400 m).

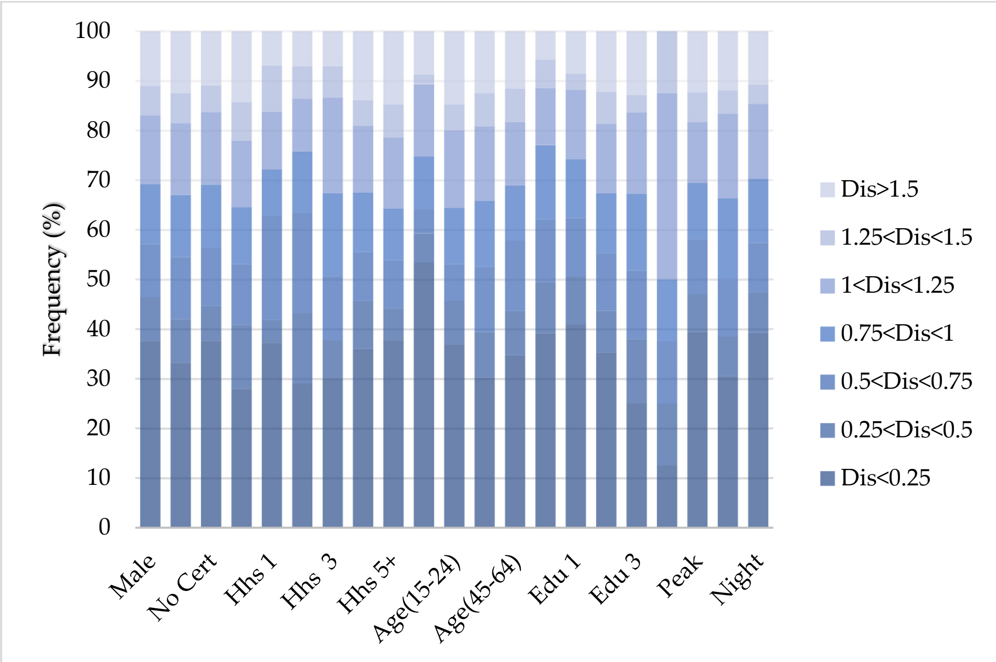

Figure 3. Analysis of the discretionary walking trip distance in terms of socio-economic/trip characteristics.

The share of discretionary walking trips for men is greater than women in distances shorter than 0.25 (400 m) miles. Further, the share of discretionary walking trips for those without a driving license is greater in distances shorter than 0.25 (400 m) and between 0.75–1 (1200–1600 m) and 1–1.25 (1600–2000 m) miles compared to those with a driving license. The majority of discretionary walking trips in distances shorter than 0.25 (400 m) and greater than 1.5 (2400 m) miles belong to households with more than five members; while, for distances of 0.5–1 (800–1600 m) and 1–1.25 miles (1600–2000 m), three-person households account for the highest portion. Those younger than 15 years claim the highest share of walking trips with a distance shorter than 0.25 miles (400 m) among different age groups. For those 15–24 years (compared to the other age groups), the highest share belongs to walking trips with distances of 1–1.25 (i.e., 1600–2000 m) and above 1.5 miles (2400 m). The maximum share of discretionary walking trips for people with higher education is 1–1.25 miles (1600–2000 m), while the minimum is held by more than 1.5 miles. Besides, the highest portion of walking trips at peak hours, afternoon, and night, occur in distances shorter than 0.25 miles (400 m).

Table 3 presents the variables used in the statistical analysis and modeling, besides their symbols and definitions. In this paper, in addition to the trip characteristics (distance increased by 0.25-mile (~400 m) and departure time) and socio-economic characteristics (gender, driving license status, education level, age, household size, and employment), four BE variables, including residential density, job-population balance as an indicator of mixed land use, intersection density and walking time to transit stations are calculated and used in the modeling. It is noteworthy that, considering individuals' different perceptions and attitudes toward the quantity and quality of the surrounding environment, BE variables are calculated through an objective rather than a subjective approach by using a geographic information system (GIS). The population density of each TAZs is calculated dividing the population by the TAZ area (inhabitants per square kilometers); Intersection density is calculated as the number of intersections per area unit at TAZ level; the job-population balance [41] is a useful indicator to calculate the extent of mixed land-use (Equation (1)). This index allows assessment of the balance between jobs and the population living in a zone:

Table 3. Descriptive analysis of the examined variables by trip purpose.

