The effect of daily activity patterns on crash involvement

Wafa Elias, Tomer Toledo and Yoram Shiftan[1]

Transportation Research Institute, Technion - Israel Institute of Technology

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Abstract

The main purpose of this study is to analyze the effect of daily activity and travel patterns on the risk of crash involvement. To this end, we develop a model that integrates daily activity and travel choices in a single framework, recognizing that these variables affect the risk of crashes. This model can therefore provide predictions of the expected changes in risk levels from the implementation of measures that affect the daily activity patterns and the socio-economic characteristics of the population.
The empirical analysis makes use of data collected during a household survey that includes crash information and trip diaries. The model is applied in a case study of an Arab town in Israel to analyze various transportation policies. The results of this research show that in addition to individuals' demographic and socio-economic characteristics, their daily activity and travel patterns also have an impact on the risk of being involved in car crashes. The case study showed the potential of this framework for analyzing the effect of various social and transportation policies on road safety. To the best of our knowledge, this is the first time such relationships have been tested by using a disaggregate model and the first time activity-based models have been used to analyze exposure to the risk of road crashes.

Keywords: Daily activity patterns; Crash involvement; Risk, Logit model

1. Introduction

The wide variety of measures that have been proposed and implemented in order to improve safety treat the three main factors present in crashes: the roadway (Noland and Oh, 2004; Mayora and Robio, 2003; Kononov and Allery, 2004) including environmental factors such as light and weather conditions (Daniel et al., 2002; Cardoso et al., 2004), the vehicle (Stuckey et al., 2007), and the driver (Ogle, 2005). Most of the studies relating to the driver factor focus on the relations between demographic and socio-economic characteristics and crash involvement, using such variables as driver age and gender (Junkwood et al., 2007a; Harre, 2000; McColl, 2001; Foret et al., 2003; Al-Balbissi, 2003; Al-Bustan, 2003; Busch et al., 2002; Spallek et al., 2006) and income and level of education (Hasselberg et al., 2005; Kulanthayan et al., 2004; Al-Bustan, 2003; Abdulmajid, 2007; Van-Vuuren, 2001; Petridou and Belechri, 2002; Al-Balbissi, 2003; Spallek et al., 2006). Many studies also attempted to examine the effectiveness of various prevention policies to change driver behavior so to reduce crashes and their severity, such as the use and

[1] Correspondence author: Tel: +972-4-8292381, Fax: +972-4-8295708, Email: shiftan@technion.ac.il

consumption of alcohol (Tay, 2005; Freeman et al., 2006), speed (Tay, 2005), and use of seat belts (Şimşekoğlu and Lajunen, 2009; Vinod et al., 2009).

This paper focuses on the effect of individuals' activity patterns and travel behavior on their risk of being involved in a crash. Car-crash involvement is a by-product of participation in activities and the travel they require. Thus, an individual's risk of involvement in a car crash depends not only on the activities themselves in which the individual takes part, but also on their location, timing, and the attributes of the trip undertaken to participate in these activities, such as mode, route, and time of day/week. These activity and travel patterns are affected by the socio-economic characteristics of the individual and the activities of other members of the household (e.g., through shared and drop-off trips), as well as by urban-form and land-use variables. The latter are directly influenced by infrastructure investments, which can change the level of access to various activities. Most crash risk studies employ simple and crude measures of risk exposure, such as distance traveled, number of intersections crossed, trip duration, or average speed (Junkwood et al., 2007a; Thouez et al., 2005; Spallek et al., 2006; Al-Balbissi, 2003; Junkwood et al., 2007b; Knoblauch et al., 1984). These variables, though, have limited power to explain the risk of crash involvement (Janke, 1991; Greenshields and Platt, 1967), since they do not account for trip attributes. For example, Chliaoutakis et al. (1999, 2005) showed that the travel distance alone is insufficient to reflect the exposure to risk, since risk levels are affected by trip purpose. Similarly, Thouez et al. (2005) showed that for pedestrians the risk varies with residence location. Spallek et al. (2006) claimed that crash risk estimates generally do not account for different risk levels in different situations. They attributed this deficiency mainly to the lack of knowledge on a traveler's exposure to various situations (e.g., time of day, type of road. etc.). Therefore, these various measures suggested in the literature do not fully capture the potential effects of various transportation, urban, and social policies on road safety.

