CONFERENCE PROCEEDINGS 35

Research on Women's Issues in Transportation

Report of a Conference

VOLUME 2: TECHNICAL PAPERS

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

PROCEEDINGS 35 Research on Women's Issues in Transportation—Volume 2: Technical Papers TRB

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Report of a Conference

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November 18–20, 2004
Chicago, Illinois

Sponsored by
Transportation Research Board
Federal Highway Administration
Department for Transport, United Kingdom
Michigan Department of Transportation
General Motors Corporation
Iowa Department of Transportation
New Mexico Department of Transportation
National Highway Traffic Safety Administration
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Maritime Administration
Washington State Department of Transportation
Oak Ridge National Laboratory

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Washington, D.C.
2005
www.TRB.org

Transportation Research Board Conference Proceedings 35
ISSN 1073-1652
ISBN 0-309-09394-5

Subscriber Categories
IA planning and administration
IVB safety and human performance

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Printed in the United States of America.

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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The views expressed in the presentations and papers contained in this report are those of the authors and do not necessarily reflect the views of the committee, the Transportation Research Board, the National Research Council, or the sponsors of the conference.

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Preface

On November 18–20, 2004, the Transportation Research Board (TRB) convened a Conference on Research on Women's Issues in Transportation in Chicago, Illinois. The conference—TRB's third held on this subject—was sponsored by the following agencies, organizations, and companies with an interest in advancing the understanding of women's issues in transportation: TRB; the Office of Planning, Office of Interstate and Border Planning, and Office of Transportation Policy Studies of the Federal Highway Administration; the Department for Transport, United Kingdom; the Michigan Department of Transportation; General Motors Corporation; the Iowa Department of Transportation; the New Mexico Department of Transportation; the National Highway Traffic Safety Administration; the Federal Transit Administration; the Maritime Administration; the Washington State Department of Transportation; and Oak Ridge National Laboratory.

Approximately 120 individuals from across the transportation research community—at national, state, regional, and local levels and from the public and private sectors and academia—participated. An unusual number of international participants attended, including individuals from the United Kingdom, Denmark, Norway, Sweden, Finland, Germany, the Netherlands, Bangladesh, Cambodia, Cameroon, Australia, Canada, South Africa, and Burkina Faso.

Background

This event followed two earlier conferences on women's issues in transportation, the first of which was sponsored by the U.S. Department of Transportation in 1978. Attendees at that groundbreaking conference were predominantly researchers and scholars. By the time the second conference was held in 1996, concerns about women's issues had moved well beyond the research community into policy making and the planning and engineering processes. The second conference, sponsored by the Federal Highway Administration, was organized by the Drachman Institute of the University of Arizona and by Morgan State University. The third conference has continued the trend of expanding the sponsorship, the breadth of topics covered, and participants' backgrounds.

Conference Planning

This conference had two primary objectives: (*a*) to identify and explore additional research and data needed to inform transportation policy decisions that address women's mobility, safety, and security needs and (*b*) to encourage research by young researchers. TRB assembled a committee, appointed by the National Research Council, to organize and develop the conference program. The committee members, who are listed on page ii, possessed expertise in the wide range of transportation topics that affect women's travel.

The committee selected four subject areas as a basis for organizing the conference, and four committee members assumed responsibility as the topic leaders, as follows:

- Understanding Travel Issues—Sandra Rosenbloom, committee chair;
- Transportation, Access, and Community Design—Susan L. Handy;
- Injury Prevention and Ergonomics—Susan A. Ferguson; and
- Policy and Planning—Michael D. Meyer.

After identifying the four main topic areas listed above, the committee issued a call for abstracts. The process for soliciting and conducting peer reviews of full papers to be presented at the conference is described later in this preface.

Topic leaders drew on information and findings in the papers to be presented at the conference, together with their own extensive knowledge, to prepare an overview paper to frame the issues within their respective topic areas and to summarize the findings of the accepted papers. The overview papers were peer reviewed and are published in Volume 1 of these proceedings.

Conference Format

The conference program was designed to maximize the exchange of information and perspectives among the participants. The four overview papers were each presented in a plenary session, and each paper was followed by an open discussion with the audience. Breakout sessions followed each plenary session to encourage the exchange of research findings and relevant information and experience. Additional papers were presented in poster sessions during the conference. Each type of session is described in further detail below.

Plenary Sessions

The plenary sessions began with each of the topic leaders making a presentation (based on the leader's written overview paper). The plenary sessions were designed to

- Frame the issues within the respective subject areas,
- Provide a summary of current issues,
- Summarize the state of current research, and
- Summarize the conclusions of research papers presented in the related breakout sessions.

Breakout Sessions

Following each plenary session were three or four concurrent breakout sessions, during which several peer-reviewed papers were presented. These sessions allowed the participants to hear more in-depth information on specific research or policy issues. The sessions also provided an opportunity to share similarities and differences in the communities represented by the participants.

Poster Session

Additional peer-reviewed papers accepted by the committee that could not be accommodated in the breakout sessions were presented in a poster session. The poster session allowed for a lively exchange of ideas directly with the authors.

Conference Proceedings Format

Volume 1

Volume 1 includes the conference summary, the four peer-reviewed overview papers presented by the topic leaders, the keynote presentation, and a list of conference participants.

Volume 2

Volume 2 contains the peer-reviewed breakout and poster papers and several abstracts of papers on subjects of particular interest to the committee.

Peer Review Process

The full committee reviewed 100 abstracts initially submitted in response to the call for papers and selected 70 that would go to the second step of the review process. The accepted abstracts were organized into the four conference topic areas, and at this point the topic leaders assumed responsibility for the review process for the papers falling within their respective topic areas.

The selected authors were asked to write a first draft paper for the next stage of the review process. Each topic leader, with other committee members, reviewed the resulting papers. The best papers were selected for presentation at the conference: 43 papers for presentation in the breakout sessions and 10 for the poster session. Authors also received extensive comments to assist in developing the final version of their papers.

After the conference, authors submitted their final papers, updated on the basis of the review comments received and the discussion held at the conference. The 22 full papers and nine abstracts that were accepted for publication at that final stage appear in Volume 2.

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Understanding Travel Issues

Travel Characteristics of Native- and Foreign-Born Women in the United States

Jonaki Bose and June Taylor Jones, *Bureau of Transportation Statistics, U.S. Department of Transportation*

This study used the 2001 U.S. National Household Travel Survey (NHTS) to examine the travel patterns of foreign-born adult women living in the United States and to compare their patterns with those of native-born women. Typically, foreign-born women and their households are different from those of the native born; they themselves are younger, less educated, and less likely to be employed than the native born. They are more likely to live in a rental property, have more members in the household, and live in a household with children. However, even when these demographic factors were controlled for, the authors found differences in the travel patterns of foreign- and native-born women. Foreign-born women are less likely to be drivers, but even among those who are drivers, foreign-born women are less likely to use an automobile and are more likely to use public transit. Although foreign-born women live in larger households, their households have fewer personal vehicles. In fact, a greater percentage of foreign-born women live in households with no vehicles. Both groups spent similar amounts of time traveling on the travel day, but foreign-born women took fewer trips and traveled fewer miles. Not surprisingly, foreign-born women take more international trips and travel with more household members. Foreign-born drivers are also more likely to be concerned about road conditions such as involvement in a traffic accident, highway congestion, and distracted drivers. The study findings clearly show important differences in travel behavior between foreign-born and native-born women, differences that persist even when other salient variables are controlled for. Unfortunately, the data cannot indicate why these differences exist. Future research should focus on the impact on the travel patterns of foreign-born women of acculturation over time (i.e., the length of time spent in the United States, for which data are available in the 2001 NHTS) and answer several questions: What will have a greater impact over time, the country of residence or citizenship or the country of birth? Do foreign-born women and men have comparable travel patterns, patterns that differ from those of native-born men and women, and if so, do these differences continue or converge over time? How influential are standard socioeconomic variables like education, income, employment, and number and age of children? How much will the travel behaviors and patterns of aging foreign-born women mimic the greater culture of which they are a part and how much will they reflect the lifestyles these women left behind?

Abstract prepared by Sandra Rosenbloom, University of Arizona.

Influence of Residential Location on Travel Behavior of Women in Chennai, India

Sumeeta Srinivasan, *Harvard University*

The visible impact of urban transportation is in access to employment. However, transportation also affects access to other services such as shopping and social service facilities. Past research in Chennai, a large city in India, indicates that the relocation of the very poor in peripheral informal settlements severely affects their accessibility to jobs and services because of the commuting distances involved when employment opportunities continue to remain highly centralized. In this study an attempt was made to understand the influence of relative location within the city on travel behavior by using a sample of 116 low-income households from a variety of locations in Chennai. In particular, the travel behavior of women as affected by location was assessed. Models estimated to determine the influence of location characteristics on household travel behavior indicate that availability of transportation choices did affect the travel behavior of women even after differences in their life-cycle stage are accounted for. Recently, Chennai has been investing heavily in rail for public transportation without estimating current travel demand by spatial location within the city. The implications of this policy for integrated land use and transportation planning are especially pertinent in this context.

The debate on the underlying relationships between travel demand and land use patterns continues in North America (*1*, *2*). However, cities in developing countries like India are growing rapidly, and land use and travel behavior interactions are of increasing importance in planning for sustainable growth. Chennai is among the largest cities in India (*3*) and unlike some other cities in India has invested and continues to invest in public transportation. The current planning strategy in Chennai, described as a "minimally directed organic strategy to manage market-led development" (*4*), has not worked to the benefit of the low-income residents in the city. The 2001 census estimate suggests that low-income residents constitute over 25% of the total population of Chennai. Large investments in public transit like the Mass Rapid Transit System (the heavy-rail system under construction in Chennai) have failed to attract trips by these low-income households (both men and women) at the levels that were predicted (*5*). The poor continue to depend on nonmotorized modes and the relatively inexpensive modes like buses as their primary choice for travel to work (*6*). In this study, differences in travel behavior are investigated on the basis of differences in accessibility to employment and the availability of transportation choices. In particular, the travel behavior of women in terms of frequency of trips, travel time, and mode choice is compared with the travel behavior of men. These differences in travel behavior have implications not only for transportation planners who decide bus and train routes but also for land use planners who designate investments in infrastructure that will decide future employment growth.

Background

Accessibility is an essential quality of cities. Substantial literature exists dating back at least 30 years on the definition of accessibility (*7*). Accessibility can be defined as proximity to jobs, to shopping, to recreation, and ultimately to a decent quality of life. In this study, because of the lack of supplementary transportation studies for Chennai, accessibility is measured as average travel time to work and nonwork opportunities available within one location relative to other locations in the city.

Shen (*8*) estimates models (for the Boston metropolitan area in the United States) that suggest that an increase in general employment accessibility leads to a decrease in average commute time. Thangavel (*9*) finds that accessibility (to employment), average land value, social environment, and average population density affect land development in peripheral Chennai. He suggests that accessibility is expected to play a greater role in shaping the urban structure of Madras (now known as Chennai). An earlier study in Chennai (*6*) found that women in a location with better accessibility were more likely to make more trips and travel farther for work trips. Travel behavior of residents who are otherwise similar (in terms of socioeconomic status) is likely to be different if they live in locations with differing employment and transportation opportunities.

Measures of travel behavior that have been studied in the United States and other developed countries include trip time, trip length, mode choice, trip frequency, and route choice (both spatial as well as time choice). A recent study in Seattle, Washington, by Limanond and Niemeier (*10*) suggests that land use patterns are associated with decisions about the type of shopping tours undertaken. Their study indicates that households with poorer accessibility tend to make fewer one-stop shopping tours and are more likely to combine nonwork trips with other trips and that households with greater accessibility are more likely to use nonautomobile modes for one-stop shopping tours. Thus, location affects both work and nonwork travel behavior. In a study in Jordan, Hamed and Olaywah (*11*) find that bus commuters are less likely to pursue social activities as compared with private vehicle commuters. The choice of mode affects trip frequency, especially in the case of low-income households because of the cost of travel.

Gender-related accessibility disadvantages are also of concern in Chennai. Many activities performed by women (including child care, school drop-off, shopping, and jobs in the informal sector) are different from typical male activities. Women in both developed and developing countries tend to make more trips than men, which are often more complex trip chains (*12–14*). In Chennai, a previous study (*6*) found that women conducted more trips and tended to use the least expensive mode (usually walking). Glick (*15*) notes in a West African study that women devote a substantial amount of time to household work while engaging in income-earning activities, and the hours spent on these activities are outcomes of an optimization process in which allocations of time to "home work," "market work," and leisure are jointly determined. His study also notes that the cost of transportation to the city commercial center was key in affecting women's entry into self-employment. It is in that context that this study tries to link the travel behavior of women to their relative location within the city.

Context of Chennai

Chennai has a population of 4.2 million (*3*) and is the capital city of the southern state of Tamil Nadu in India. The city itself (excluding the greater metropolitan area of over 1,000 km^2) is spread over an area of 174 km^2 that is administered by the Chennai Metropolitan Development Authority (CMDA). The larger metropolitan area includes a total population estimated to be about 6 million. Chennai is the fourth most populous city in India, and an estimated 1 million people live in shanty towns (or slums) in the city according to the most recent census. The city has had severe water and other infrastructure-related problems in recent years (*16*), especially in the peripheral locations. In many ways it is typical of rapidly growing urban areas in India. However, one way in which it diverges from some of the other large cities in India is that it also has a long tradition of investment in public transit.

Data and Methodology

Research on the travel behavior of those living in the cities of developing countries is scarce. Most studies tend to focus on limited data collected for large-scale transportation models (*4*). Further, these data are restricted to one point of time (1991 for Chennai) and do not include travel behavior variables at the individual level. Surveys are not conducted at regular intervals by local public agencies. Therefore the transportation data for Chennai, a rapidly growing city, are outdated, and primary surveys have to be conducted to obtain detailed data that can link location and travel behavior. Chennai is not unusual in this regard. As an example, Delhi (the capital of India) has not had a large-scale transportation survey for nearly 15 years.

The data for this study come from a survey of 116 households (with a total of 509 persons conducting 1,862 trips) selected through geographically stratified sampling. The 41 geographical locations are based on a 1984 census conducted by the Slum Clearance Board (a public agency in Chennai) supplemented by the latest available census data for the city. The survey recorded one working day of the week for each household and included both work and nonwork activities conducted by the households. A separate location survey was also carried out that recorded the distance and time to travel to the nearest available services (schools, hospitals, etc.). These 116 households are from within the CMDA boundaries (174 km^2) and exclude the larger metropolitan area beyond the boundaries (about 1,000 km^2). The data for this study are part of a larger sample that collected travel diaries for 160 low-income households from various locations in the Chennai metropolitan area. The focus on quantitative methods rather than qualitative methods for the study was mainly because of the cultural context. A qualitative study is less likely to influence the planning agencies in Chennai, especially transportation agencies, which are strongly dominated by engineers.