Symbol	Variable Definition	Unit	Mandatory		Discretionary	
			Mean	S.D.	Mean	S.D.
Dis < 0.25	If travel distance is lower than 0.25 mile = 1; Otherwise = 0	-	0.09	0.28	0.14	0.34
Dis (0.25–0.5)	If travel distance is the range of 0.25 to 0.50 mile = 1; Otherwise = 0	-	0.03	0.16	0.04	0.19
Dis (0.5–0.75)	If travel distance is the range of 0.50 to 0.75 mile = 1; Otherwise = 0	-	0.06	0.23	0.06	0.25
Dis (0.75–1)	If travel distance is the range of 0.75 to 1.00 mile = 1; Otherwise = 0	-	0.08	0.27	0.08	0.28
Dis (1–1.25)	If travel distance is the range of 1.00 to 1.25 mile = 1; Otherwise = 0	-	0.16	0.37	0.15	0.36
Dis (1.25–1.5)	If travel distance is the range of 1.25 to 1.5 mile = 1; Otherwise = 0	-	0.14	0.34	0.13	0.34
Dis > 1.5	If travel distance is higher than 1.5 mile = 1; Otherwise = 0	-	0.46	0.50	0.40	0.49
Cert	If the individual has a driving license = 1; Otherwise = 0	-	0.42	0.49	0.43	0.50
Female	If the individual is a female = 1; Otherwise = 0	-	0.30	0.46	0.64	0.48
Edu	Ordered education level of individuals	-	4.88	2.15	4.45	2.19
Edu1	If the individual is illiterate = 1; Otherwise = 0	-	0.02	0.15	0.04	0.19
Edu2	If the individual has a diploma or lower degree = 1; Otherwise = 0	-	0.74	0.44	0.79	0.40
Edu3	If the individual has an associate degree or bachelor's degree = 1; Otherwise = 0	-	0.21	0.41	0.15	0.36
Edu4	If the individual has masters or higher degree = 1; Otherwise = 0	-	0.02	0.15	0.01	0.11
HHS	household size	Person	4.09	1.06	3.86	1.15
Hhs1	If household size is one = 1; Otherwise = 0	Person	0.01	0.09	0.02	0.14
Hhs2	If household size is two = 1; Otherwise = 0	Person	0.04	0.20	0.09	0.28
Hhs3	If household size is three = 1; Otherwise = 0	Person	0.18	0.39	0.23	0.42
Hhs4	If household size is four = 1; Otherwise = 0	Person	0.49	0.50	0.42	0.49
Hhs5+	If household size is five or more = 1; Otherwise = 0	Person	0.28	0.45	0.24	0.43

Table 3. *Cont.*

Symbol	Variable Definition	Unit	Mandatory		Discretionary	
			Mean	**S.D.**	**Mean**	**S.D.**
Age	individual's age	Year	30.60	15.55	31.10	16.38
Age < 14	The individual has an age lower than 14 = 1; Otherwise = 0	-	0.20	0.40	0.05	0.23
Age (15–24)	The individual has an age in the range of 15 to 24 = 1; Otherwise = 0	-	0.30	0.46	0.15	0.36
Age (25–44)	The individual has an age in the range of 25 to 44 = 1; Otherwise = 0	-	0.33	0.47	0.49	0.50
Age (45–64)	The individual has an age in the range of 45 to 64 = 1; Otherwise = 0	-	0.15	0.36	0.26	0.44
Age > 65	The individual has an age higher than 65 = 1; Otherwise = 0	-	0.02	0.14	0.05	0.22
EMP	If the individual is an employee = 1; Otherwise = 0	-	0.13	0.34	0.07	0.26
Peak	If the departure time is within 6–8 a.m. or 5–7 p.m. = 1; Otherwise = 0	-	0.69	0.46	0.35	0.48
Afternoon	If the departure time is within 1–5 p.m. = 1; Otherwise = 0	-	0.12	0.33	0.43	0.50
Night	If the departure time is within 8 p.m.–5 a.m. = 1; Otherwise = 0	-	0.03	0.18	0.21	0.41
Ori-Den	Residential density at origin	$\frac{\text{person}}{\text{km}^2}$	0.01	0.01	0.01	0.01
Des-Den	Residential density at destination	$\frac{\text{person}}{\text{km}^2}$	0.01	0.01	0.01	0.01
Ori-Bal	Job-Population balance at origin	-	0.79	0.04	0.79	0.04
Des-Bal	Job-Population balance at destination	-	0.78	0.04	0.79	0.04
Int_den	Intersection density (4-legs)	$\frac{\text{number}}{\text{km}^2}$	0.017	0.03	0.017	0.03
Tran_WT	Walking time to transit station	Second	483.99	238.35	479.79	264.29

$$\text{Job} - \text{Popbalance} = 1 - \left| \frac{\text{Job} - 0.2 \times \text{Pop}}{\text{Job} + 0.2 \times \text{Pop}} \right| \quad (1)$$

where:

Job—represents the occupational opportunities of a zone, and

Pop—indicates the population of that zone.

The value of this index ranges between 0 and 1, where 0 represents regions with only residential or administrative uses, while 1 indicates the proper ratio of jobs to zone residents. Hence, based on [41], zones with single land use do not attract pedestrians to have a walking trip.

4. Estimation Results and Discussion

After calibrating a large number of binary logit models Nlogit 5, the best fit model is reported in Table 4 for mandatory and discretionary trips. The dependent variable (walking likelihood) was defined as the choice of walking versus other transportation modes [34]. It is worth noting that model fitting was evaluated using several goodness-of-fit criteria, including logical signs, P-value, t-stat, F-value, and likelihood ratio index [42–44]. As a result, most explanatory variables are significant at a 95% confidence level. The significant categorized results will be discussed in the following subsections.