This paper suggests the use of an activity-based risk measure that tries to capture the individuals' risks of crash involvement as a function of their daily activity patterns and travel behavior. It reports on the development of a model that integrates daily activity choices with the risk of crash involvement in a single framework recognizing that activity and travel patterns themselves may affect the risk of crash involvement. This model, therefore, can provide predictions of the expected changes in risk levels that are due to the implementation of measures affecting the daily activity patterns and socio-economic characteristics of the population. The paper demonstrates the potential of this newly suggested framework by applying the estimated model system to analyze various policies in a case study.

The paper is organized as follows: The next section presents the theory of the suggested framework while Section 3 describes the practical development from this theoretical basis for this research. Section 4 describes the methodology including the data used. Section 5 presents and discusses the various results, and the final section offers conclusions.

2. Theory

This study develops a theoretical framework to explain the risk of crash involvement by means of the attributes of the travel that individuals undertake. These travel demand patterns are derived from the participation in various activities. A model that integrates both activity and travel patterns on one hand and crash involvement on the other has important advantages for evaluating various social and transportation policies (e.g., educational programs, changes in traffic arrangements) that can affect daily activity and travel patterns and thereby influence traffic safety. The overall framework of this activity-based risk model is presented in Figure 1. It includes two main sub-models:

- A daily activity model that captures activity and travel patterns and can predict changes in these patterns in response to various policies.
- A crash risk model that captures the impact of travelers' daily activity and travel patterns on the risk of their crash involvement.

Activity-based travel-demand models derive the demand for trips from the demand for participation in various activities. These models look at the overall daily activity and travel pattern, taking into account time and space constraints, rather than examining each trip individually. For a detailed discussion of these models see for example Kitamura, (1988); Ettema and Timmermans, (1997); Axhausen and Garling, (1992); Ben-Akiva and Bowman, (1998a); and Arentze and Timmermans, (2000). In the past decade, these models have become practical planning tools in various metropolitan areas, including New York, Columbus OH, Atlanta (Bradley and Vovsha, 2005), and Tel Aviv, Israel (Shiftan et al., 2004).

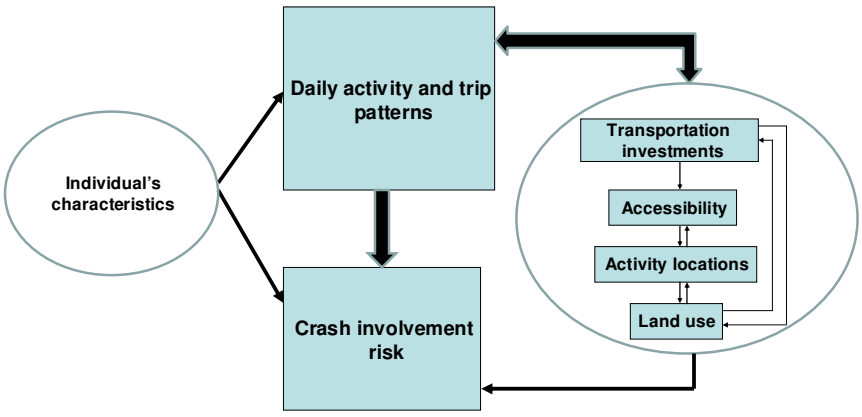

Figure 1. Framework of the activity-based risk model

3. Calculation

3.1 The Model Structure

The structure of the activity-risk model developed in this project is shown in Figure 2 and includes two main elements:

1. A daily activity model consisting of three sub-models: the highest level estimates the choice of the main daily activity; the second level estimates the choice of a daily activity pattern; and the third level estimates the choice of travel routes. The first two-levels are estimated as a nested logit model and the third is estimated as a binary logit model. The choices at the lower levels of the model depend on the choice at the higher levels. The availability of various travel modes in this rural town of Majd-Elcrum is limited, and therefore mode choices are incorporated into the daily activity alternatives and not modeled explicitly.