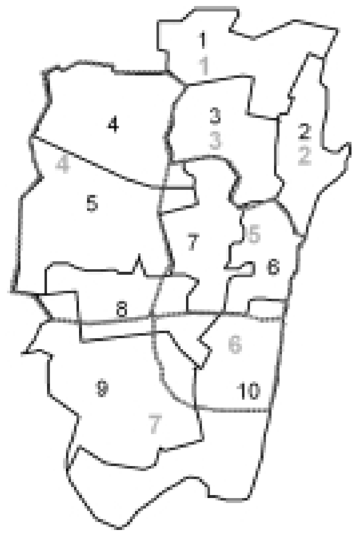

FIGURE 1 Zones in Chennai as designated by CMDA (dotted boundaries and gray numbers indicate modified zone numbers) (map for thematic purposes and not to scale).

Location and Travel Behavior

Ideally, travel behavior characteristics should be linked to location at the individual level. However, there were no publicly available spatial (geographic information system) data for Chennai. Therefore, an aggregated spatial location variable, or zone, was used to classify the location characteristics of Chennai. There are 10 zones in Chennai as designated by the local planning authority (the CMDA) aggregated from 155 census wards, which are the most disaggregated geographical unit (Figure 1). However, the CMDA zones are not representative of relative accessibility to employment. For this study, the 155 wards were aggregated to seven zones based on their location within the city and the availability of employment and transportation opportunities. The modified zones were congruent with the 10 CMDA zones in the northern, central, and western sections of the city. However, they were different in the south (which has seen most of the population growth and public infrastructure investment in the past 10 years). The highly accessible central zones (Zones 6, 7, and parts of 8 and 10 of the CMDA zones) were aggregated into one zone (designated Zone 5). Table 1 indicates the differences between households sampled from the CMDA zones and those from the modified zones.

As mentioned earlier, accessibility is measured as average travel time to work and nonwork opportunities. Average location characteristics are shown in Tables 2, 3, 4, and 5. There are marked differences in travel time to the major employment and commercial centers in Chennai among the zones (Table 2). Locations in the central and western parts of Chennai have better bus-based accessibility than other zones do. Overall, the northernmost zones (1 and 2) have the poorest accessibility to employment centers. This trend is apparent in services including schools, markets, and medical facilities (Table 3). Bus services are also dissimilar, with central, western, and southern locations having shorter walks to bus stops, better bus frequency, and larger numbers of bus route choices (Table 4). For this study, train-based accessibility was not examined because the

TABLE 1 Number of Households, Persons, and Trips by CMDA Zone and Modified Zones

CMDA Zone	Number of Households	Number of Persons	Number of Trips	Modified Zone	Number of Households	Number of Persons	Number of Trips
1	10	44	115	1 (North)	10	44	115
2	19	96	296	2 (North)	19	96	296
3	19	79	306	3 (North West)	19	79	306
4	5	16	70	4 (West)	16	64	255
5	3	13	64	5 (Central)	21	87	353
6	14	65	258	6 (South)	14	66	330
7	5	13	57	7 (South)	17	73	409
8	3	14	59	Total	116	509	2064
9	7	30	100				
10	31	139	739				
Total	116	509	2064				

sample showed limited use of trains (they are much more expensive modes than buses in Chennai and are limited in their availability). Table 5 suggests poor sidewalk access overall except in the central zone and some older locations in the north.

Household Characteristics

The data indicate that over 80% of the households lived in rented housing (as perceived by the residents since ownership is not always clear). Housing stock in the north had relatively high ownership (as perceived by the household). In the peripheral zones of the north, west, and south, 60% of the families consisted of four or more people. In contrast, the central zone had relatively small household sizes. Income did not show any distinct variations across zones in the sample. The northern zones had higher-than-overall proportions of the lowest-income households but also had higher-than-overall levels of the highest-income households (Table 6). The southern zones had higher-than-overall proportions of the middle-income households. It should be noted that these ranges fall within an overall low-income range [less than 2,000 rupees (Rs) per month] for Chennai, where the per capita income was Rs 1,800 per month in 2003. Table 6 also suggests that the proportion of the sample employed was higher in the central zones than in the peripheral zones. Peripheral zones had relatively high vehicle ownership (Table 7), and the central zones had a higher proportion of households with no vehicles (not even bicycles). However, the families in the peripheral zones also tended to drive older vehicles as compared with those in the central zones.

Travel Behavior Indicators

This study focuses on the travel behavior of persons over the age of 15, since they make most of the work- and non-work-related trips. The indicators of time and

TABLE 2 Average Travel Times by Bus from Zones to Various Centers in Chennai

From Zone	To T Nagar (South)	To Nungumbakkam (South)	To Ambattur (West)	To Luz (Central)	To Anna Salai (Center)	To Purusawakkam (North)	To Parrys (North)
1 (North periphery)	115	80	96	78	68	75	49
2 (North)	75	90	127	57	67	60	52
3 (North Central)	58	51	62	49	39	26	31
4 (West)	36	38	47	41	28	38	34
5 (Central)	35	33	70	28	22	44	31
6 (South Central)	32	38	88	17	23	47	43
7 (South periphery)	40	44	98	33	45	56	54

Note: Times are given in minutes; shading indicates lower-than-average travel time.

TABLE 3 Average Travel Times by Walking in Zones to Nearest Location

Zone	Grocery Store	Primary School	Temple	Doctor	Market	Autorikshaw Stop
1 (North periphery)	12	20	18	18	26	16
2 (North)	13	22	16	22	28	14
3 (North Central)	11	26	14	13	18	12
4 (West)	11	23	13	14	14	13
5 (Central)	11	20	13	11	15	11
6 (South Central)	11	15	16	17	18	11
7 (South periphery)	11	21	10	11	13	11

Note: Times are given in minutes; shading indicates lower-than-average travel time.

TABLE 4 Average Bus-Related Variables in Zones

Zone	Average Bus Frequency (Minutes)	Average Number of Bus Routes	Time by Walk to Bus Stop (Minutes)
1 (North periphery)	15	2	18
2 (North)	24	2	17
3 (North Central)	20	7	17
4 (West)	10	14	14
5 (Central)	11	12	13
6 (South Central)	9	10	12
7 (South periphery)	12	11	13

Note: Shading indicates lower-than-average travel time and higher-than-average number of bus routes from zone.

TABLE 5 Safety-Related Variables by Zones

Zone	Locations with Sidewalk to School (%)	Locations with Safe Walk to School (%)	Locations with Sidewalk to Market (%)
1 (North periphery)	12.5	12.5	37.5
2 (North)	16.7	25	25
3 (North Central)	7.1	0	21.4
4 (West)	12.5	0	12.5
5 (Central)	33.3	25	8.3
6 (South Central)	11.1	0	22.2
7 (South periphery)	16.7	8.3	41.7

TABLE 6 Household Characteristics: Income and Jobs

Zone	Percentage in Each Income Group			Percentage		
	Rs 0–1000	Rs 1000–2000	Rs 2000+	Women (Employed)	Men (Employed)	Difference
1 (North periphery)	30	30	40	42	80	38
2 (North)	21	47	32	33	90	57
3 (North Central)	53	47	0	69	93	24
4 (West)	40	20	40	52	92	40
5 (Central)	29	52	19	66	76	10
6 (South Central)	14	57	29	68	95	27
7 (South periphery)	12	71	18	53	91	38
Overall	29	48	23	55	88	33

Note: Shading indicates higher-than-overall averages.

TABLE 7 Household Characteristics: Vehicle Ownership

Zone	Percentage of Households with No Vehicles	Vehicles per Household	Bicycles per Household	Two-Wheelers per Household	Percentage of Households with Two-Wheelers Less Than 3 Years Old	Percentage of Households with Bicycles Less Than 3 Years Old
1 (North periphery)	40	1	0.4	0.6	17	0
2 (North)	53	0.6	0.4	0.1	100	38
3 (North Central)	74	0.3	0.3	0	0	20
4 (West)	50	0.6	0.4	0.2	100	67
5 (Central)	62	0.4	0.3	0.1	100	67
6 (South Central)	64	0.6	0.4	0.2	67	33
7 (South periphery)	47	0.8	0.6	0.1	0	30
Overall	57	0.6	0.4	0.1	59	38

Note: Shading indicates higher-than-overall averages.

cost are among the most basic measures of travel behavior because they indicate the utility of the activities to the trip makers. The relationship between travel to work and accessibility is of immediate concern to transportation planners in Chennai since they are in the process of designating employment zones and planning future transportation routes. Understanding mode choice is also important because the planners are in the process of designating funds for development of bus versus train routes.

In all the zones, men tend to have higher travel costs than do women. However, the ratio of average travel cost of men and women is highest in the peripheral zones. Only the central zone shows parity in travel costs between the genders. Men in peripheral zones spend more than two times as much as women do in traveling to work. Overall men spend Rs 11.5 every day for their travel to work as compared with Rs 8 for women. Average travel costs for men are highest in the north (Rs 20) followed by the central zone (Rs 16). The travel times for men followed the same pattern as the costs. However, women in the peripheral zones tend to spend less on travel to work than the women in the central (Rs 16) and western zones (Rs 10). This finding suggests that both men and women on the periphery tend to have fewer work opportunities and transportation choices to get to the jobs in the business districts, but men are forced to spend more to get to work. Both men and women appear to stay close to home beyond a fixed cost threshold.

Figure 2 indicates that men and women in the peripheral zones (especially northern Zones 1, 2, and 3 and southern Zones 6 and 7) tend to walk more than those in the other zones do. However, their lack of transit choices (Table 4) and their higher-than-average travel time reflect the fact that walking is often the only mode available to them. Although men in the central zone also have higher-than-average travel times, a larger proportion travel by bus than do those on the periphery. In all zones women tend to walk more than men.

Trip frequency also shows distinct differences based on location as well as gender. Women tend to make more trips then men do in all the zones since they perform most of the household-related tasks: they conduct 76% of all grocery shopping trips, 85% of all drop-off trips, and all trips to fetch water. The ratio of male and female trips to work was almost equal in all the zones except in the northern and western periphery, where the number of work tours by men was over two times that by women. This finding follows the patterns indicated in the travel cost and time variations between genders. The ratio of shopping tours by women in the central zones was two times the number of shopping tours done by men. However, in the peripheral zones women con-

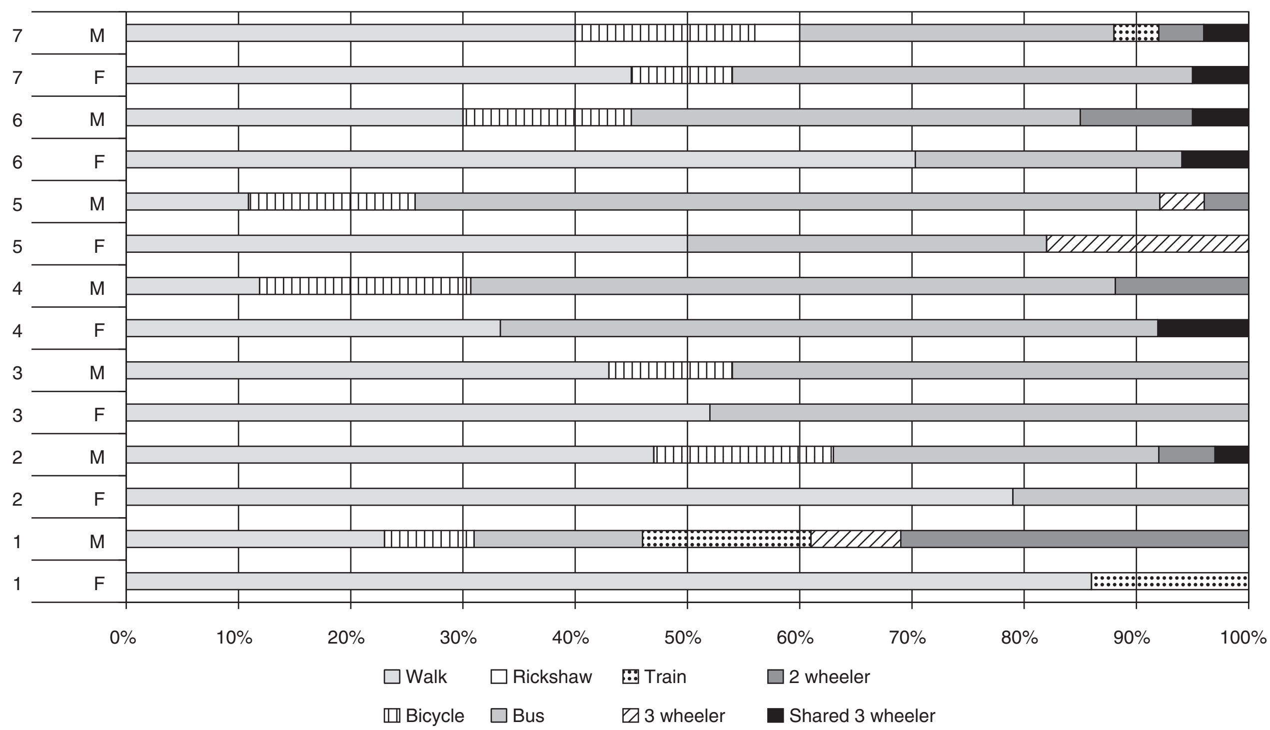

FIGURE 2 Travel behavior characteristics: proportion of persons who conduct work and school trips in each mode choice category.

ducted over five times the number of shopping tours as did men. Further, peripheral zones (especially the northern zone) tend to have a higher proportion of trips devoted to work (47% of all the trips conducted in the northern zone as compared with 33% in the central zone). In the central zones, the proportion of social or recreational trips was higher than that of shopping or drop-off trips. In the peripheral zones (1, 2, and 7) most of the nonwork trips were shopping or drop-offs. Figure 3 summarizes some of the disparities in showing that women tend to have higher trip frequencies than do men in all the zones but a higher proportion of men and women in the peripheral zones make two or fewer trips a day.

These patterns are modeled in the next section in order to assess the statistical significance of location in affecting the travel behavior of an area's residents.

Modeling Travel Behavior

Travel Time

Travel time (in minutes) for trips made by those who work was regressed over several independent variables (Table 8). The model had an adjusted R^2 of 31%. The results indicate that activity time (the number of minutes spent at the activity for which the trip was being made) was significant in estimating travel time. Several location variables were also significant. Bus trips made by workers living on the periphery took 14 min longer than did private-vehicle trips, confirming the lack of bus service. Walk trips (which have to be restricted to shorter distances) were about 8 min less than private-vehicle trips. Thus a peripheral worker given the current transit choices would probably turn to private transportation with a rise in personal income. In contrast, bus trips made by male workers living in the center were about 10 min shorter than private-vehicle trips were, whereas walk trips were about 23 min longer. All work trips made by workers living on the periphery were longer than the trips made by workers living in the central areas (trips from the west were about 17.5 min longer, whereas trips originating from the north or south were about 7 min longer). This finding suggests that employment, like public transportation choices, is not evenly distributed over the city. Work trips made by women living in the central zones were about 7.5 min longer than work trips made by women living in the periphery. As discussed in the section on travel behavior indicators, women in the central zones have better opportunities to find work and tended to use the public transportation choices that were available to them.