Table 4. Binary logit estimation results of walking likelihood by mandatory and discretionary trips.

Variables	Mandatory Trips			Discretionary Trips		
	Coef.	T-Stat	M.E.	Coef.	T-Stat	M.E.
Constant	−2.16 ***	−3.59	-	−3.22 ***	−3.14	-
Dis (0.25–0.5)	−0.29 **	−1.90	−0.0331	−0.55 **	−2.23	−0.0710
Dis (0.5–0.75)	−1.13 ***	−8.09	−0.1103	−0.82 ***	−4.73	−0.1023
Dis (0.75–1)	−1.14 ***	−10.10	−0.1122	−1.44 ***	−9.35	−0.1680
Dis (1–1.25)	−2.03 ***	−19.28	−0.1986	−2.12 ***	−15.40	−0.2511
Dis (1.25–1.5)	−2.64 ***	−21.28	−0.2301	−3.08 ***	−19.16	−0.3320
Dis > 1.5	−3.56 ***	−23.73	−0.4187	−3.58 ***	−25.90	−0.5131
Cert	−0.94 ***	−10.59	−0.1084	−0.82 ***	−9.09	−0.1144
Female	-	-	-	0.27 ***	2.94	0.0372
Edu	−0.05 ***	−2.65	−0.0061	-	-	-
HHS	0.09 ***	3.05	0.0102	0.10 ***	2.68	0.0132
Age	−0.28 ***	−6.67	−0.0330	0.10 **	2.07	0.0136
Afternoon	-	-	-	−0.56 ***	−6.64	−0.0792
Night	−0.60 ***	−3.04	−0.0652	-	-	-
Peak	−0.21 ***	−3.25	−0.0252	0.30 ***	3.58	0.0429
Ori-Bal	-	-	-	2.46 **	2.06	0.3408
Des-Bal	4.95 ***	6.87	0.5904	2.41 **	2.09	0.3339
Ori-Den	0.002 ***	4.49	0.0002	-	-	-
Des-Den	-	-	-	0.001 **	2.09	0.0002
Tran-WT	−0.00017 **	−2.48	−0.00002	-	-	-
Int_den	0.0079 **	2.37	0.005	0.0105 **	2.06	0.0135
EMP	−0.46 ***	−3.20	−0.0513	-	-	-
Age < 14 * Dis > 1.5	0.64 ***	3.56	0.0815	-	-	-
Age (15–24) * 0.5 < Dis < 0.75	0.54 ***	2.62	0.0706	−0.73 **	−1.97	−0.0929
Age (15–24) * Dis > 1.5	0.64 ***	4.15	0.0795	-	-	-
Age (25–44) * 0.25 < Dis < 0.5	-	-	-	0.83 **	2.18	0.1265
Age (25–44) * 1.25 < Dis < 1.5	−0.67 **	−2.43	−0.0718	-	-	-
Age (45–64) * 1.0 < Dis < 1.25	0.65 ***	3.06	0.0849	-	-	-
Age > 65 * 0.5 < Dis < 0.75	−1.88 *	−1.80	−0.1560	-	-	-
Age > 65 * 0.75 < Dis < 1.0	-	-	-	1.01 **	1.99	0.1550
Model statistics						
Number of observations		10,000			4463	
Log-likelihood at convergence		−3793.08			−1949.84	
Restricted Log-likelihood (constant only)		−5269.08			−2790.01	
Log-likelihood at zero		−6931.47			−3093.52	
ρ_0^2		0.452			0.369	
ρ_c^2		0.280			0.301	

Note: *** Significance at the 99% level, ** Significance at the 95% level, * Significance at the 90% level; M.E.: Marginal Effect.

4.1. Individual and Socio-Economic Characteristics

Based on the "*Cert*" estimated coefficient, possessing a driving license decrease the likelihood of choosing walking for both trip purposes; however, the reduction is higher in mandatory trips, as shown in Kaplan et al. [32]. Women are more likely to choose walking for their discretionary trips than men; however, the gender difference is not significant in mandatory trips, as Agrawal and Schimek [20] reported. With an increase in the education level and age, the tendency to walk for mandatory trips decreases. Concerning the level of education, the main reason for choosing walking is the reduction effect of increased income. About the age, more senior individuals have less tendency to walk.

Walking due to the specific and predetermined time windows of mandatory trips, which is in line with Tian et al. [29] and Rodriguez and Joo [24]. Conversely, with an increase in age, people tend to choose walking for discretionary trips. This is because discretionary trips have more recreational and leisure aspects, for which the older people have more free time; such a finding is consistent with that of Pucher and Dijkstra [22] and Omrani et al. [45]. Individuals in larger households are more likely to choose walking for their mandatory and discretionary trips, as reported by Tian and Ewing [29].