2. A crash-risk model estimating the probabilities of three alternatives: non-involvement in car crashes; crash involvement as a pedestrian; and crash involvement as a driver or passenger. This model is estimated as a multi-nomial logit model where the explanatory variables include demographic and socio-economic characteristics of the household, residential location, and the daily activity patterns as endogenously estimated by the activity-based models described above.

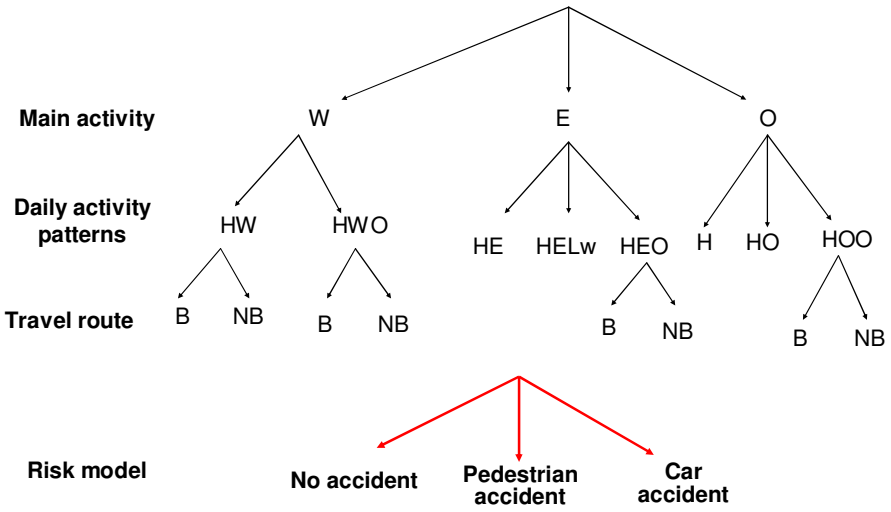

Figure 2. Structure of the daily activity crash risk model

3.2 The Daily Activity Model

The highest level in the daily activity model developed for this project is the choice of the main activity in the day. It consists of three alternatives: Work (W), Education (E), and Other (O), which represents activities such as shopping, leisure, dropping off a child, a trip without purpose, or staying at home.

The second level is the daily-activity pattern model; the various alternatives were aggregated to eight choices, depending on the main activity:

1. When the main activity is work, there were two alternatives: a simple tour from home to work and back by car (HW) and a more complex tour that may include more destinations for any purpose, as well as the use of additional travel modes (HWO).
2. When the main activity is schooling, there were three alternatives: walking from home to school and back without any further activities during the day (HE), walking to school with additional walk trips for leisure after returning from school (HELw), and traveling to school and other destinations, such as shopping and leisure, using mixed modes of transportation (walking and using a vehicle as a passenger) (HEO).
3. When the main activity is other, there are three alternatives: staying at home without any travel (H), walking from and to home for a single activity (HO), and undertaking multiple trips to various destinations by using mixed modes of transportation, which may include walking and using a vehicle either as a driver or a passenger (HOO). This category also includes trips without purposes.

In the third level, the route selection is modeled as a binary choice between two available routes. The first is a route that uses the historic main street (NB) through the town center; the second uses the old bypass (B). This choice set characterizes the real alternatives facing travelers in this town.