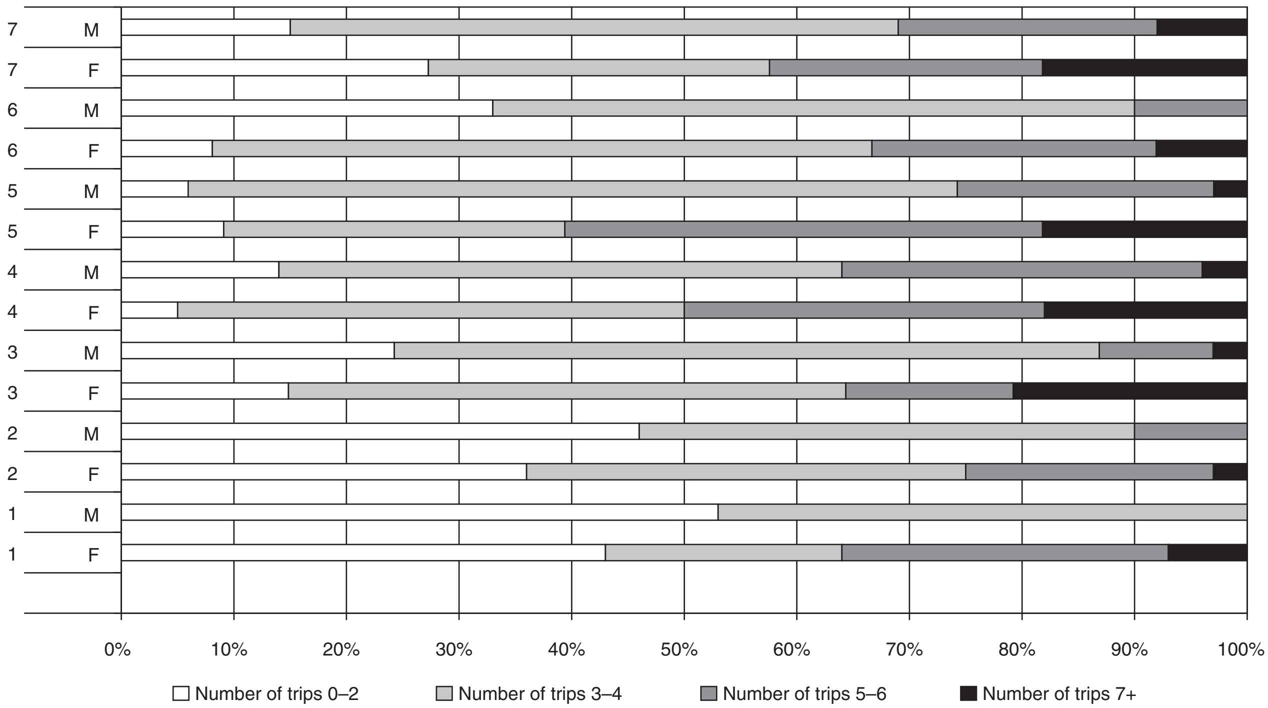

FIGURE 3 Travel behavior characteristics: proportion of persons who conduct work and school trips in each trip frequency category.

TABLE 8 Regression of Travel Time in Minutes of Trips Made by Persons over Age 15 Who Work

Independent Variable	Estimated Coefficient	*t*-Statistic	*P*-value
Constant	22.56**	15.48	0.00
Activity time (minutes)	0.01**	2.44	0.01
Middle income	–0.55	–0.35	0.72
Bus trips from the periphery	14.21**	5.14	0.00
Walk trips from the periphery	–7.80**	–4.42	0.00
Work trips from north	7.09**	2.57	0.01
Work trips from south	7.59**	3.24	0.00
Work trips from west	17.47**	4.69	0.00
Men in center who take the bus (work trip)	–9.71**	–3.09	0.00
Men in center who walk (work trip)	23.13**	7.03	0.00
Women in center (work trip)	7.50**	2.21	0.03
Women in west (work trip)	–3.04	–0.52	0.60

Note: N = 588; R^2 = 32.4%; R^2 (adjusted) = 31.1%; F = 25.1 (P = 0.00).
**Significant at the 5% level.

Trip Frequency

Trip frequency was categorized as follows: less than average (fewer than three), average (three to four), and higher than average (over four trips). Nearly 50% of the persons in the sample made an average number of trips per day, and the rest were evenly divided into the other two categories:

Trip Frequency	*No. of Trips*	*Percentage of Trips*
Less than average	66	23
Average	143	50
Higher than average	75	27

A discrete choice model (*17*) was estimated by regressing trip frequency choice on socioeconomic and location variables (Table 9). The household characteristics that were significant were the number of vehicles in the household and the income level. Persons in households with more vehicles were more likely to have an average or higher-than-average number of trips per day. Women living in the central and southern areas were likely to have higher-than-average trip frequency. Also, the coefficient in the central zone was much higher than that for the southern zone, confirming that trip frequencies for women in the central zones are higher. Men who lived in the north were significantly likely to have a less-than-average trip frequency, which is perhaps related to

TABLE 9 Discrete Choice Model of Trip Frequency Category of Persons over Age 15 Who Work

Independent Variable	Estimated Coefficient	Standard Error	*t*-Statistic
Constant (less than average trip frequency)	0.56*	0.29	1.88
Constant (average trip frequency)	0.96**	0.19	5.05
Number of vehicles in household (less than average trip frequency)	–0.51**	0.26	–1.99
Household income relatively high (less than average trip frequency)	–0.09	0.37	–0.26
Household income relatively low (less than average trip frequency)	–1.05**	0.39	–2.64
Person lives in the central zone and is female (higher than average trip frequency)	1.69**	0.47	3.57
Person lives in the northern zone and is female (average trip frequency)	–0.25	0.41	–0.61
Person lives in the southern zone and is female (higher than average trip frequency)	0.69*	0.38	1.78
Person lives in the central zone and is male (average or below average trip frequency)	–0.28	0.48	–0.58
Person lives in the northern zone and is male (less than average trip frequency)	0.74*	0.39	1.87
Person lives in the southern zone and is male (less than average trip frequency)	0.08	0.42	–0.19

Note: $\rho^2 = 0.10$; $N = 284$; percent correctly predicted = 51.8%.
**Significant at the 5% level. *Significant at the 1% level.

their longer travel times. The adjusted ρ^2 for this model was, however, very low (0.1).

Mode Choice

Mode choice by workers over the age of 15 was also estimated within a discrete choice framework by using a multinomial logit (MNL) model with four choices: walk, bicycle, bus or train, and a fourth category called "gasoline operated," which included two-wheeled, three-wheeled, and shared three-wheeled vehicles. About 40% of the trips made by the persons over 15 in the sample who worked were by walking, about 10% were bicycle trips, about 40% were bus or train trips, and about 10% of the trips were by gasoline-operated vehicles:

Mode	*No. of Trips*	*Percentage of Trips*
Walk	297	42
Bicycle	65	9
Bus or train	270	38
Gasoline-operated vehicles	74	11

Table 10 shows the results of the MNL mode choice model. Travel time for the trip was significant and negative, indicating that choices involving the least travel time were made. Travel cost was not significant although it had the expected negative sign, indicating the choice of the least travel cost. Households without vehicles were significantly more likely to use walk or transit for their trips. Work trips made by women living in the periphery as well as at the center were likely to be walk-based trips. However, the coefficient was much higher for working women living in the center, which may indicate better availability of job opportunities within walking distance. Men living in the periphery were significantly more likely to walk, although the coefficient was smaller than the coefficient for women. Men living in the central zones were significantly more likely to use transit. The adjusted ρ^2 for this model was relatively high (0.45) although the location variables accounted only for a 0.02 increase in the adjusted ρ^2. However, the significance of location-related variables suggested similar patterns in conjunction with other measures of travel behavior.

Summary of Results

The better distribution of employment opportunities and wider range of transportation choices within the central zone in Chennai improved the transportation choices available to the woman residents who were employed. It also allowed both men and women to conduct activities besides maintenance activities (work, shopping, and drop-off trips). Further, it was more likely that residents of the central zone could walk to these nonwork activities, unlike the residents on the periphery. Living in the central zone also allowed for more parity in the travel costs and times between men and women. This finding could also be linked to the fact that the women were now able to bring in more of the household share of earnings. Some of these differences

TABLE 10 MNL Model of Mode Choice of Trips Made by Persons over Age 15 Who Work

Independent Variable	Estimated Coefficient	Standard Error	*t*-Statistic
Constant (walk)	3.66**	0.34	10.71
Constant (bicycle)	2.78**	0.32	8.79
Constant (transit)	3.05**	0.25	12.12
Cost	–0.003	0.004	–0.78
Time	–0.06**	0.006	–10.10
Zero-vehicle household (walk and transit)	–0.57**	0.24	–2.38
High-income household (transit or gasoline operated)	0.32	0.29	1.08
Work trip made by female living on the periphery (walk)	0.95**	0.36	2.66
Work trip made by female living in the center (walk)	2.07**	0.60	3.45
Trip made by male living in the periphery (walk)	0.55*	0.29	1.89
Trip made by male living in the center (transit)	0.84**	0.41	2.05

Note: $\rho^2 = 0.45$; $N = 706$; percent correctly predicted = 79.6%.
**Significant at the 5% level. *Significant at the 1% level.

in travel behavior are probably linked to the fact that households in the central zone are at a different life-cycle stage. However, the relatively job-rich southern zones (with larger families with children) also tended to have travel behavior more like that of the central zone than of the job-poor northern zones.

Other studies of the travel patterns of low-income communities and women in the United States (*18*) indicate that employment opportunities are affected not only by distance from the city center but also by the travel times and availability of transit. In the case of Chennai, better public transportation in the central and southern zones appears to help both men and women in getting to work even if the jobs are not located close to them. Even though the northern peripheries have some employment opportunities, they are restricted to fewer jobs by the lack of inexpensive transportation choices. Further, even the relatively job-poor locations in the western and southern periphery appear to be able to use the availability of buses to their advantage. Although local planning agencies (including the Slum Clearance Board) have been less interested in the travel behavior of low-income women when the data are presented qualitatively, the estimation of statistical models has generated some interest among local planners.

Implications for Policy

Indian cities like Chennai continue to have highly centralized employment. This factor can be an advantage if public transportation to the center of the city is given priority and land use planners focus on sustaining the high densities at the center. Chennai has recently invested in heavy rail at the high cost of over Rs 7 billion to improve the transit-based accessibility of the southern periphery and its connections to the central zone and the northern zones (*19*). However, the new elevated railway is not patronized by low-income travelers for several reasons: fares are much higher than current bus fares, the fares are not integrated with bus fares, and there are no connections to bus service at any of the stops. Middle-income travelers do not use the train either because there are no park-and-ride facilities and the stations are badly linked with bus and taxi services. Integrating the railway lines and the bus service instead of having them compete with each other would help improve overall transit-based accessibility in Chennai.

As in many other developing cities (*20*), the general focus of transportation policy in Chennai has been on improving travel times for automobiles through marginal improvements to roads. Planners have tended to focus on mitigating congestion by mitigating traffic conditions at selected locations and building large overpasses that only increase overall congestion in the system. Policy makers have not investigated changes in the structure or distribution of employment and other services. Several trends in vehicle ownership are also worrying in that the lack of public transportation and jobs will create more dependency in the periphery on private forms of transportation. As incomes rise this dependency may lead to higher two-wheeler ownership in locations that are not designed for their use. Many of the peripheral residents in Chennai, regardless of income, have no choice other than three-wheelers and two-wheelers for travel to work.

Also, regardless of gender, the lack of integration of transit and land use planning has meant that job opportunities are unevenly distributed throughout the city. The northern periphery in Chennai has been the worst affected by the lack of investment in infrastructure; such investment could lead to more employment opportunities in that zone. The better infrastructure in the southern and western periphery has been able to attract more middle-income and upper-income residents. The informal sector jobs that the low-income residents need occur in locations where the upper-income residents live. In this situation, the planners in Chennai need to intervene rather than let "minimally directed market-led forces" dictate the future urban structure of the city.

Acknowledgments

The author thanks Josephine Edward and Angel Anthony for their assistance in conducting the survey. This research was funded by the American Institute for Indian Studies, the Harvard University Asia Center, and the Milton Fund of Harvard University Medical School.

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Comparing Women's and Men's Morning Commute Trip Chaining in Atlanta, Georgia, by Using Instrumented Vehicle Activity Data

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Differences between women's and men's morning commute trip-chaining patterns are examined by using a subset of instrumented vehicle activity observations for 10 days of morning commute journeys made by 182 drivers from 138 households in Atlanta, Georgia. Morning commute trips that involve trip chaining are longer both in distance and in duration for both men and women compared with morning commutes without trip chaining. On the basis of analysis of the Atlanta data reported, overall gender differences in the morning commute trip-chaining patterns for men and women appear to exist. Men traveled a greater distance and spent more time in the morning commute than did women. Men stopped more frequently than women, and women tended to have shorter stop durations than did men. Some of the findings contradict previous research. It is not clear whether the differences reported here are specific to Atlanta, to the households involved in the sample, or perhaps to the specific time frame in which the analyses were undertaken. A larger sampling of the instrumented vehicle data (1 year of commute travel for 250+ households in the Commute Atlanta project) is currently being prepared to further assess these differences and to examine whether gender roles may be changing, at least in Atlanta.

Empirical evidence in previous research efforts indicates that a secondary role of the commute journey is to provide an opportunity to link nonwork travel with the commute itself (*1*). Commuting trips are becoming increasingly complex as workers incorporate personal, household, and child-care activities into their trips (*2*). Since women's participation in the labor force is at an all-time high, many working women fulfill household and family responsibilities as well as their work duties. Given the gender roles in many households, women's commute patterns are potentially different from men's and may be affected by a typically greater share of household and family responsibilities. These differences in commute behavior may also vary depending on their socioeconomic and life-cycle status. This study compares men's and women's morning commute trip-chaining patterns by using a subset of instrumented vehicle activity observations.