4.2. Trip and Environmental Characteristics

With an increase in the population density in the origin point, the walking likelihood in mandatory trips increases. However, the population density in the destination of discretionary trips positively impacts walking likelihood, as shown by Greenwald [46]. In other words, individuals are more likely to choose walking to go to destinations with higher population densities in their discretionary trips. In addition, in discretionary trips, as the job-population balance at origin/destination increases, the accessibility will increase, leading to an increase in the probability of choosing walking. However, this subject is only significant in the destination of mandatory trips. Comparison of estimated coefficients for this variable (4.95 for mandatory and 2.41 for discretionary trips) indicates that it is twice as more influential on walking utility in mandatory trips than the discretionary ones, in line with Hatamzadeh et al. [13] findings. In conformity with Reid and Cervero's [36] results, walking time to transit stations have been significant with a negative sign in the mandatory walking trips, indicating a lower likelihood of choosing walking as the walking time to transit station increase. Further, following Sehatzadeh et al. [31] outcomes, intersection (four-leg) density have a positive impact on walking likelihood in both trip types, but it is a more influential factor in discretionary trips for individuals. Concerning trip characteristics, discretionary trips in the afternoon (13–17) and mandatory trips at night reduce walking utility. On the one hand, the individuals who accomplish their mandatory trips during peak hours have a lower tendency to walk. On the other hand, if individuals are willing to perform their discretionary trip during these hours, they are more likely to choose walking; this result is consistent with Hatamzadeh et al. [13]. Given the lack of flexibility in starting time of working trips, employees have less tendency to choose walking for their mandatory trips.

4.3. Analyzing Trip Distance and Age Groups More Deeply

The model outputs reveal that the categorical distance variables are significant with a negative sign. Besides, with an increase in the trip distance, the value of estimated parameters becomes more negative, leading to a more reduction in walking likelihood (note that distance shorter than 0.25 miles, i.e., ~400 m, is considered the reference). It is worth pointing out that such findings align with previous studies in the field, i.e., [16,18]. Figure 4 indicates that people have a greater tendency to walk in all of their mandatory trips at all distances except for 0.5–0.75 (800–1200 m) miles, compared to discretionary trips. This suggests that at distances shorter than 0.5 (800 m) and longer than 0.75 miles (1200 m), people's sensitivity to distance is greater in discretionary trips, considerably reducing the utility of walking (compared to mandatory trips). On the one hand, the coefficient of trip distance within 0.25–0.5 (400–800 m), 0.75–1 (800–1200 m), and 1.25–1.5 (2000–2400 m) miles in discretionary trips is 17% more negative, on average, compared to mandatory trips. On the other hand, the absolute estimated value of Dis -(0.5–0.75) is larger by around 37% in mandatory trips. Finally, coefficients' values suggest no considerable difference in people's tendency to choose walking at 1–1.25 miles (1600–2000 m) and longer than 1.5 miles (2400 m).

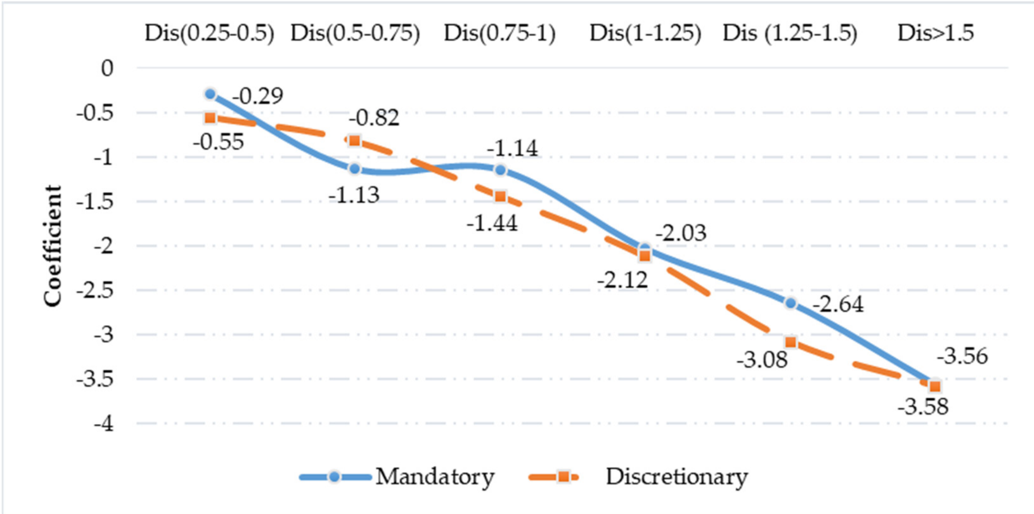

Figure 4. Comparison of the estimated coefficients of different trip distance by trip purpose.