4. Methodology

The methodology for this research include choosing a case study, design a questionnaire and collect data through household surveys, analyze the data, and estimate the models describes in Section 3. Finally the whole framework is demonstrated by applying it to analyze the potential impacts of various policies. Section 4.1 describes the case study and the data used for this research and Section 4.2 describes the application of the model to test the impact of various policies on safety. The models describes in Section 3 were estimated using the Biogeme software.

4.1 Case study and data

To demonstrate the activity-based risk model framework, the model was estimated and applied in the town of Majd-Elcrum in rural northern Israel. Majd-Elcrum is an Arab town whose population is 12,700, with about 2,300 households (the average household size is 5.04). Regional Route 85, the main highway in the area, bypasses the town to the south. This bypass, opened in 1996, replaced an earlier bypass, which

has now become a major artery in the town. This town suffers from relatively high crash involvement rates among its residents.

Data were collected through a household survey, which included trip diaries. The survey was conducted in 2007, and encompassed 161 households, 101 of which were randomly selected. The random sample was enriched by 60 households with individuals who had been involved in car crashes in the prior three years in order to provide the sample with a sufficient number of such subjects. Ben-Akiva and Lerman (1985) showed that the parameters of a logit model with a full set of alternative-specific constants can be efficiently estimated in such cases by using an exogenous sample maximum likelihood with proper correction of the alternative-specific constants and that all other parameter estimates are consistent

Phone calls were made in advance to set up a convenient time for each interview, which was conducted in the respondents' homes. Travel diaries were completed for each member of the household over age six for the day preceding the visit. If necessary, the reviewer returned to houses more than once to make sure all household members were interviewed. A typical survey session took an hour and a half per household. The resulting sample consisted of 655 individuals, 344 male and 311 female, ranging in age from 6 to 93.

4.2 Model Application

For application purposes, three scenarios were defined as follows:

1. "Business as usual"; namely, nothing is change in the infrastructure and urban plan or the socio-demographic characteristics of the population.
2. Social improvement, including a rise in the level of education and status of women as expressed in an increase in the proportion of licensed women drivers from their current 37% to 52%, and an improvement in education levels, such that the proportion of people with higher education (i.e., more than 12 years) increases from 26% to 45%. For men, the scenario included an increase in the proportion of persons who have received a higher education, from 29% to 46%. These changes are realistic and based on the extrapolation of existing trends in this and other similar towns. Based on the daily activity models, these two variables have an important impact on participation in the work force and a significant influence on the travel patterns of children. The purpose of this scenario is to test how such changes influence the daily activity patterns of women and men, and whether they also have an impact on people's involvement in road accidents. This scenario does not include any changes in the transportation system or accessibility levels and relates only to changes in demographic and socio-economic characteristics.
3. Transportation accessibility is changed by reducing the speed limit on the old bypass road, which today passes through the town, by means of traffic calming. The risk model is sensitive to variables that express access to activities including travel time and the number of times the road user travels along the bypass road. In this scenario the posted speed limit on the old bypass was reduced from 70 kmh to 30 kmh and as a result the travel time increased; this would likely divert some trips to the historical town center.

The application of the model is based on the sample enumeration method, which involves calculating the probabilities of choosing each of the alternatives along each of the modeled decision dimensions for each individual within the sample. The calculation of the probability for individuals is based on their characteristics. The overall expected rate of crash involvement is calculated by the summation of the individual crash risks:

$$P(crash = l) = \frac{1}{N}\sum_{n=1}^{N} P_n(W, HW)P_n(l \mid HW) + P_n(W, HWO)P_n(l \mid HWO) + \\ + P_n(O, HO)P_n(l \mid HO) + P_n(O, HOO)P_n(l \mid HOO) + \\ + P_n(O, H)P_n(l \mid H) + P_n(E, HE)P_n(l \mid HE) + \\ + P_n(E, HELw)P_n(l \mid HELw) + P_n(E, HEO)P_n(l \mid HEO) \quad (1)$$

Where:
n is the index of the individual
l is the index of alternatives in the risk model.