Literature Review

Previous research (*3–6*) indicates that women are more likely than men to trip-chain on the way to and from work. On the basis of the 1990 Nationwide Personal Transportation Survey (NPTS) data, Strathman and Dueker (*5*) found that women make stops on their way to and from work or during work 42% of the time, whereas men make stops 30% of the time. Wegmann and Jang (*7*) examined the trip-chaining behavior of workers and developed nine work-related trip-chaining patterns from the 1990 NPTS data. They found that women have a higher total number of trip-chaining activities per day than men. Yet they did not find significant differences in the amount of home-to-work trip chaining of men and women.

On the basis of the 1990 NTPS data, Strathman and Dueker (*5*) found that the trip purpose "other family/personal business" is the most heavily represented in chains that are made both to work and from work. Wegmann and Jang (*7*) compared activity types pursued by men and women during morning commute trip chaining. They found that family and personal business trips and school or church trips account for 60% to 70% of the morning commute trip-chaining activities. Men and women made a comparable number of work-related business trips, shopping trips, school or church trips, and trips to visit friends or relatives. In these studies, men made significantly more other social and recreation trips compared with women, and women made significantly more other family and personal business trips compared with men.

McGuckin and Murakami (*8*) compared the trend of trip-chaining patterns noted between 1995 and 2001 by using the 1995 NPTS and 2001 National Household Travel Survey (NHTS) data. Thus research identified a robust growth in trip chaining that occurred between 1995 and 2001, nearly all in the direction of home to work. Men increased their trip chaining more than women, and a robust amount of the increase was due to stops for coffee.

On the basis of trip purpose in the 2001 NHTS data, for workers who made stops on the way to work, the most common type of trip embedded in the home-to-work chain was a serve-passenger trip (33%), followed by family or personal business (16%) and stops for a meal or coffee (14%). In families in which both parents worked on weekdays, 61.3% of the trips to drop off a child were made by women compared with 38.7% made by men.

Gender effects on trip chaining may differ across households in different life-cycle stages. Strathman et al. (*9*) determined that certain household types contributed the largest amounts of peak-period trip-chaining behavior. Single adults with young children have the highest propensity to form complex trip chains on the way to and from work, followed by single adults with school-age children, dual-income couples without children, and dual-income couples with preschoolers. Working mothers are more likely to link trips than working fathers (and they are more likely to link trips when the children are younger). On the basis of 1982 and 1985 data from France, the Netherlands, and the United States, Rosenbloom (*4*) determined that 65% of working women with children under 6 years old linked trips to work, whereas only 42% of comparable men did.

From the literature review, it appears likely that a difference exists in commute trip-chaining behavior between men and women and among different household structures. In previous studies, women were more likely to trip-chain on the way to and from work compared with men, and women made more serve-passenger trip chains compared with men. Previous research results were mostly based on household travel surveys. However, one of the problems with household travel surveys is misreporting, as revealed in previous research (*10–14*).

Advancements in Global Positioning System (GPS) technology provide a new method for multiday data collection for travel diary studies and other transportation applications. On the basis of the summary by Pendyala (*15*), GPS technologies capture travel behavior better during a long period of time and eliminate the survey fatigue problem of the multiday travel diary survey. GPS-based travel data can capture short and infrequent trips that may not be obtained in a traditional travel diary survey. Yalamanchili et al. (*16*) compared the trip-chaining indications provided by the GPS data with those provided by the recall data. Results of their study show that the GPS-based data performed in a manner superior to the recall data in capturing multistop chains in that the former captured more than twice as many multistop chains as the latter when comparisons were made in the context of a 1-day travel period. On the basis of the GPS study carried out in the California statewide household travel survey, Zmud and Wolf (*14*) found, on an aggregated level, that travel survey data underreport 27.4% of trips compared with the GPS-measured data. Especially for short-duration trips (between 0 and 10 min), 70.9% of the trips captured by GPS technology were missed in the travel survey.

GPS-Based Vehicle Activity Studies

The data used in this study were taken from the Georgia Institute of Technology Commute Atlanta project. This project instrumented approximately 487 vehicles from 268 representative households in the 13-county Atlanta metropolitan area with event data recorders (EDRs). The EDR provides an accurate itinerary of vehicle trips, including those short, intermediate, and infrequent stops that would otherwise be missed with traditional travel diary data collection methods. The network of EDR-equipped vehicles logs more than 2 million vehicle-seconds of activity each day. The research team collected second-by-second speed and position data for more than 600,000 trips during the first 10 months of the project. The Commute Atlanta research included standard household sociodemographic interviews and the collection of standard 2-day travel diaries (via computer-assisted telephone interview methods) for the participating households (*17*).

Sample Summary

Ten days' worth of morning commute journeys for 182 drivers from 138 households make up the data subset used for the analyses presented here. To meet the research goal of this study, only the 182 drivers whose gender information was known and who work full time at a fixed location and do not share their vehicle with another household member were included in the data subset. Significantly fewer lower-income households meet all of these conditions. The household recruitment strata used in the Commute Atlanta project and the subset of these households used in the analyses reported here are provided in Table 1. The recruitment process and study refusal rates are detailed elsewhere (*17*).

For the data subset employed in the gender-based analyses reported here, the average household size is 2.86 persons. The average age of the drivers is 43. Most of the drivers have resided at their current residence location for more than 3 years, indicating a good level of familiarity with their travel areas. The respondents are divided fairly equally between men and women, with 49.5% being men. Children less than 16 years of age are present in 52 households (70 commuters) and children 5 years or younger are present in 20 households (25 commuters). The ratio of workers per household is 1.45, which is comparable with 1.37 from the U.S. census data in 2000 for the Atlanta Metropolitan Statistical Area (MSA). Household vehicle ownership of the sample is higher than the average value in the 2000 census for the Atlanta MSA (2.37 vehicles per household compared with the 1.8 vehicles per household). This difference is expected since the objective of the project is to determine effects of by-the-mile congestion pricing on commute travel behavior, and only households that own vehicles were recruited.

At least 55% of the drivers have either undergraduate or postgraduate educations, and the median household income of the sample is between $75,000 and $99,000. Household income in the sample is significantly higher than the median household income of the Atlanta MSA ($51,948 in the 2000 census) because of higher-than-expected refusals and opt-outs of lower-income households and higher-than-expected retention of upper-income households (*17*). It may also be due to the fact that the commuters with white-collar occupations usually have a higher salary and a fixed working schedule, whereas commuters with blue-collar occupations who work in shifts may have commute schedules different from the traditional morning and afternoon peak periods. Hence household incomes for the commuters identified during the morning peak periods are higher than those of the overall working population. The net result, however, is that upper-income households and more educated individuals are overrepresented in the sample when compared with census demographic profiles of the Atlanta MSA population. Conclusions regarding behavior with demographics need to be restricted to each sample stratum in which sufficient data are available (see Table 1).

The home address of each household and the work address of each worker were geocoded. The series of trips in which the first trip starts at home, the last trip ends at the workplace, and all intermediate trips are included that take place during the morning commute period (weekdays from 5:00 to 10:00 a.m.) on a given day is considered a single morning journey to work. Because drivers may or may not turn off the car's engine when they stop, stops made during the morning commute were divided into two types. Engine-off stops take place when the driver turns off the engine during the stop; such trips are captured automatically in the data stream since one data file records activities between engine-on and engine-off stops. Occasionally, drivers will turn the engine on and off without moving and generate a false trip. These false trips were screened out from the data set. Engine-on stops take place when the driver does not turn off the engine during the stop; these stops are detected by a script that examines the travel trace in detail. An engine-on stop is detected if the vehicle's position falls outside of the 75-ft buffer of the road network and the vehicle speed is less than 5 mph for a duration longer than 1 min. A manual check of the detection results was tested against a set of sample trips. The algorithm detected the stops successfully under most situations. Figure 1 shows an example of one

TABLE 1 Household Recruitment Strata

Sampling Strata	Annual Income	Household Size	Vehicles per Household	Atlanta Population (percent)	Household Sample Target No.	Households Recruited (percent)	Households Used (percent)
0	Any	Any	0	7.4	0	0 (0%)	0 (0%)
1	<$30,000	Any	1+	18.4	35–40	20 (7.46%)	4 (2.90%)
2	$30,000–$75,000	1	1+	11.3	35–40	34 (12.69%)	17 (12.32%)
3	$30,000–$75,000	2+	1	6.8	35–40	18 (6.72%)	7 (5.07%)
4	$30,000–$75,000	2	2+	10.6	35–40	38 (14.18%)	13 (9.42%)
5	$30,000–$75,000	3+	2+	13.9	35–40	34 (12.69%)	14 (10.14%)
6	$75,000+	1	1+	2.8	0	5 (1.87%)	4 (2.9%)
7	$75,000–$100,000	2+	1+	12.1	35–40	41 (15.30%)	26 (18.84%)
8	$100,000+	2+	1+	16.8	35–40	73 (27.24%)	51 (36.96%)
99	Unknown	Any	Any	na	0	5 (1.87%)	2 (1.45%)
Total				100	280	268 (100%)	138 (100%)

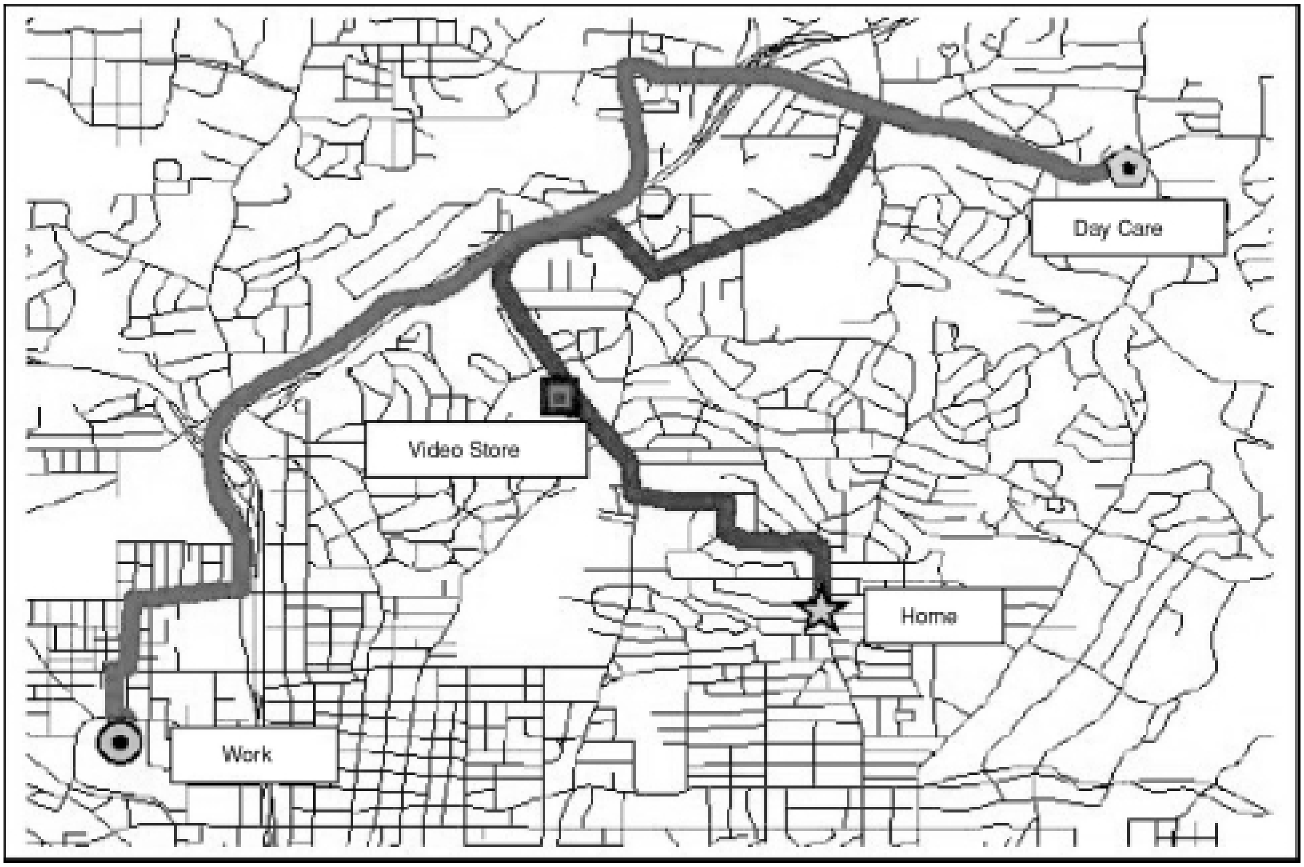

FIGURE 1 Morning commute: trip-chaining example.

engine-off stop (at a daycare center) and one engine-on stop (at a video store). Among the 1,820 commute journeys from 182 commuters during the 10-day period analyzed, a total of 722 vehicle stops were detected in the sample. Among them, 460 were engine-off stops and 262 were engine-on stops.

Findings

Commute Time and Distance

Mean values of morning commute distance, travel time, and commute duration (stopping time plus travel time) of men and women in the sample are summarized in Table 2. The results of *t*-tests conducted to compare the mean values between men and women indicate that men traveled longer distances and spent more time in their morning commute than did women. This result is consistent with previous research results summarized by Sarmiento (*18*).

A previous study indicated that a large percentage of households' total travel is undertaken in conjunction with the journey to and from work and that the growth of nonwork vehicle trips made during the commute contributes to traffic congestion (*19*). Work trips with nonwork stops contribute to the vehicle miles and vehicle hours traveled in an urban area (*20*). In this study, *t*-tests of paired sample means (Table 3) indicate that for both men and women, commute journeys with trip chaining tend to be longer in distance than those with no chaining. However, trip chaining adds less distance to women's morning commutes than to men's.

TABLE 2 Gender Comparison of Average Commute Distance, Duration, and Travel Time

	Men	Women	Difference	*t*-Statistics	Significance (two-tailed)
Travel distance (miles)	16.42	14.77	1.65	3.143	0.002
Commute duration (minutes)	40.80	36.02	4.78	3.319	0.001
Travel time (minutes)	32.05	29.58	2.47	2.872	0.004

TABLE 3 Travel Distance Comparison of Commutes With and Without Trip Chaining

	With Trip Chaining	Without Trip Chaining	Difference	*t*-Statistics	Sig. (two-tailed)
Distance (miles)	18.19	16.33	–1.8618	–4.996	0.000
Distance (miles) (men)	19.56	17.18	–2.1669	–3.280	0.002
Distance (miles) (women)	16.72	15.42	–1.5568	–4.484	0.000

Stop Frequency

In the data subset, the research team detected slightly more stopping than was found in previous research. A total of 537 (30.5%) out of 1,820 morning commute journeys had one or more stops. Similarly, Hanson (*21*) found 29.4% of passenger vehicle trips having one or more stops between home and work. In a survey of 164 respondents, Mahmassani et al. (*22*) found that 24.3% of morning commute trips had one or more stops. On the basis of an empirical analysis with data from an activity survey conducted in the Boston metropolitan area and San Francisco Bay Area, Bhat and Singh (*23*) determined that 85.2% of the morning commute journeys had no stop, with the remaining 14.8% having one or more stops. Although commuting may be significantly different in Atlanta, GPS-based data collection methods may simply be more effective in capturing trip-chaining behavior.