Moreover, to investigate the heterogeneity of people's walking behavior, the variable of age (classified from *age < 14* to *age > 65*) is multiplied by the trip distance (categorized from *Dis (0.25–0.5)* to *Dis > 1.5*), their significance is analyzed in both models. Results show that younger than 14 are mostly students who have less sensitivity to the distance longer than 1.5 miles (2400 m) in mandatory trips. The "*Age < 14 * Dis > 1.5*" interaction variable is significant with a positive sign; this coefficient modifies the extent of utility reduction in the "*Dis > 1.5*" variable. This is also true for persons aged 15–24 years and distances of "*Dis (0.5–0.75)*" and "*Dis > 1.5*" and also 45–64 years for "*Dis (1–1.25)*". It is observed that people aged 25–44 years or older than 65 are less likely to choose walking for their mandatory trips between 1.25–1.5 (2000–2400 m) and 0.5–0.75 (800–1200 m) miles, respectively. In discretionary trips, individuals aged 15–24 years old with a trip distance of 0.5–0.75 (800–1200 m) miles are less likely to choose walking than other age groups. Moreover, the older adults have less reduction in utility caused by Dis (0.75–1) compared to the other age groups.

4.4. Implications for Policy and Practice

Coefficients and their levels of significance provide some important insights as to policy measures designed to promote walking but do not give much insight for planning; the marginal effect was computed to determine the effect of one unit change in the explanatory variables on the likelihood of choosing walking [47]. In this paper, marginal effects are calculated for each decision maker and weight each individual marginal effect by the decision maker's associated choice probability, known as the probability-weighted sample enumeration (PWSE) method [41]. It is worth noting that some variables (such as age, gender, etc.) are out of policymakers' hands, and computing marginal effects does not make sense.

According to the results, distance is one of the most important factors in walking, especially in discretionary trips. Considering the marginal effect value of the variable Dis > 1.5, it can be seen that the probability of walking decreases by 51.3% and 41.8% in discretionary and mandatory trips, respectively, compared to the reference value (400 m). To this end, it is proposed as a policy that policymakers establish recreational areas such as parks, gyms, and shopping malls within less than 1.5 miles (2400 m) of individuals' residence location. Further, regarding the significant effect of *Age < 14 * Dis > 1.5*, Although distance negatively affects the mandatory walking trips, students are less sensitive to this issue and can be considered a threshold for school construction as a proposed policy. Furthermore, having a driving license increases the use of private cars in both discretionary and mandatory trips and reduces the likelihood of walking. Policymakers can take essential steps to reduce car use and encourage more people to engage in active transportation modes by implementing travel demand management (TDM) policies.

Concerning BE variables, a proposed policy based on research findings is planned to enhance mixed-use developments. Due to the significant effect of job- population balance on the origin and destination of discretionary and mandatory trips, as the accessibility of people increases, the likelihood of choosing walking in these two types of trips will increase. Another BE variable is the residential density, which increases the likelihood of walking on discretionary and mandatory trips. As a proposed policy, local authorities should establish discretionary trip attraction centers such as parks and shopping malls in densely populated zones. As another proposed policy, given the impacts of walking time to the transit station, it is recommended to implement transit stations within a reasonable distance that it is possible to walk. The four-leg intersections are factors that increase the connectivity in the network, which will increase the walking likelihood. Based on the significant effect of this variable on walking likelihood in discretionary and mandatory trips, policymakers should avoid the construction of three-leg intersections because it will reduce the likelihood of walking, especially on discretionary trips.

5. Conclusions

In order to achieve sustainable transportation and economic development, the dependence on private cars should be reduced while encouraging "greener" transport modes, such as public transit, walking, and cycling [48,49]. Determining the explanatory factors affecting pedestrians' mobility and how these factors affect walking likelihood have always been of interest to authorities. This paper identified the strongest predictors of walking likelihood by emphasizing trip distance and differentiation between the factors in mandatory and discretionary trips. Moreover, taking into account the differences in people's responses in diverse situations, trip distance and age interaction variables were used to explore the extent of their preference for walking. The examined variables were classified into three groups, including trip (distance and departure time), SE characteristics (age, gender, possessing or lacking a driving license, level of education, and household size), and BE variables (population density, job-population balance at origin and destination, walking time to transit stations and intersection density). The descriptive analysis of available data reported that individuals without a driving license, more than five-person households, less than 14 years old, high school diploma and lower education levels, and peak hour trips have a greater share of walking on mandatory trips.

Furthermore, walking is more prevalent in discretionary trips among the following individual classes: women, people without a driving license, one-person households, younger than 14 years, illiterate, and peak hour trips. Besides, estimation results of binary logit models showed a greater reduction in walking likelihood in discretionary trips with distances of 0.25–0.5 (400–800 m) and more than 0.75 (1200 m) miles compared to mandatory ones. Additionally, women have a greater tendency to choose walking for discretionary trips. An increase in the household size increases the walking likelihood for different trip purposes, while possessing a driving license reduces that. With an increase in age, people tend more to choose walking for discretionary trips, while in mandatory trips, the utility of walking diminishes with increased age. The heterogeneity in individuals' behavior showed that people of different ages have diverse preferences for distance according to trip purposes. More properly, teenagers have less sensitivity to distances longer than 1.5 miles (2400 m) in mandatory trips. It was also found that individuals between 25–44 years old or above 65 are less likely to choose walking for mandatory trips with the length of 1.25–1.5 (2000–2400 m) and 0.5–0.75 miles (800–1200 m). These findings are almost different in discretionary trips; compared to other age groups, people aged 15–24 years are less likely to choose walking on discretionary trips with a distance of 0.5–0.75 miles (800–1200 m). Moreover, in choosing walking on trip distances of 0.75 -1 mile (1200–1600 m), the elderly have a greater tendency than other age groups. Concerning BE variables, it was found that job-population density at origin and destination and intersection density have the most influence on walking likelihood.