5. Results and Discussion

5.1 Descriptive Statistics

Table 1 summarizes the socio-demographic characteristics of the sample. Not surprisingly, women's participation in the workforce is less than half (34.3%) that of the men (68.6%), with more than half of the women being housewives (59.6%). 58.0% of the working men worked outside the town, compared to 38.0% of the working women. Finally, 63.1% of the men have a driving license, compared to 36.9% of the women.

In terms of crash involvement, the survey results show that only 15.0% of the respondents involved in crashes as drivers were women, which is 2.5 times lower than their proportion in the Majd-Elcrum driver population. In contrast, 27.6% of the crashes involved novice drivers (up to 2 years after licensure), which is almost three times their share in the Majd-Elcrum driver population (9.6%). An important factor that can account for the predominance of men in crash involvement is the differences in the exposure to crash risk. The data showed that women made fewer trips than men. Furthermore, only 37.8% of the travel conducted by women is done by driving, compared to 65.5% of men's travel. The average travel time for women is shorter than that for men and women make fewer tours (defined as a sequence of trips that commences and terminates at the residence) and fewer stops per tour.

Table 1
Socio-demographic characteristics in the Majd-Elcrum sample

			Men	Women
Gender (entire sample)		655	344	311
Age	Mean	28.4	29.6	28.6
	S.D.	16.9%	17.9	16.3
Education Level (over age 17)	0 to 8 years	22.9%	22.5%	23.5%
	9 to12 years	52.1%	49.6%	54.9%
	13 to 16 years	21.2%	22.9%	19.2%
	>16 years	3.8%	5.1%	2.3%
Status	Married	70.0%	64.4%	75.6%
	Unmarried	30.0%	35.6%	24.4%
Income level	Below average*	30.5%	-	-
	About average	12.0%	-	-
	Above average	57.5%	-	-
Work location**	Outside the town	50.6%	58.0%	38.0%
	Within the town	49.4%	42.0%	62.0%
Work Status (over age 17)**	Salaried	38.8%	50.0%	26.3%
	Self-employed	13.6%	18.6%	8.0%
	Unemployed***	6.0%	9.7%	1.9%
	Pensioner	9.6	17.8	0.5
	Housewife	28.3%	0%	59.6%
	Student	3.8%	3.8%	3.8%
Have driving license **	Yes		63.1%	36.9%
Number of cars in household	0	16.1%	-	-
	1	66.4%	-	-
	2	16.8%	-	-
	3	0.7%	-	-

*Average = 7,500 Shekels. (1US$=3.75 Shekels)
** Significant difference: $p<0.05$.
*** Unemployment does not include the housewives

A further analysis of crashes was made only for those drivers who were convicted for having caused the crash. Based on the interviews, significant differences were found between convicted driver and all drivers. The rate of convicted drivers possessing up to 9 years of education is 39.3%, which is 2.1 times the rate of this education level among all drivers (15.7%). The rate of convicted drivers possessing 13 or more years of education is 10.7%, which is 2.7 times less than the rate among all drivers (35.5%). Results in Table 2 show a comparison of the distribution of trip purposes for all drivers and for convicted drivers in the trips in which crashes occurred. It shows that work trips are substantially underrepresented in crash trips. In contrast, trips without a purpose constitute 0.6% of the trips, but account for 19.3% of the crashes.

Table 3 presents the distribution of daily activity patterns for those involved in car crashes and those that were not. The highest risk of being involved in a crash occurs when the daily activity pattern includes a number of trips for various purposes, excluding work and study. As expected, the risk of being involved in a car crash is also higher when the daily activity pattern includes, besides the work trip, a number of various activities by mixed modes (car, bus or car passenger, walk). For children

whose daily activity pattern includes a walk to school and other trips on foot after school are at a higher risk of being involved in crashes compared to those who only walk to and from school and those who participate in various activities by mixed modes. Among the children involved in crashes, 73.6% are under 15 years old, and 55.2% are under 9 year old. This last figure is roughly double their share in the population (28.0%). Furthermore, children whose parents possess a low level of education are at a higher risk of crash involvement. The rate of injured children whose mothers have 13 or more years of education is 8.6% less than the average rate in the town. The rate of injured children whose fathers have 13 or more years of education is 3.5% less than the average rate in the town. The statistics shown in these tables suggest that education, lifestyle and activity patterns may have an important effect on crash risks.