The frequency of nonwork stops during the morning commute by gender is shown in Figure 2. Of the 1,820 commutes, 90 men made 900 commutes and 92 women made the remaining 920 commutes. Chi-square test results at the 0.05 level indicate that in the sample, men are more likely to make one or more stops than are women.

For each commuter, a stops ratio was calculated by dividing the number of commute journeys with stops by the total number of commute journeys for each driver. Among the 182 commuters, 50 never stopped, and the remaining 132 commuters (66 men and 66 women) stopped at least once during the 10-day period. Approximately one-third of the drivers stop during at least half of the commute journeys, and 5.49% of the drivers stop every day during their morning commute journey. These results indicate that making nonwork stops during the morning commute is a common phenomenon among a large percentage of commuters. The stops ratio during the morning commute grouped by gender is shown in Figure 3. Chi-square test results at the 0.05 level indicate that the men in the sample generally had a higher stop ratio than the women.

Stop Locations

In this study, stop locations were recorded in latitude and longitude format. For the 132 commuters (66 men and 66 women) who stopped at least once during the journey to work, the number of stop locations was compared across genders. If two stop locations were within 600 ft, they were considered to be the same. On average, men commuters stopped at an average of 3.05 locations compared with 2.86 for women. The *t*-test that assumes men and women have the same number of stop locations is not rejected at the 0.05 significance level.

If the stop locations are divided into two groups—routine locations, at which a commuter stopped at least twice during the 10-day commute period, and nonroutine locations, at which a commuter only stopped once during the 10-day commute period—77 out of the 132 commuters stopped at routine locations. The male commuters have an average of 0.89 routine stop locations compared with 0.92 for women. The *t*-test that assumes men and women have the same number of routine stop locations is not rejected at the 0.05 significance level.

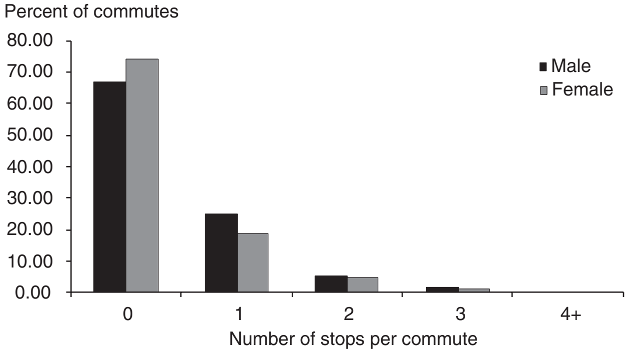

FIGURE 2 Morning commute: number of stops by gender.

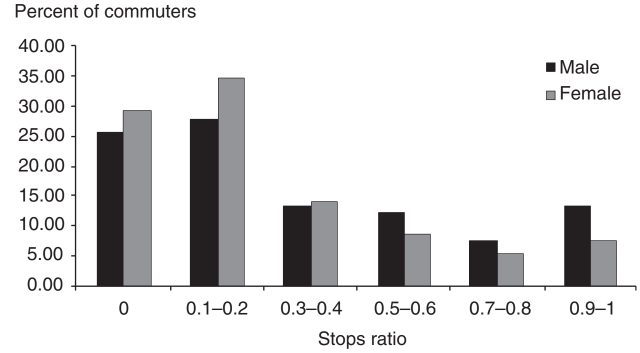

FIGURE 3 Morning commute: stops ratio by gender.

Stop Duration

Few previous studies examined trip-chaining stop durations. In this study, the median durations for engine-off stops are 315 s for women and 375 s for men. The median durations for engine-on stops are 146 s for women and 150 s for men. The stop duration distribution of men versus women is shown in Figure 4. Women tend to have shorter stop durations than men (finding significant at the 0.05 level by the chi-square test).

CONCLUSIONS

The research team conducted a cross-classification analysis of repeated behavioral data to examine the morning commute trip-chaining patterns for 182 men and women in Atlanta. This study employed a 10-day subset of on-road travel observations collected by GPS-equipped vehicles in the Commute Atlanta project.

On the basis of the sample in this study, the existence of nonwork stops during the morning commute is a common phenomenon for both men and women. Some significant gender differences in morning commute trip-chaining patterns were noted in this analysis. For example, men traveled longer distances and spent more time in their morning commute than did women. Men also made more stops and stopped for longer durations than did women in morning commutes. However, the number of stop locations did not differ significantly across genders.

Some of the research findings here contradict previous research results reported in the literature. Because the analytical results reported here are constrained to the household sample employed in the study (a higher presence of relatively affluent, car-owning households in the Atlanta commuting environment), it is not clear whether the differences identified also hold true for other sociodemographic groups and across regions. Hence, one should exercise caution in directly comparing the results in this paper with previous research results based on national travel surveys. However, it is also important to note that the Atlanta results did not rely on user-reported data but on revealed travel data collected by means of vehicle instrumentation. Hence, some of the differences may be associated with differences in underreporting of travel by men and women and the characteristics of the trips that go unreported. Additional research into the underreporting issue is currently under way in Atlanta through comparisons of instrumented vehicle data and travel diary data.

Travel behavior of demographic groups is constrained by different circumstances. Working women, in particular, often face constraints arising from their multiple roles in the workplace and in the household. As the division of labor between men and women equalizes, corresponding changes in the division of household responsibilities should also occur. Although women continue to retain primary responsibility for housework, the gap may be narrowing over time. One important piece of information that is missing in this study is the trip purposes for trip-chaining stops. Until this information is collected in the household travel diary surveys and until the parcel-level land use database is integrated into the analysis, it will be difficult to further evaluate the division of household labor between genders with this sample. However, once the new data are available, it will be possible to examine whether the differences reported here are likely due to increased sharing of household and family responsibilities between men and women workers in the same household, at least in Atlanta.

A larger sampling of the instrumented vehicle data (1 year of commute travel for 250+ households in the Commute Atlanta project) is currently being prepared for more detailed analysis. More than 1 year's instrumented vehicle data have been collected in Atlanta. Such detailed commute data, over such a long period of time, have never been previously available to travel behavior researchers. As instrumented vehicle sampling programs become more pervasive and data are collected across multiple cities and in larger sociodemographic segments, the research community will be able to expand and improve the core body of knowledge associated with trip-chaining behavior significantly.

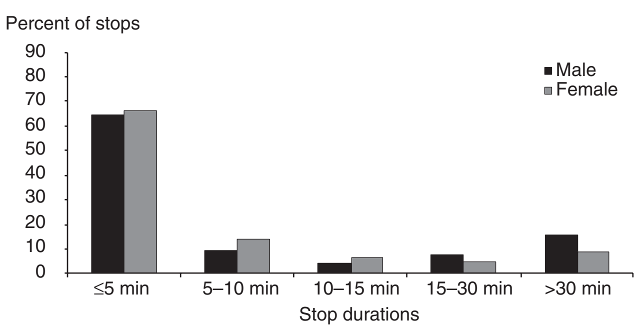

FIGURE 4 Stop duration (engine-on and engine-off stops combined) by gender.

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Activities, Time, and Travel

Changes in Women's Travel Time Expenditures, 1990–2000

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This study examines the constancy and change in total travel time expenditures of women and men in the San Francisco Bay Area across the 10-year period from 1990 to 2000. The data sets analyzed are the 1990 and 2000 Bay Area Travel Surveys. Total travel time expenditures for women and men are examined across various sociodemographic and household attributes including age, race and ethnicity, employment status, and household life-cycle category. The results show that for both women and men, reported daily travel time expenditures increased significantly from 1990 to 2000. In addition, the results show that for some subgroups of women and men, differences in travel time expenditures have equalized from 1990 to 2000, whereas differences between other subgroups have increased.

The evolution of the labor force, which includes more women and working mothers than ever before, has increased the interest in the travel behavior of women, particularly the unique needs, burdens, and patterns associated with women's travel. A growing body of research has surfaced to address the variation in travel behavior between women and men, and from this research, several behavioral patterns have emerged. Results have been well documented over the past few decades, but as equality in the work force is approaching, is this translating over time into equality within the household? Specifically, are travel patterns equalizing between women and men? This study addresses these questions by examining the constancy and change in total travel time expenditures of women and men across the 10-year period from 1990 to 2000 in the San Francisco Bay Area.

Studies on women's and men's travel have found many significant differences between the behavior and patterns of the two genders. The most pronounced finding is the increase of working women (and in particular, working mothers) in the labor force over the past few decades (*1–3*). However, this increase has not translated into an equal share of household maintenance and childcare activities between women and men, though the disparity has perhaps become less stark over the past 30 years (*4–6*). Specific to the San Francisco Bay Area, Taylor and Mauch (*7*) found that white, Hispanic, and low-income women were particularly burdened with household maintenance activities. Another consistent difference in the literature is that women typically have shorter trip durations but make more trips than men (*8–10*). In particular, women's work commutes tend to be shorter (*11*, *12*). Despite these consistencies, there is evidence of change.

A few studies have shown that women and men are becoming more alike in their travel for certain markets and for certain trip characteristics. McGuckin and Murakami (*13*) found that single adult women and men without children are more similar than different in their travel, and Pucher and Renne (*14*) show that, at the aggregate level, women and men are becoming more alike in their travel on the basis of travel mode distributions. Robinson and Godbey (*15*) report that from 1965 to 1985, total time spent on travel increased for both women and men, but women's travel time was consistently lower. For employed individuals, however, Robinson and Godbey found that total travel time in 1985 for working women was actually longer than that for working men. The current research extends these efforts to determine what changes have occurred in the Bay Area relative to travel time expenditures of women and men by using the 1990 and 2000 Bay Area Travel Surveys (BATS).

Methodology and Data

Two household travel surveys from the San Francisco Bay Area are used in this analysis to characterize and compare the constancy and change in women's and men's travel time expenditures: BATS1990 and BATS2000.

The 1990 survey was trip-based and collected only weekday travel information from individuals aged 5 and over in more than 9,000 sample households. The most recent Bay Area household travel survey is BATS2000. More than 15,000 households participated. BATS2000 is an activity-based travel survey that collected information on all in-home and out-of-home activities over a 2-day period, including weekday and weekend pursuits. Unlike the 1990 survey, BATS2000 collected travel information from all members of the household, regardless of age. For the purposes of this study, only individuals aged 5 and over are included. In addition, weekend, interregional, and external trips are excluded.

For both data sets, survey results were weighted and expanded on the basis of census data, and trips were linked to produce the results discussed here. A detailed explanation of sample weighting, expansion, and trip-linking procedures may be found elsewhere (*16, 17*). As mentioned previously, only weekday travel within the nine-county Bay Area is reviewed. The result is 16.9 million trips made in 1990 by more than 5 million persons. Just over 51% of respondents were women, and they made nearly 52% of 1990 trips. BATS2000 includes 19.6 million trips made by 6.1 million individuals. Approximately 52% of BATS2000 participants were women, and they made over 53% of the trips in 2000.

Note on Travel Times

At the onset of this analysis, the most significant change found between the 1990 and 2000 surveys was in reported durations, which are significantly higher in the 2000 survey. Figure 1 shows that 30% of the trips in the 2000 survey were reported with durations greater than 30 min compared with only 17% of the 1990 trips. The average total travel time per person from the 2000 survey is 92 min, a 48.5% increase from 1990 (see Table 1). This large increase in travel times was unexpected since past work by Kollo and Purvis (*18*) and Purvis (*19*) shows only modest increases in total travel times and average travel time per trip for the San Francisco Bay Area.

Purvis (*19*) shows that increases in average trip durations by trip purpose from 1981 to 1990 ranged from 7.8% to 11.0%. However, increases in average trip duration ranged from 23.0% to 62.0% from 1990 to 2000. Purvis also found that average total travel time per person decreased from 64 min in 1981 to 62 min in 1990 (a 3.7% decrease). In these examples, average travel time and total travel time are not increasing as significantly as the duration results of BATS2000 suggest. However, when BATS2000 data are compared with national surveys, the increase in travel times appears to be more reasonable.

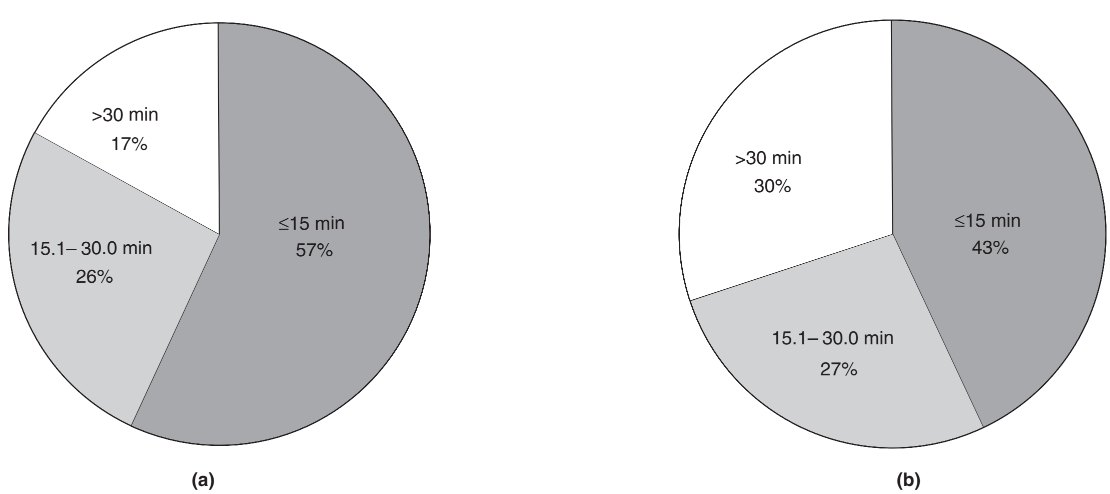

FIGURE 1 Distribution of reported trip durations in (*a*) BATS1990 and (*b*) BATS2000.

TABLE 1 Trip Rates, Total Travel Time, and Average Travel Time by Gender

	1990		2000		Percent Difference Between Women and Men	
	Women	Men	Women	Men	1990	2000
Trips per capita	3.23	3.17	3.25	3.11	1.9%	4.5% **
Total travel time per capita (minutes)	65.1	71.6	90.3	93.6	–9.1% **	–3.5% **
Average trip time (minutes)	20.1	22.6	27.8	30.1	–11.1% **	–7.6% **

**Significant at the 0.01 level.

Toole-Holt et al. (*20*) studied trends in the Nationwide Personal Transportation Survey (NPTS) and the 2001 National Household Travel Survey (NHTS) and found that the amount of time spent on daily travel has steadily increased by approximately 2 min per person per year. If this rate is applied to total travel time expenditures in 1990 to estimate daily travel in 2000, the results are within 2 and 5 min of the reported daily travel times in BATS2000. In addition, the average travel time per capita reported in the 1990 NPTS for the San Francisco–Oakland–San Jose area was 60.1 min. Data from the 2001 NHTS show that average travel time per person per day for the Bay Area was 80.2 min. Although BATS2000 averages are still a bit higher than those of the NPTS and NHTS data, travel time expenditures in these surveys are comparable and make the BATS2000 duration data credible.