It is worth stressing that the primary outcomes achieved in this research can provide a basis for modeling other Iranian cities. Nevertheless, the models with the specified parameters cannot be applied directly to other countries or cultures because of their different situations and perspectives. Currently, there is minimal availability of data and information on walking behavioral approaches in developing countries such as Iran. This is especially true for Qazvin; that is why it was not possible to analyze the impacts of some environmental variables such as destination accessibility, residential self-selection, and attitude. Regardless, a follow-up of the present research will investigate whether and how accessibility to public transit infrastructure and services could affect specific user classes' modal choice in wider urban environments. In doing so, people's attitude to choose walking, according to the main SE characteristics, will also be considered. The above analysis will be carried out also considering the impacts of the pandemic due to COVID-19 on walking behaviors and attitudes: a pandemic which, at the time of writing, is still affecting the lives of all humanity. Additional future research will be based on collecting longitudinal data for affective variables to explore further how different explanatory variables might impact walking distance and likelihood over time. The above will likely support the policy decision-making process, thus providing evidence that human capital is crucial in achieving sustainable mobility goals.

Author Contributions: Conceptualization, E.M., A.K., I.F., M.A., A.R.M. and C.P.; methodology, E.M., A.K., I.F., M.A., A.R.M. and C.P.; software, E.M., A.K., I.F. and M.A.; formal analysis, E.M., A.K., I.F., M.A. and C.P.; investigation, E.M., A.K., I.F., M.A. and C.P.; resources I.F. and M.A.; data curation, E.M., A.K. and I.F.; writing-original draft preparation, E.M., I.F. and M.A.; writing-review and editing, E.M., A.K., I.F., M.A., A.R.M. and C.P.; visualization, E.M., I.F., M.A. and C.P.; supervision, E.M., A.R.M. and C.P.; project administration, E.M., A.R.M. and C.P. All authors have read and agreed to the published version of the manuscript.

Funding: This paper has not received external funding.

Institutional Review Board Statement: Ethical review and approval were waived for this study because it is not apllicable for this study due to the reasons including: (1) not involving human who lacks capacity; (2) not working with human tissues; (3) not conducting any experimental or scientific procedures with animals and humans; and (4) not involving human biology or experimental human psuchology that falls outside the RGFHSC.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors would like to acknowledge the Transportation and Traffic Organization of Qazvin for providing parts of the data. However, it had no responsibility for this study design, analysis and interpretation of data, writing the paper, or decision to the paper for publication. Moreover, the authors would like to gratefully acknowledge the reviewers who provided helpful com-ments and insightful suggestions on the manuscript draft.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Perchoux, C.; Brondeel, R.; Wasfi, R.; Klein, O.; Caruso, G.; Vallée, J.; Klein, S.; Thierry, B.; Dijst, M.; Chaix, B.; et al. Walking, trip purpose, and exposure to multiple environments: A case study of older adults in Luxembourg. *J. Transp. Health* **2019**, *13*, 170–184. [CrossRef]
2. Mehdizadeh, M.; Mamdoohi, A.; Nordfjaern, T. Walking time to school, children's active school travel and their related factors. *J. Transp. Health* **2017**, *6*, 313–326. [CrossRef]
3. Macioszek, E. Changes in Values of Traffic Volume–Case Study Based on General Traffic Measurements in Opolskie Voi-vodeship (Poland). In Proceedings of the Directions of Development of Transport Networks and Traffic Engineering. Lecture Notes in Net-works and Systems, Katowice, Poland, 17–19 September 2018; Macioszek, E., Sierpiński, G., Eds.; Springer International Publishing: Cham, Switzerland, 2019; pp. 66–76.