Table 2
Distribution of trip purposes for all drivers and for convicted drivers in the trips in which crashes occurred

Trip Purpose	Convicted Drivers Frequency (%)	All Drivers Frequency (%)
Work	6 (10.5)	267 (39.8)
Leisure	17 (29.8)	157 (23.4)
Personal arrangements	13 (22.9)	125 (18.6)
Pick-up and drop-off	10 (17.5)	118 (17.6)
No particular purpose	11 (19.3)	12 (0.6)
Total	57 (100)	671 (100)

Table 3
Distribution of daily activity pattern, by involved/not involved in road accidents

Daily Activity Pattern	Not Involved in Crashes Frequency (%)	Involved in Crashes Frequency (%)
Back and forth to work by car	80 (15.0)	19 (15.8)
Trip to work and additional trips to various activities	95 (17.8)	26 (21.7)
Back and forth to school on foot	97 (18.1)	3 (2.5)
Back and forth on foot to other activities (excluding work and study)	40 (7.5)	6 (5.0)
A number of trips to various destinations by using mixed modes (excluding work and study)	82 (15.3)	37 (30.8)
Walking back and forth to school with additional walk(s) to various activities after school	50 (9.3)	21 (17.5)
Trip to school and to other destinations, such as shopping and leisure, using mixed modes	58 (10.8)	8 (6.7)
Staying home	33 (6.2)	0 (0.0)
Total	535 (100)	120 (100)

5.2. The Daily Activity Model

For brevity, we will present here only the principal results of the daily activity model.

5.2.1 The main activity model

The results show that participation in the labor force increases with the level of education. This result is much stronger for women than for men. It is also higher for individuals who possess a driving license. Married woman are less likely to work. Among other things, this may reflect the combined effect of a lack of employment opportunities within the town and the lack of well-developed public transportation, resulting in limited job opportunities for those who do not drive. The high positive correlation between education level and women's participation in the labor force arises from the occupational structure. Many studies show that most Israeli Arab women work in the public sector (Epstein et al., 1994), and this type of work necessitates a high level of education; at the same time, there are not enough job opportunities for uneducated women.

5.2.2 The daily activity pattern model

The estimation results show that men with a higher level of education are more likely to choose a more complex pattern of activity. A possible explanation is that the physical labor and low wages usually experienced by men with lower education levels do not encourage participation in a variety of activities beyond work. The results also show that the more children living at home, their mother is significantly less likely to make complex tours. Men with more children living at home, on the other hand, are more likely, though not significantly, to make more complex tours.
Among children, the results show that when mothers possess a driving license, the children are more likely to have a daily activity pattern that includes trips to various activities, in addition to walking to school by mixed modes. The same variable among fathers was not significant. These results were expected, given that in the traditional Arab society raising the children is the responsibility of the mother. The more children in a household, they are less likely to participate in various activities using mixed modes. In contrast, the more cars in a household, the more likely children are to participate in various activities. Finally, the results show that the further the home is from the school, the greater is the tendency for children to remain at home upon returning home and not to go out to additional activities, even on foot.

Among people whose main daily activity is other (i.e., neither work nor study), the results show that married people are more likely to take part in activities outside home, and that women aged 18 to 40 are the most likely to stay at home. Similarly, women with more children are more likely to stay at home.