Another factor that may be contributing to the significantly higher travel times is the different survey methodologies used in BATS1990 and BATS2000. It should be recalled that the 1990 survey was trip-based, whereas the 2000 survey was activity-based. Research suggests that intermediate stops are better captured with activity-based surveys (*21*). If this is indeed the case, the increase in recorded (or captured) trips would obviously add to the amount of travel time that individuals pursue on a daily basis. The difference between trip-based and activity-based surveys is an area that has not been adequately explored, and as noted by other researchers, studying the differences between these survey methodologies is an area for future research (*22*).

Since the heart of this research is an analysis of travel time expenditures, it is important that this substantial change in reported durations be considered. However, the authors believe that using the travel time information from the BATS2000 survey is valid to determine shifts in travel time expenditures that have (or have not) occurred between women and men from 1990 to 2000.

Total Travel Time Expenditures

Travel time expenditures for women and men are examined in this paper by trip purpose and select sociodemographic and household characteristics: age, race or ethnicity, employment status, and life cycle. This research began with an investigation of additional sociodemographic variables, including household income and vehicle availability. However, results for only those variables that showed the most significant trends are provided and discussed.

Trip Rates, Total Travel Time, and Average Trip Time

Total travel time, trips per capita, and average trip times for women and men in 1990 and 2000 are provided in Table 1. The difference between women's and men's trip rates increased slightly from 1990 to 2000; women averaged nearly 5% more trips per day than men in 2000. Total travel time per capita increased from 1990 to 2000 for both women and men by more than 20 min per person. In 2000, men spent only 3.3 min more per day on travel compared with a 6.5-min travel time gap between women and men in 1990. Average travel times for both men and women increased from 1990 to 2000 by approximately 7.5 min. However, the difference in average trip travel times between women and men remained relatively stable in the two survey years, with men traveling roughly 2 min longer per trip than women.

Travel Time Shares by Trip Purpose

Five different trip purpose categories are analyzed with relation to total travel time expenditures from 1990 to 2000: home-based work, home-based shop (other), home-based social-recreational, home-based school, and non-home-based. A more detailed description of the groupings used for each trip purpose follows.

Home-based work, home-based school, and non-home-based trips are traditional trip-based definitions. Several activities are incorporated in the home-based shop (other) category such as shopping, household chores and personal care, sleep, personal services (banking, dry cleaning), time spent sick or at a medical appointment, nonwork or nonshop Internet use, picking up or dropping off passengers, or changing modes. Home-based social-recreational trips encompass activities such as meals, entertainment, hobbies, exercise, social activities, relaxing, volunteer work, and religious activities.

Figure 2 shows travel time shares by trip purpose for men and women in 1990 and 2000. Some interesting trends are evident. First, Figure 2 indicates that in 1990, men spent 10% more of their total travel time budgets on work trips than women did. In 2000, the difference in travel time work shares between women and men is still roughly 10%, but the share of travel time spent on home-based work trips decreased for both sexes. This decrease in the travel time shares for home-based work trips is balanced by an increase in the portion of travel time spent for social-recreational and shopping trips.

The decrease in time spent on work trips does not imply that men and women are spending less time traveling for work. Average travel times for work trips increased for both women and men, and in 2000, women's commute times were much more comparable with those of men. In 1990, men averaged 30 min between home and work, whereas women commuted for only 20 min. In 2000, men spent 39 min commuting, whereas women averaged a 36-min commute. These average commute times paired with the travel time shares shown in Figure 2 indicate that even though women in 2000 are commuting for almost the same amount of time as men, they still bear more of the burden for home-based shop (other) trips. Women spent roughly 9% more of their travel budget on home-based shop (other) activities than men in both survey years. It must be recalled that within the home-based shop (other) category are activities like household chores, shopping, child care, and serving passengers. This result reinforces the idea that women are disproportionately burdened with household maintenance and child-care responsibilities.

Effects of Sociodemographic Variables

Travel time expenditures are analyzed next by various sociodemographic characteristics and household attributes, which include age, race or ethnicity, employment status, and household life-cycle category. Gender as well as employment status are used as controlling factors in the analysis of each sociodemographic and household characteristic. The effects of each attribute on total travel time expenditures between working women and men and nonworking women and men are discussed in the following sections. Income and vehicle availability were also investigated, but the results were not as significant as those for the variables included in this section.

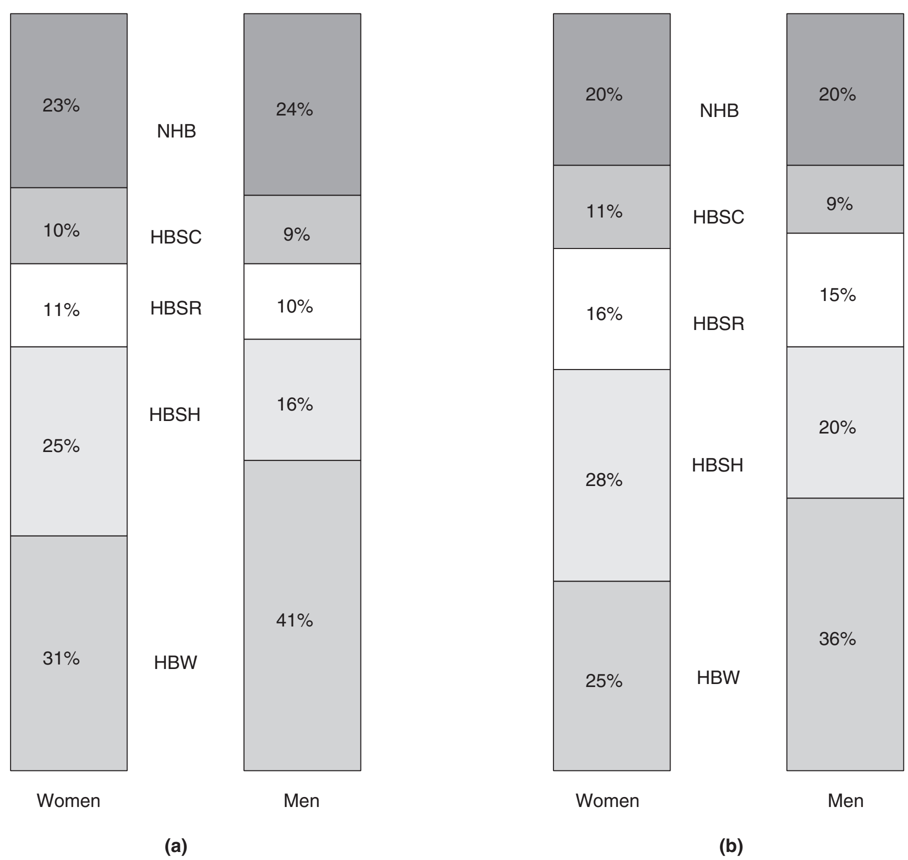

FIGURE 2 Total travel time shares by trip purpose and gender: (*a*) 1990; (*b*) 2000. (HBW = home-based work; HBSH = home-based shop (other); HBSR = home-based social/recreational; HBSC = home-based school; NHB = non-home-based.)

Age

The first sociodemographic variable reviewed relative to travel time expenditures is age of the trip maker. Table 2 provides results for working and nonworking women and men in eight age categories.

Differences in travel time expenditures between working women and men equalized from 1990 to 2000, and in fact, these differences in travel time expenditures disappeared except for working women in their fifties, who still spent less time traveling per day than their male counterparts did. Travel gaps decreased primarily because of the increases in women's travel. For almost all age groups, women's daily travel time expenditures increased at a faster rate than those of men; in some cases, women's travel times increased 1.5 to 2 times as much as men's. Although age cohorts were not analyzed in this work, there appears to be an interesting trend with individuals who were in their forties in 1990 and in their fifties in 2000. Men in this group spent significantly more time traveling per day than their female counterparts did in both survey years.

For nonworking women and men, there was no significant difference in travel time expenditures in 1990 for almost all age groups. However, in 2000, changes occurred for several age groups. Young girls reported more time traveling than young boys. Nonworking men in their late twenties spent significantly more time (nearly 30 min) on travel than did nonworking women in this age group, and in fact, these young men averaged the most on travel across all age and employment categories. Another significant change from 1990 is that nonworking women between 40 and 59 years old spent more time traveling than their male counterparts did. The results in Table 2 suggest that, barring the 23-to-29 age group and individuals over 60, nonworking women spent more time on daily travel than unemployed men.

For both survey years, workers spent more time on travel than nonworkers, but the nonworkers' travel time expenditures increased at a higher rate so that the difference in travel time between workers and nonworkers was less pronounced in 2000. Finally, the results in Table 2 suggest that children reported significantly less time on travel than adults in each survey year. To account for this finding and make a more appropriate comparison between workers and nonworkers, age is controlled for in the remainder of the analysis.

Race or Ethnicity

Travel time expenditures by five race or ethnicity categories are explored in Table 3. As with Table 2, employment status is considered; however, in the case of nonworkers, two groups are reviewed: adult nonworkers and nonworking children.

For almost all race or ethnicity and employment categories, there was no significant difference in travel time expenditures between women and men in either survey year. The most interesting results by race or ethnicity are

TABLE 2 Travel Time per Capita in Minutes by Gender, Employment, and Age Group

Age Group	1990 Women	1990 Men	2000 Women	2000 Men	Percent Difference Between Women and Men 1990	Percent Difference Between Women and Men 2000
Workers, all ages						
5–17	—	—	—	—	—	—
18–22	65.1	76.1	98.1	94.0	–14.5% *	4.4%
23–29	74.5	76.0	103.3	102.6	–1.9%	0.7%
30–39	85.5	85.5	101.6	105.9	–0.1%	–4.0%
40–49	82.9	90.0	110.1	112.2	–7.9% **	–1.9%
50–59	71.4	86.2	95.8	108.2	–17.1% **	–11.5% **
60–64	64.9	86.6	103.7	106.0	–25.0% **	–2.1%
65–99	67.9	82.5	95.0	102.2	–17.7%	–7.0%
Nonworkers, all ages						
5–17	41.3	39.4	66.2	60.8	4.8%	8.9% **
18–22	58.5	58.1	84.0	76.5	0.6%	9.8%
23–29	57.5	64.9	82.2	112.0	–11.3%	–26.7% **
30–39	59.6	66.0	88.8	83.0	–9.8%	6.9%
40–49	60.4	50.2	97.3	84.9	20.3%	14.6% *
50–59	58.1	50.3	89.5	76.2	15.4%	17.4% *
60–64	49.0	51.4	91.2	99.5	–4.8%	–8.4%
65–99	45.8	51.6	72.3	83.7	–11.4% *	–13.6% **
Total, workers and nonworkers						
Workers, all ages	78.5	84.3	102.9	106.8	–6.9% **	–3.7% **
Nonworkers, age 18 and over	53.9	55.8	84.9	86.0	–3.4%	–1.3%
Nonworkers, age 17 and under	43.5	41.4	68.2	61.9	5.1%	10.2% **

Note: The dash represents values that could not be calculated and cells with no observations.
*Significant at the 0.05 level. **Significant at the 0.01 level.

TABLE 3 Travel Time per Capita in Minutes by Gender, Employment, and Race or Ethnicity

	1990		2000		Percent Difference Between Women and Men	
Race/Ethnicity	Women	Men	Women	Men	1990	2000
Workers, all ages						
White, not Hispanic	79.1	86.9	103.8	106.3	–9.0%	–2.3%
Hispanic/Latino, any race	72.1	74.5	97.6	105.9	–3.2%	–7.8% *
Black/African American, not Hispanic	93.3	88.1	103.4	106.0	5.9%	–2.5%
Asian/Pacific Islander, not Hispanic	72.5	77.2	104.8	105.8	–6.1%	–0.9%
Other	75.1	80.5	101.0	120.6	–6.7%	–16.3% **
Nonworkers, age 18 and over						
White, not Hispanic	57.3	58.7	86.8	89.7	–2.3%	–3.2%
Hispanic/Latino, any race	40.6	56.6	92.9	80.7	–28.2% *	15.2%
Black/African American, not Hispanic	52.2	40.7	83.9	80.9	28.3%	3.8%
Asian/Pacific Islander, not Hispanic	49.7	52.1	73.9	78.3	–4.5%	–5.6%
Other	40.7	47.8	91.6	86.0	–14.8%	6.6%
Nonworkers, age 17 and under						
White, not Hispanic	42.9	42.0	64.5	64.1	2.2%	0.7%
Hispanic/Latino, any race	38.5	38.6	71.7	53.3	–0.2%	34.4% *
Black/African American, not Hispanic	54.1	51.7	88.3	79.0	4.7%	11.8%
Asian/Pacific Islander, not Hispanic	44.0	36.7	63.8	56.8	19.9%	12.2%
Other	46.4	43.9	60.4	65.1	5.7%	–7.1%
Total	65.1	71.6	90.3	93.6	–9.1% **	–3.5% **

*Significant at the 0.05 level. **Significant at the 0.01 level.

for Hispanic-Latino women and men. In 2000 working Hispanic-Latino men spent roughly 8 min more per day on travel than did working Hispanic-Latino women. This same trend was evident in 1990 for nonworking Hispanic-Latino women and men, but in 2000, the difference in travel times for this group was negligible because of the increase in travel times for Hispanic-Latino women. In fact, daily travel expenditures for nonworking Hispanic-Latino women increased more than twice as much as those for nonworking Hispanic-Latino men.

Household Life-Cycle Category

The final sociodemographic factor used to compare travel time expenditures among different groups of women and men is life-cycle category. Household life-cycle categories in this study are based on categories used in the 2001 NHTS. Use of the life-cycle variable allows for the comparison of travel time expenditures for persons living alone, individuals without children, parents in single- and multiadult households with children of various ages, and retirees. Table 4 shows the distribution of travel time per capita for working and nonworking adults by the 10 life-cycle categories.

The results of the household life-cycle analysis show that employed men in multiadult households spent more time on travel than their female counterparts did in both survey years. Aside from this finding, working women and men in each of the different household types in 2000 spent approximately the same time on travel across all life-cycle groups. The exception is for single working mothers with very young children (<6). The sample of single working fathers with young children in 2000 was small (only 37 respondents) and not statistically significant, but the travel time averages suggest that single working mothers with young children spent much more time traveling than single working fathers in this group. In addition, these single working mothers averaged between 10 and 20 min more time on daily travel than almost all other workers; the exception is single working fathers with school-age children, who averaged 117 min per day on travel.