4. Macioszek, E. Roundabout entry capacity calculation–a case study based on roundabouts in Tokyo, Japan, and Tokyo surroundings. *Sustainability* **2020**, *12*, 1533. [CrossRef]
5. Abbasi, M.; Hosseinlou, M.H.; Jafarzadeh Fadaki, S. An investigation of Bus Rapid Transit System (BRT) based on economic and air pollution analysis (Tehran, Iran). *Case Stud. Transp. Policy* **2019**, *8*, 553–563. [CrossRef]
6. Gao, J.; Chen, H.; Dave, K.; Chen, J.; Jia, D. Fuel economy and exhaust emissions of a diesel vehicle under real traffic condi-tions. *Energy Sci. Eng.* **2020**, *8*, 1781–1792. [CrossRef]
7. World Health Organization. Ambient Air Pollution: A Global Assessment of Exposure and Burden of Disease. Available online: https://apps.who.int/iris/handle/10665/250141 (accessed on 4 June 2021).
8. World Health Organization. Obesity and Overweight. Available online: http://www.who.int/mediacentre/factsheets/fs311/en/ (accessed on 5 June 2021).
9. Schäfer, C.; Mayr, B.; de Battre, F.L.P.; Reich, B.; Schmied, C.; Loidl, M.; Niederseer, D.; Niebauer, J. Health effects of active commuting to work: The available evidence before GISMO. *Scand. J. Med. Sci. Sports* **2020**, *30*, 8–14. [CrossRef] [PubMed]
10. Abbasi, M.; Piccioni, C.; Sierpiński, G.; Farzin, I. Analysis of Crash Severity of Texas Two Lane Rural Roads Using Solar Altitude Angle Based Lighting Condition. *Sustainability* **2022**, *14*, 1692. [CrossRef]
11. Blečić, I.; Congiu, T.; Fancello, G.; Trunfio, G.A. Planning and Design Support Tools for Walkability: A Guide for Urban Analysts. *Sustainability* **2020**, *12*, 4405. [CrossRef]
12. Mehdizadeh, M.; Nordfjaern, T.; Mamdoohi, A. The role of socio-economic, built environment and psychological factors in parental mode choice for their children in an Iranian setting. *Transportation* **2016**, *45*, 523–543. [CrossRef]
13. Hatamzadeh, Y.; Habibian, M.; Khodaii, A. Walking behavior across genders in school trips, a case study of Rasht, Iran. *J. Transp. Health* **2017**, *5*, 42–54. [CrossRef]
14. Park, H.; Noland, R.B.; Lachapelle, U. Active school trips: Associations with caregiver walking frequency. *Transp. Policy* **2013**, *29*, 23–28. [CrossRef]
15. Copperman, R.B.; Bhat, C.R. An analysis of the determinants of children's weekend physical activity participation. *Transportation* **2006**, *34*, 67–87. [CrossRef]
16. Larrañaga, A.M.; Rizzi, L.I.; Arellana, J.; Strambi, O.; Cybis, H.B.B. The influence of built environment and travel attitudes on walking: A case study of Porto Alegre, Brazil. *Int. J. Sustain. Transp.* **2014**, *10*, 332–342. [CrossRef]
17. Paydar, M.; Fard, A.K.; Khaghani, M.M. Walking toward metro stations: The contribution of distance, attitudes, and perceived built environment. *Sustainability* **2020**, *12*, 10291. [CrossRef]
18. Tsunoda, K.; Soma, Y.; Kitano, N.; Jindo, T.; Fujii, K.; Okura, T. Acceptable Walking and Cycling Distances and their Corre-lates among Older Japanese Adults. *J. Popul. Ageing* **2021**, *14*, 183–200. [CrossRef]
19. Piccioni, C.; Valtorta, M.; Musso, A. Investigating effectiveness of on-street parking pricing schemes in urban areas: An em-pirical study in Rome. *Transp. Policy* **2019**, *80*, 136–147. [CrossRef]
20. Agrawal, A.W.; Schimek, P. Extent and correlates of walking in the USA. *Transp. Res. Part D Transp. Environ.* **2007**, *12*, 548–563. [CrossRef]
21. Hatamzadeh, Y.; Habibian, M.; Khodaii, A. Walking mode choice across genders for purposes of work and shopping: A case study of an Iranian city. *Int. J. Sustain. Transp.* **2019**, *14*, 389–402. [CrossRef]
22. Pucher, J.; Dijkstra, L. Promoting Safe Walking and Cycling to Improve Public Health: Lessons from The Netherlands and Germany. *Am. J. Public Health* **2003**, *93*, 1509–1516. [CrossRef]
23. Teshome, M. Logit Model of Work Trip Mode Choice for Bole Sub-City Residents. Ph.D. Thesis, University School of Graduate Studies Faculty of Technology, Addis Ababa, Ethiopia, 2007.
24. Rodriguez, D.A.; Joo, J. The relationship between non-motorized mode choice and the local physical environment. *Transp. Res. Part D Transp. Environ.* **2004**, *9*, 151–173. [CrossRef]
25. Mehdizadeh, M.; Mamdoohi, A.R. Active school travel: Homogeneity or heterogeneity? That is the question. *Transp. Plan. Technol.* **2020**, *43*, 443–462. [CrossRef]
26. Mehdizadeh, M.; Nordfjaern, T.; Mamdoohi, A. Environmental norms and sustainable transport mode choice on children's school travels: The norm-activation theory. *Int. J. Sustain. Transp.* **2019**, *14*, 137–149. [CrossRef]
27. Zavareh, M.F.; Abolhasannejad, V.; Mamdoohi, A.; Nordfjærn, T. Barriers to children's walking to school in Iranian and Chinese samples. *Transp. Res. Part F Traffic Psychol. Behav.* **2020**, *73*, 399–414. [CrossRef]
28. Ton, D.; Duives, D.C.; Cats, O.; Hoogendoorn-Lanser, S.; Hoogendoorn, S.P. Cycling or walking? Determinants of mode choice in the Netherlands. *Transp. Res. Part A Policy Pract.* **2018**, *123*, 7–23. [CrossRef]
29. Tian, G.; Ewing, R. A walk trip generation model for Portland, OR. *Transp. Res. Part D Transp. Environ.* **2017**, *52*, 340–353. [CrossRef]
30. Khan, M.; Kockelman, K.M.; Xiong, X. Models for anticipating non-motorized travel choices, and the role of the built en-vironment. *Transp. Policy* **2014**, *35*, 117–126. [CrossRef]
31. Sehatzadeh, B.; Noland, R.B.; Weiner, M.D. Walking frequency, cars, dogs, and the built environment. *Transp. Res. Part A Policy Pract.* **2011**, *45*, 741–754. [CrossRef]
32. Kaplan, S.; Nielsen, T.A.S.; Prato, C.G. Walking, cycling and the urban form: A Heckman selection model of active travel mode and distance by young adolescents. *Transp. Res. Part D Transp. Environ.* **2016**, *44*, 55–65. [CrossRef]