5.2.3 The route choice model

The estimation results for the route-choice model show, as expected, that travel time is an important factor affecting route choices. However, the model also shows that route choices depend on the trip destination and purpose, as well as individual daily

activity patterns. A few socio-economic characteristics were found to have a significant effect on route choice including employment status, gender, number of cars in the household and marital status.

5.3 The crash involvement risk model

The estimation results of the risk model are presented in Table 4. The affects of the various daily activity patterns are significant. Children who walk back and forth to school and have additional walk trips for leisure after returning from school are the most likely to be involved in crashes as pedestrians . In contrast, those who only walk to school are the least likely to be involved in crashes as pedestrians.

People whose main activity is work and whose daily activity pattern is only a round trip to work by car and those who go to work and to various other activities using mixed modes of travel are more likely to be involved in crashes as a driver or passenger. People whose daily activity pattern consists of neither work nor study, but includes a number of trips for various activities using mixed modes are even more likely to be involved in crashes either as driver or passenger than those who travel to work.

To test the joint significance of the variables capturing the impact of the daily activity patterns on involvement in crashes, the model was compared against a simplified model without these variables. The likelihood value of the simplified model was -333.03. A likelihood ratio test rejected the simplified model assuming all these coefficients are not significantly different from zero at the 5% confidence level.

The results show that the more someone uses a bypass road, the more likely it is for that person to be involved in a car crash and less likely to be involved in crashes as a pedestrian.

Among the demographic factors, it was found that children aged 6-12 are at a significantly higher risk of being involved in crashes as pedestrians. Drivers aged 26-40 are at a higher crash involvement risk than other age groups. This result may reflect the higher exposure level for this age group. As expected, men have a higher probability of being involved in crashes both as pedestrians and as drivers or passengers. This finding may again partly reflect men's higher exposure levels as the travel diaries showed that women made significantly fewer trips than men. Married people are significantly less likely to be involved in crashes compared to the unmarried. Individuals in households with more cars are significantly less likely to be involved in pedestrian crashes. Given that most of those involved in pedestrian crashes were young children, the more vehicles there are in a household, the more likely it is that the children will be driven by their parents rather than walk, and so they will be less exposed to pedestrian crashes.

These results support and enhance previous findings by Chliaoutakis et al. (1999, 2005) who showed the effect of trip purpose on crash risk. Our results also confirm that crash risk is higher in trips without a specific purpose. Spallek et al. (2006) also emphasized the important affect of the trip attributes on crash risks, and Al-Balbissi (2003) showed that men were more involved in road crashes than women because their participation in various social and economic activities was almost three times

that of women. Our results go a step forward by explicitly showing the effect of the daily activity pattern on the risk of being involved in crashes.

5.4 Demonstration application

Table 5 presents the probabilities of participating in the work force for women and men for two scenarios: business as usual and social improvement. The results for the third scenario are identical to those of the business as usual, since it does not affect the daily activity model. The results show that the major change in the social improvement scenario is an increase in women's employment rate from 36% to 73%. For men, who already had an employment rate of 72%, there was a marginal increase of 2%. These changes have also led to changes in the activity and travel patterns, which are shown in Table 6. There is a significant increase in work as the main activity and a decrease from 4.9% to 3.0% in persons who stay at home,. There is also a decrease in the patterns of activity that include one trip on foot and in the patterns that include a number of trips using mixed modes of transportation. Table 7 shows the effects of the changed in activity and travel patterns on the crash involvement risks. It indicates that the social improvement scenario will result in a 15.7% reduction in car crash involvement and 7.0% in pedestrian crashes.

The accessibility scenario also contributes to a decrease in the risk of car crash involvement by 9.8%. This reduction is a result of the reduced usage of the bypass road. However, the traffic that was diverted to the town center causes an increase in pedestrian crash involvement.