Table 4 shows that in general, nonworking adult women in households with children have higher travel time expenditures than do nonworking men in family households. In addition, in both survey years, nonworking men living alone spent nearly 30 additional minutes per day on travel than did nonworking women living alone. This finding also holds for multiadult households in 2000, though the difference in average travel time is only 11 min between nonworking men and women. Retired women and men spent about the same amount of time traveling in each survey year.

CONCLUSIONS

Travel behavior research on the differences between women and men travelers has yielded interesting and fairly consistent results over the past two decades in gauging the effect of the surge of women in the work force. However, as new policies take effect and society adjusts to the increasing role of women in the labor force, these observed trends in travel behavior are likely

TABLE 4 Travel Time per Capita in Minutes by Gender, Employment, and Life-Cycle Category

Life-Cycle Category	1990 Women	1990 Men	2000 Women	2000 Men	Percent Difference Between Women and Men 1990	Percent Difference Between Women and Men 2000
Workers, all ages						
Single adult, no children	88.4	92.5	107.1	104.8	–4.5%	2.2%
Two or more adults, no children	74.7	81.2	99.5	106.9	–8.0% **	–6.9% **
Single adult, youngest child under 6	70.6 †	105.9 †	117.5	88.9 †	–33.4% †	32.2% †
Two or more adults, youngest child under 6	82.7	76.5	100.7	105.4	8.1%	–4.5%
Single adult, youngest child 6–15	89.3	93.3	107.9	117.3	–4.2%	–8.0%
Two or more adults, youngest child 6–15	82.5	88.1	107.6	111.4	–6.4% *	–3.4%
Single adult, youngest child 16–21	76.6	81.9	98.3	106.5	–6.5%	–7.7%
Two or more adults, youngest child 16–21	71.0	82.9	98.6	100.8	–14.3% **	–2.2%
Single adult, retired, no children	—	—	—	—	—	—
Two or more adults, retired, no children	—	—	—	—	—	—
Nonworkers, age 18 and over						
Single adult, no children	61.0	90.7	77.2	106.3	–32.7% *	–27.4% *
Two or more adults, no children	50.6	54.4	78.7	89.5	–7.0%	–12.1% **
Single adult, youngest child under 6	35.2 †	143.8 †	76.7 †	53.0 †	–75.5% †	44.7% †
Two or more adults, youngest child under 6	59.9	53.9 †	85.5	72.5	11.1% †	17.9%
Single adult, youngest child 6–15	72.7	48.6 †	107.9 †	204.0 †	49.7% †	–47.1% †
Two or more adults, youngest child 6–15	60.0	55.9	97.7	83.2	7.2%	17.4% *
Single adult, youngest child 16–21	44.5	41.7 †	108.3 †	58.9 †	6.9% †	83.7% †
Two or more adults, youngest child 16–21	51.1	54.7	73.1	64.4	–6.6%	13.6%
Single adult, retired, no children	55.5	54.8	82.3	92.9	1.4%	–11.3%
Two or more adults, retired, no children	49.9	54.0	83.8	85.6	–7.6%	–2.1%
Total	65.1	71.6	90.3	93.6	–9.1% **	–3.5% **

Note: The dash represents values that could not be calculated and cells with no observations.
†Insufficient sample size (less than 50 individuals). *Significant at the 0.05 level. **Significant at the 0.01 level.

to change. This study examined the 1990 and 2000 BATS to determine which changes have occurred in the 10-year period from 1990 to 2000. Specifically, this study focused on the constancy and change in travel time expenditures of women and men from 1990 to 2000.

The findings suggest that at aggregate levels, the differences in travel time expenditures between women and men have indeed decreased over time and are less pronounced in 2000 than they were in 1990. However, when women and men are stratified by various socioeconomic and household variables, different patterns emerge.

A few key points found in this study are as follows:

- Reported daily travel time expenditures significantly increased from 1990 to 2000 for both women and men.
- At the aggregate level, women in 2000 averaged slightly more trips per day than men.
- From 1990 to 2000, the share of total travel time spent on home-based work trips decreased, whereas shares for home-based shop (other) and social-recreational trips increased for both women and men.
- Women in 1990 spent 10 fewer minutes commuting to work than men. In 2000, however, women commuted for nearly the same amount of time (36 min for women versus 39 min for men) and had a much higher increase in work-trip travel times (19 min versus a 6-min increase for men).
- Except for women in their fifties, working women in 2000 across all age groups spent approximately the same amount of time on travel by all purposes as did men.
- Although nonworking women and men in 1990 spent roughly the same amount of time traveling across different age groups, nonworking women in 2000 generally spent more time traveling than nonworking men.
- Working Hispanic-Latino men spent 8 more minutes per day traveling in 2000 than did working Hispanic-Latino women.
- Among workers, Hispanic-Latino women spent the least amount of time on travel. However, nonworking adult Hispanic-Latino women had the highest average travel time of nonworkers, and their travel times increased twice as much as those of nonworking Hispanic-Latino men.
- Single working parents with young children spent more time on travel in 2000 than did women and men in other life-cycle groups.
- Nonworking adult women in households with children traveled more than nonworking men in family households.

The results of this study imply that for some subgroups, women and men are beginning to approach more equal levels of travel time expenditures. That is, women's travel time expenditures are increasing at a faster rate than men's so that the travel time gap has lessened between 1990 and 2000. Further analysis should be undertaken and more data sets should be analyzed to determine whether the changes are unique to the Bay Area or are an artifact of comparing trip-based with activity-based surveys. It is hoped that this style of reporting travel time expenditures will be replicated for other national, statewide, and metropolitan travel surveys to gain a better understanding of how women and men spend their time. The cross-classifications examined do show that differences in travel time expenditures are higher for some subgroups of women. Therefore, these data should be used to find ways in which these additional burdens can be alleviated.

Areas of future research might include examining the effects of age cohorts. In addition, it would be beneficial to study the differences between activity-based and trip-based survey results. Finally, this research used simple means tests to compare women's and men's travel behavior; multivariate analyses would be useful in exploring the effects of different combinations of variables. Clearly, this research shows that women's travel is still on the rise, and as such, warrants further research and consideration.

Acknowledgments

The current version of this paper reflects feedback from participants in the Conference on Research on Women's Issues in Transportation. The authors thank these reviewers as well as Sandra Rosenbloom and three anonymous referees for valuable comments essential in the development of this work.

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Do High-Occupancy Toll Lanes Serve Women's Travel Needs?

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This study examined differences in how women and men perceived three high-occupancy toll (HOT) lanes in California: State Route 91 in Orange County, Interstate 15 in San Diego, and proposed lanes on Interstate 680 in Alameda County. The literature suggested that women travelers aged 30 to 50 were more likely than other groups to choose to use a toll road, possibly to allow them to better handle their complicated household and employment responsibilities. The study found that women were statistically more likely to use SR-91 HOT lanes more frequently than men and more often during off-peak hours; they were also statistically more likely to say that it saved them more than 30 min and to express satisfaction with the lanes. The study came to similar conclusions about I-15 in San Diego; women were more likely to use the HOT lane more frequently than men but less likely to drive alone in the lane; both men and women supported the use of the HOT lanes, but women supported them slightly more strongly. With regard to the proposed HOT lane in Alameda County, an opinion survey found that women were statistically more likely to support a demonstration project to test the concept than were men. Women were also slightly more likely to support certain proposed operational features such as using a FasTrak toll collection system, using toll revenues to support public transit services, and allowing carpools free use of the lane. A higher percentage of women also supported the idea of enhanced enforcement through electronic surveillance, video cameras, and greater California Highway Patrol involvement. Additional research should focus on evaluating and comparing other HOT lane experiences; exploring equity issues related to women's use of these lanes versus their ability to pay; analyzing differences in perceptions and use by race, ethnicity, and immigration status; and identifying the specific reasons why women tend to use HOT lanes more frequently and evaluate them more highly.

Abstract prepared by Sandra Rosenbloom, University of Arizona.

Gender Differences in Bicycling Behavior and Facility Preferences

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This study focuses on bicycling and specifically the differences by gender in terms of use and facility preferences. It is hypothesized that there are observable differences in bicycle use and how bicycle facilities are perceived; the researchers attempt to understand where differences exist and to document these differences in a manner that provides a baseline for future research. Secondary data from five different surveys were used to examine actual cycling behavior (commuting and other), desired amenities, and safety perceptions, as well as cycling facility preferences of women versus men. In general, the research uncovered a number of differences between men and women but also several other important differences. For example, there are distinct gender differences in the purpose of bicycle trips, desired amenities and safety perceptions, and the degree to which separate facilities are valued. This work contributes to the planning, transportation, and public health (physical activity) literature by providing a quantitative baseline documentation on which to build future work on a specific but often-glossed-over topic.

Travel researchers, transportation professionals, public health practitioners, and policy makers have been steadfast in encouraging increased rates of walking and bicycling. Although most transportation analysis aggregates these two modes, there are considerable differences between them in terms of use, facilities, and preferences. Even considering each mode independently, there exist differences across populations. It is unlikely that a single population of current (and potential) walkers or cyclists exhibits similar characteristics, uses, and preferences (*1*). Cycling use among youth may differ from that among adults, who differ from the elderly. Likewise, income levels and geographic areas certainly have a role. This study focuses on bicycling and specifically the differences by gender in terms of use and facility preferences. It is hypothesized that there are observable differences in bicycle use and how bicycle facilities are perceived; the researchers attempt to understand where differences exist and to document these differences in a manner that provides a baseline for future research. A key dimension to encouraging heightened bicycle use—for men or for women—is to understand the extent to which it is currently being employed, the purpose, and the preferences that affect its use.

An extensive body of research identifies gender as an important predictor of travel. The focus of this literature is relatively broad; most of it examines the journey to work. Little focuses on differences by mode, especially cycling. Part of the difficulty in examining cycling behavior is that it is affected by myriad factors, including safety along a planned route, the need to carry goods, limitations imposed by schedule or attire, distance, weather, risk, or the need to combine errands. Gender may affect how strongly such factors are weighed. Existing transportation and urban theory literature related to travel and gender, however, offers only general insights to inform the thinking on cycling behavior, some of which leads to contradictory expectations.

Existing research, for example, is unified in finding that women in the aggregate work closer to home.

Women have shorter commutes than men (*2–4*). Furthermore, they make fewer and shorter trips than men do (*5*). The consideration that distance is a dominant factor in deciding to bicycle suggests that it is easier for women to cycle to work than for men (*6*). Higher rates of adoption would be expected for women (*7*). In addition, lower rates of employment, on average, suggest an increase in discretionary time. This increase would allow greater time for recreational activities, which may or may not result in increased cycling.

In contrast, equally compelling reasoning suggests that women would have lower rates of cycling than men. Women typically shoulder typical household responsibilities (*8*); such trips require serving passengers, linking multiple errands, or carrying household goods (e.g., groceries). None are well suited for bicycle travel (*9*). Such generalities suggest that women would have fewer cycling trips than men. Furthermore, there may also be differences in motivation, attitudes, and preferences for travel between women and men (*10*). Cycling is well recognized as being among the riskiest of transportation modes (*11*); there is a considerable body of literature documenting women as tending to be more risk averse than men (*12*), suggesting lower rates of adoption.

Which of the foregoing described theories likely hold true? A central problem in research on bicycle use is that information about cycling, much less about differences between women and men, is scarce. Anecdotal evidence suggests that men are more likely to cycle than women. However, the authors are aware of fewer than a handful of studies to confirm such evidence, hardly a reliable research base. Rodriguez and Joo (*13*) find that women have between 72% and 83% lower odds of using nonmotorized modes than do men (though their analysis combines cycling and walking). Krizek and Johnson (*14*) conclude that women have 52% lower odds of making a bicycle trip. Cervero and Duncan (*15*) demonstrate that bicycle trips are more likely to be made by men. In terms of cycling distance, women have longer bicycle commutes (in terms of travel time) going from suburb to central business district and shorter ones for suburb to suburb (*16*). A relatively recent survey based in San Francisco aimed to understand why low-income women do not ride bicycles (*17*). Different studies analyze different phenomena, ranging from rates of use to distance to reasons for use. Unfortunately, available data prevent robust analysis to reconcile such complexities reliably because cycling is a mode of transportation used by so few, at least in the United States. Its relatively rare use makes it extremely difficult to break down such data by gender, purpose, or geographic area. For a rigorous explanation of why a rare event occurs, a targeted survey design and instrument, a relatively large survey, and a sample able to detect subtle differences are required.

The aim in this study is to focus on gender and cycling and document such relationships by exploiting secondary data sources. By using the foregoing studies as a springboard, it is hypothesized that rates of cycling are greater for men than for women—for all types of trips. Furthermore, it is theorized that men make longer cycling trips than women because women typically work closer to home. It is also theorized that part of the reason why women bicycle less is because men are less affected by inferior cycling facilities (e.g., cycling in traffic). To shed light on these hypotheses, results are described by using an analysis from five different surveys. Each survey is based in Minneapolis, Minnesota, and the accompanying region,[1] except for the National Household Travel Survey (NHTS), which is relied on to offer a general perspective.

The core of this paper lies in two different analysis sections. The first reports on findings from three different surveys measuring revealed behavior (two travel surveys and the U.S. census). All three data sets are relied on to focus on rates of cycling by gender, commute mode share, and differences between city and suburb. The second analysis section switches to explaining stated-preference data from two other surveys. The first stated-preference survey focuses on cycling infrastructure preferences and safety perceptions; the second is an adaptive stated-preference survey examining the value of different types of bicycle facilities. The central purpose throughout this pilot study is to provide baseline information about how different types of bicycle use and facility preference differ by gender and to direct more concentrated work in this area. Employing a combination of surveys (revealed behavior and stated preference) helps to establish a stronger empirical base for continued dialogue and future research concerning the unique needs and preferences of women cyclists.

Revealed Behavior Analysis of Cycling Behavior

Data Sources of Revealed Behavior

To examine rates of cycling behavior, three comprehensive surveys of revealed behavior were used. The first is the 2001 NHTS, which aims to collect a sample of the nation's daily travel. The survey includes demographic characteristics of households, people, and vehicles, and detailed information on daily travel for all purposes by all modes.[2] The other two data sets used in this part of the analysis focus on the Twin Cities, Minnesota, metropolitan area. One is the 2000 Twin Cities metropolitan area Travel Behavior Inventory (TBI), which contains individual and household-level demographic data as well as travel behavior characteristics for a sample of Twin Cities metropolitan area residents.[3] The other data set is the 5% Public Use Microdata Sample (PUMS) from the 2000 U.S. census.