33. McMillan, T.E. The relative influence of urban form on a child's travel mode to school. *Transp. Res. Part A Policy Pract.* **2007**, *41*, 69–79. [CrossRef]
34. Hatamzadeh, Y.; Habibian, M.; Khodaii, A. Walking Behaviors by Trip Purposes. *Transp. Res. Rec. J. Transp. Res. Board* **2014**, *2464*, 118–125. [CrossRef]
35. Bhat, C.R.; Guo, J.Y.; Sardesai, R. *Non-Motorized Travel in the San Francisco Bay Area*; University of Texas: Austin, TX, USA, 2005; pp. 17–27.
36. Reid, E.; Cervero, R. Travel and the built environment: A meta-analysis. *J. Am. Plan. Assoc.* **2010**, *76*, 265–294.
37. Besser, L.M.; Dannenberg, A.L. Walking to Public Transit: Steps to Help Meet Physical Activity Recommendations. *Am. J. Prev. Med.* **2005**, *29*, 273–280. [CrossRef]
38. Piccioni, C. Accessibilità territoriale e dinamiche d'uso delle infrastrutture stradali: Un approccio alla pianificazione integrata/Territorial accessibility and dynamics in road infrastructures use: An integrated planning approach. *Ing. Ferrov.* **2011**, *66*, 621–641.
39. Frank, L.D.; Pivo, G. Impacts of mixed use and density on utilization of three modes of travel: Single-occupant vehicle, transit, and walking. *Transp. Res. Rec.* **1994**, *1466*, 44–52.
40. Ewing, R.; Tian, G.; Goates, J.P.; Zhang, M.; Greenwald, M.J.; Joyce, A.; Kircher, J.C.; Greene, W.H. Varying influences of the built environment on household travel in 15 diverse regions of the United States. *Urban Stud.* **2014**, *52*, 2330–2348. [CrossRef]
41. Krizek, K.J. Neighborhood services, trip purpose, and tour-based travel. *Transportation* **2003**, *30*, 387–410. [CrossRef]
42. Hensher, D.A.; Rose, J.M.; Rose, J.M.; Greene, W.H. *Applied Choice Analysis: A Primer*; Cambridge University Press: Cambridge, UK, 2005.
43. Macioszek, E. The comparison of models for follow-up headway at roundabouts. In *Recent Advances in Traffic Engineering for Transport Networks and Systems. Lecture Notes in Networks and Systems 21*; Macioszek, E., Sierpiński, G., Eds.; Springer International Publishing: Cham, Switzerland, 2018; pp. 16–26.
44. Macioszek, E. The application of HCM 2010 in the determination of capacity of traffic lanes at turbo roundabout entries. *Transp. Probl.* **2017**, *11*, 77–89. [CrossRef]
45. Omrani, H.; Mamdoohi, A.R.; Farzin, I. Taste variation of the elderly mode choice. *Int. J. Transp. Eng.* **2021**, *8*, 341–362. [CrossRef]
46. Greenwald, M.J. *SACSIM Modeling-Elasticity Results: Draft*; Fehr & Peers Associates: Walnut Creek, CA, USA, 2009.
47. De Dios Ortúzar, J.; Willumsen, L.G. *Modelling Transport*; John Wiley & Sons: Hoboken, NJ, USA, 2011.
48. Abbasi, M.; Hosseinlou, M.H.; Sarreshtehdari, A.; Mandzuka, S. Evaluation of Transit Signal Priority for Bus Rapid Transit in Heterogeneous Traffic Flow. *Teh. Vjesn.* **2021**, *28*, 2080–2087. [CrossRef]
49. Karami, A.; Hosseinlou, M.H.; Abbasi, M.H.; Figuerira, M. Priority Order for Improvement of Intersections using Pedestrian Crash Prediction Model. *Int. J. Transp. Eng.* **2020**, *7*, 297–313. [CrossRef]