6. Conclusions

The main purpose of this research was to suggest a framework to analyze the effect of individuals' daily activity patterns and travel behavior on the risk of crash involvement and to test it empirically by a case study. The results show that in addition to individuals' demographic and socio-economic characteristics, their daily activity and travel patterns do have an impact on the risk of being involved in car crashes. To the best of our knowledge, the current research is unique in explicitly formulating and testing this connection using activity-based travel demand models. The application of the model showed its potential in analyzing the effects of various social and transportation policies on road safety.

The case study demonstrated the impact of various policies and socio-demographic changes that affect travel patterns on the risk of crash involvement. For example, an improvement in women’s education and licensure levels caused an increase in their work force participation, the travel patterns of all household members, and through that in the crash involvement risks.

As this is a first study to explore the relationships between daily activity and travel patterns and the risk of crash involvement there is a need for much future work in this direction. More detailed activity-based models based on larger and richer data sets should be developed and integrated with crash risk models in order to develop better activity-based exposure measures that can provide deeper understanding of the affect of various activity and travel patterns on the risk of crash involvement. These studies should be conducted in broader geographical and cultural situations to test for differences among various population segments.

Table 4
Estimation results of the crash risk model

		Alternative (2) Pedestrian Road Accident	Alternative (3) Car Accident
	Variable	β (t-statistics)	β (t-statistics)
Constraints	Constant	-2.553 (-4.1)	-
	Constant	-	-3.26 (-6.1)
	Daily activity pattern includes walking to school and additional walking for leisure	0.832 (1.8)	-
	Daily activity pattern consists only of walking to school	-2.68 (-2.5)	-
	Daily activity pattern includes back and forth to work by car; or trip to work with many other trips for various activities by mixed mode	-	1.22 (2.8)
	Daily activity pattern includes a number of trips to purposes other than work and study by mixed mode	-	2.077 (4.8)
	Number of times an individual uses the bypass road	-0.363 (-2.1)	-
	Number of times an individual uses the bypass road	-	0.110 (1.6)
	Age category from 6-12	1.015 (2.3)	-
	Age category from 6-12	-	-0.251 (-0.4)
	Age category from 26-40	-	0.794 (2.8)
	Gender – men	1.723 (3.5)	-
	Gender – men	-	0.58 (2.1)
	Married	-0.577 (-2.2)	-0.577 (-2.2)
	One car in the household	-1.30 (-2.8)	-
	One car in the household	-	0.028 (0.1)
	Two or more cars in the household	-1.745 (-2.4)	-
	Two or more cars in the household	-	-0.434 (-0.9)
	Residential location is in the region between the two bypasses	0.6 (0.8)	-
	Residential location is in the regionbetween the two bypasses	-	-1.54 (-1.9)
Likelihood with Zero Coefficients = -714.09 Likelihood with Constants Only = -382.44 Final Value of Likelihood = -306.06 = 0.571 ρ^2 Number of Observations = 650		Statistical Summary	

Table 5
Probability of the main daily activity according to two scenarios

Scenario/ Gender	Business As Usual		Women's Advancement and Education		Business As Usual	Women's Advancement and Education
	$P(W)$ %	$P(O)$ %	$P(W)$ %	$P(O)$ %	Education 12+ %	Education 12+ %
General	54.8	45.2	73.9	26.1	25.8	45.4
Women	36.2	63.8	73.1	26.9	22.0	45.0
Men	72.2	27.8	74.7	25.3	29.0	46.0

Table 6
Day activity pattern probability according to the two scenarios

	Women's Advancement and Education (%)	Business As Usual (%)
	N=406	N=406
$P(W, HW)$	28.3	22.9
$P(W, HWO)$	45.6	31.8
$P(O, HO)$	5.9	10.6
$P(O, HOO)$	17.7	29.8
$P(O, H)$	2.5	4.9

Table 7
Changes in the risk of crash involvement compared to the base scenario of "Business as Usual"

Crash type/ Scenario	Pedestrian crash (%)	Car crash (%)
Increase in travel time along the bypass road	9.3%+	-9.8%
Women's advancement and education	7.0%-	-15.7%

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