The aim in this part of the analysis is to uncover gender differences in cycling across three dimensions: the overall frequency of all cycling trips, commute-only behavior, and cycling behavior of urban versus suburban residents by gender. However, each of the foregoing surveys has limitations in its ability to shed light on these questions. For example, the PUMS is a large sample but only reports on commuting. The NHTS includes all trips, but issues of confidentiality prevent detailed analysis of geographical attributes for either sample. The TBI, although it focuses only on the Twin Cities, includes all trips and allows geographical precision but is based on a relatively small sample size. In the following discussion, trip purpose is examined by using the NHTS, work commute is compared across all three data sources, and city and suburb differences are examined by using the TBI. Employing all three helps provide a comparative picture of relevant differences.

Trip Purpose

The initial observation on looking at the NHTS data reinforces the earlier statement that cycling is a relatively rare activity. On average, a mere 0.4% of all reported trips for adults in the United States is made by bicycle.[4] Examining how these trips break down by gender reveals interesting differences. Controlling for the number of overall trips within each gender group shows that men are more than twice as likely to complete their trip by bicycle than women (0.66% versus 0.25%). Breaking down cycling trips further by gender and purpose reveals the following differences, each of which is statistically significant at the $p = .01$ level. Men are more likely to bicycle to work than women (10.2% of men's cycling trips versus 6.24% of women's cycling trips) and to bicycle for rest and relaxation (2.14% versus 0.79%). Conversely, however, women are more likely than men to ride a bicycle to school as a student (1.2% versus 0.58%), to do shopping and errands (2.64% versus 1.11%), and to visit friends and relatives (4.53% versus 2.76%). All other purposes of travel did not reveal statistically significant differences across gender.

Work Commute

Focusing only on the work commute allows comparison of results across all three surveys. The NHTS provides a national overview. The PUMS and TBI are examined for only Minneapolis to compare similar geographies. Table 1 shows the prevalence and duration of cycling trips for employed persons in each of these surveys. Although there is considerable variation for each measure across the data sets, the consistent pattern shows women's rates of cycling to be less than those of men. However, only the NHTS and the PUMS revealed the differences to be statistically significant at the $p = .01$ level.

Mean duration in cycling commute times reveals no statistically significant differences; most times did not differ by more than 90 s. Of particular interest here is the ability to compare different survey instruments and samples for exactly the same geographic area (Minneapolis). Although the differences between cycling rates of men and women are similar in the PUMS and TBI, it is interesting to note that the TBI survey results in higher measures for both prevalence and distance.

City Versus Suburb

Differences in cycling according to urban or suburban residence, focusing on the Minneapolis–St. Paul region, are examined next. The analysis is restricted to the TBI and to the behavior of those who indicated they had

TABLE 1 Prevalence and Duration of Cycling Commute Trips by Gender for Employed Persons

Data Source	Women	Men	Total
	Cycling commute frequency in % (*n*)		
NHTS (national)[1, 3]	0.23% (119,659)	0.75% (460,612)	0.51% (580,271)
TBI (Minneapolis)[2]	4.37% (15)	5.80% (21)	5.11% (36)
PUMS (Minneapolis)[2, 3]	1.04% (33)	2.90% (96)	1.99% (129)
	Commute trip time in minutes (sd)		
NHTS (national)[1]	14.28 (9.04)	15.44 (14.78)	15.20 (12.31)
TBI (Minneapolis)[2]	22.93 (12.78)	21.57 (17.25)	22.13 (15.36)
PUMS (Minneapolis)[2]	15.36 (7.35)	16.95 (9.92)	16.55 (9.32)

[1] Includes weighted sample of full and part-time workers.

[2] Denominator includes only those who are employed residents of Minneapolis (TBI, $n = 705$; PUMS, $n = 6{,}476$).

[3] The NHTS and PUMS commute frequencies are the only gender differences shown to be statistically significant: chi-square = 63.16, $p = 0.00$ and chi-square = 117.24, $p = 0.00$.

completed a cycling trip during the survey (among those in the TBI, n = 142). Men and women cyclists vary little across sociodemographic characteristics. However, when they are stratified by urban or suburban residence, some gender differences emerge (Table 2).[5]

The last two rows of Table 2 present summary characteristics of cycling behavior for TBI cyclists by gender and household location. Overall, the mean number of bicycle trips in a day is only slightly lower for women than for men, whereas the mean distance traveled by bicycle is about a half kilometer lower for women. This pattern differs for urban residents and suburban residents, however. For the urban residents (defined as residents of Minneapolis or St. Paul), women cyclists traveled nearly a kilometer more than men, whereas the mean distance traveled by bicycle for suburban women was nearly 3 km less than that for suburban men (suburban was defined as anyone in the seven-county region except those in Minneapolis or St. Paul).

Most striking, however, are the gender differences in the purpose of bicycle trips. For the urban population, 63% of women cyclists made a work- or school-related (i.e., commute) bicycle trip compared with 38% of male cyclists. Conversely, in the suburbs, only 11% of women cyclists made a commute trip compared with 25% of men. In contrast to commute trips, gender differences for recreation trips are reversed. In other words, 13% of urban women cyclists made a recreational trip compared with 21% of men. In the suburbs, more women cyclists made a recreational trip compared with men (50% versus 31%).

TABLE 2 Characteristics of TBI Cyclists by Gender and Household Location in Seven-County Metropolitan Area, Minnesota

	Twin Cities				Suburbs				Total			
	Women		Men		Women		Men		Women		Men	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
	30	34%	58	66%	18	33%	36	67%	48	34%	94	66%
Age category												
18–29 years	11	37%	22	38%	5	28%	3	8%	16	33%	25	27%
30–49 years	14	47%	30	52%	6	33%	21	58%	20	42%	51	54%
≥50 years	5	17%	6	10%	7	39%	12	33%	12	25%	18	19%
Educational attainment												
4-year college degree or more	21	70%	44	76%	11	61%	19	53%	32	67%	63	67%
Less than 4-year degree	9	30%	14	24%	7	39%	17	47%	16	33%	31	33%
Employment status												
Employed	30	100%	48	83%	11	61%	28	78%	41	85%	76	81%
Unemployed	0	0%	10	17%	7	39%	8	22%	7	15%	18	19%
Household income												
<$50,000	14	47%	34	59%	5	28%	13	36%	19	40%	47	50%
$50,000–$74,999	12	40%	9	16%	5	28%	10	28%	17	35%	19	20%
≥$75,000	3	10%	11	19%	3	17%	8	22%	6	13%	19	20%
Missing	1	3%	4	7%	5	28%	5	14%	6	13%	9	10%
Other cyclist in household												
Yes	8	27%	7	12%	7	39%	9	25%	15	31%	16	17%
No	22	73%	51	88%	11	61%	27	75%	33	69%	78	83%
Bicycle trip purpose												
Work commute	19	63%	22	38%	2	11%	9	25%	21	44%	31	33%
No	11	37%	36	62%	16	89%	27	75%	27	56%	63	67%
Work or school commute	19	63%	28	48%	3	17%	9	25%	22	46%	37	39%
No	11	37%	30	52%	15	83%	27	75%	26	54%	57	61%
Recreation/fitness	4	13%	12	21%	9	50%	11	31%	13	27%	23	24%
No	26	87%	46	79%	9	50%	25	69%	35	73%	71	76%
Cycling Behavior Characteristics	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Number of bicycle trips	2.80	(1.40)	2.98	(1.96)	2.06	(0.64)	2.33	(1.60)	2.52	(1.22)	2.73	(1.85)
Distance (km) by bicycle	9.13	(5.87)	8.22	(7.71)	6.05	(6.62)	8.75	(11.46)	7.97	(6.26)	8.43	(9.34)

Note: Age ≥18 years.

Stated-Preference Analysis of Cycling Facilities

Omnibus Data

In the second part of the analysis, differences were examined by using results from stated-preference surveys, which were obtained from two sources. The first is the Minnesota Department of Transportation Statewide Omnibus Study 2003–2004, which provides data on preferences for cycling facility infrastructure and on perceptions of cycling. The Omnibus data were originally collected by a telephone survey from a random sample of Minnesota residents 18 years or older.[6] The preference variables represent importance ratings of cycling facility infrastructure characteristics such as paved shoulders, lighting on bicycle paths, and bicycle racks on buses. The safety perception variables represent general themes that emerged from open-ended responses provided by subjects who reported that Minnesota was less than "very safe" for cyclists.

The Omnibus data shed light on two general phenomena: gender differences with respect to (*a*) desired amenities and facilities among current and potential cycling commuters and (*b*) perceptions of safety for cycling. The Omnibus sample of cyclists is nearly evenly distributed on gender (49% women and 51% men). Only about one-fourth (28%) are central city residents (Minneapolis or St. Paul zip codes), whereas 72% live in the suburbs (Table 3). Because so few Omnibus cyclists are central city residents, all cycling facility infrastructure characteristics reported here are for the pooled sample of urban and suburban cyclists.

Among current and potential cycling commuters, few gender differences were noted with respect to amenities

TABLE 3 Characteristics of Omnibus Cyclists by Gender and Household Location in Seven-County Metropolitan Area, Minnesota

	Twin Cities				Suburbs				Total			
	Women		Men		Women		Men		Women		Men	
	16	39%	25	61%	55	52%	50	48%	71	49%	75	51%
Subject Demographics												
Age category												
18–29 years	5	31%	2	8%	7	13%	8	16%	12	17%	10	13%
30–49 years	8	50%	12	48%	39	71%	31	62%	47	66%	43	57%
≥50 years	3	19%	11	44%	9	16%	11	22%	12	17%	22	29%
Educational attainment												
4-year college degree or more	12	75%	18	72%	30	55%	26	52%	42	59%	44	59%
Less than 4-year degree	4	25%	7	28%	25	45%	24	48%	29	41%	31	41%
Employment status												
Employed	13	81%	23	92%	42	76%	42	84%	55	77%	65	87%
Unemployed	3	19%	2	8%	13	24%	8	16%	16	23%	10	13%
Household income												
<$50,000	9	56%	8	32%	14	25%	14	28%	23	32%	22	29%
$50,000–$74,999	3	19%	5	20%	11	20%	14	28%	14	20%	19	25%
≥$75,000	3	19%	10	40%	21	38%	17	34%	24	34%	27	36%
Missing	1	6%	2	8%	9	16%	5	10%	10	14%	7	9%
Cycling Behavior												
Bicycle trip purpose in past year												
Work or school-related commute	6	38%	8	32%	6	11%	9	18%	12	17%	17	23%
No	10	63%	17	68%	49	89%	41	82%	59	83%	58	77%
Nonwork or school trip	16	100%	24	96%	54	98%	49	98%	70	99%	73	97%
No	0	0%	1	4%	1	2%	1	2%	1	1%	2	3%
How safe for cyclists												
Very unsafe	1	6%	1	4%	3	5%	3	6%	4	6%	4	5%
Somewhat unsafe	4	25%	4	16%	13	24%	9	18%	17	24%	13	17%
Somewhat safe	7	44%	15	60%	25	45%	26	52%	32	45%	41	55%
Very safe	4	25%	5	20%	13	24%	12	24%	17	24%	17	23%
Don't know	0	0%	0	0%	1	2%	0	0%	1	1%	0	0%

Note: Values are in number of cycle trips in past year.

and facilities rated as "very important" to commuting by bicycle. Women and men cyclists were relatively similar in the proportion who value specific types of bicycle facilities such as on-road bicycle lanes, separate bicycle paths, and a connected system of bicycle routes as well as those who value amenities such as secure storage facilities at work or school. They were also relatively similar with respect to the lower proportions of those who value showers at work or bicycle racks on buses.

Some gender differences emerged. While none failed to reach levels of statistical significance, the differences are described briefly. Most notably, women are more likely than are their male counterparts to rate paved shoulders and lighting on bicycle paths as "very important" to commuting by bicycle (84% versus 71% and 68% versus 45%, respectively). Conversely, men are more likely to rate access to information about commuting and access to information about bicycle routes as "very important" to commuting by bicycle as compared with women (48% versus 36% and 65% versus 56%, respectively).

Perceptions of safety varied more dramatically between genders. More men cyclists than women cyclists rated Minnesota as safe for cycling (77% versus 70%). Of those who did not rate Minnesota as "very safe" for cycling (n = 111), four themes were identified: lack of bicycle paths, unsafe driver behaviors, unsafe cyclist behaviors, and unsafe road conditions. Among these reasons, there were marked differences by gender. Women were more likely than men to report lack of paths (55% versus 41%) and poor road conditions (13% versus 3%). In contrast, men were more likely than women to report unsafe behaviors of drivers (53% versus 36%) and unsafe behaviors of cyclists (22% versus 15%).

Adaptive Stated-Preference Data

The second stated-preference data set was a computer-based adaptive stated-preference (ASP) survey administered by Tilahun et al. to collect information on people's valuation of different cycling facilities (*18*). The ASP survey was primarily used to quantify how much additional time, in minutes, respondents are willing to travel to use an alternate higher-quality bicycle facility and if this valuation varies by gender. It is hypothesized that the additional time people are willing to travel in an alternate facility is a function of the attributes of the base facility they can use, attributes of the alternate facility, and personal attributes such as gender, age, and income.[7] Given the attributes of the shortest path (base facility), one can measure how much certain improvements are valued (in terms of travel time) by users of that facility. The measures are relative, and the presence of certain attributes of the base facility will affect how much one values a given improvement.

Each respondent was presented with nine scenarios comparing two facilities for four sets of travel times (see Figure 1 for infrastructure characteristics). The travel times on the higher-quality facility adapt to the subject's previous choice; if a facility is rejected at a particular travel time, the next presentation has a lower travel time.[8] The algorithm always presents a new travel time that is between the now-rejected and previously accepted or the now-accepted and previously rejected travel times. Presenting choices in this manner allows convergence on the critical travel time difference at which an individual is still willing to choose the higher-quality facility. The ASP sample was composed of civil service employees from the University of Minnesota, aged 18 years or older, who reported using a bicycle in the past year (n = 127, 85 women and 42 men).

The results show a preferential hierarchy of facilities (people are willing to trade time for higher-quality facilities) and differences between women and men. Both women and men are willing to travel longer for an off-road facility (Facility A), followed by a facility with a bicycle lane and no street parking (Facility B), a bicycle lane with side-street parking facility (Facility C), and an in-traffic facility with no parking (Facility D) (see Figure 2). Assuming a typical 20-min commute, this model predicts that individuals are willing to travel about 7.74 min [95% confidence interval (CI) = 5.85, 9.63] for an off-road facility in comparison with a facility that has no side parking and no bicycle lane (see Table 4 for parameter estimates of the full model).[9]

A key point from this analysis is that, on average, women are willing to travel more additional minutes than men for a preferred facility. Assuming a 20-min

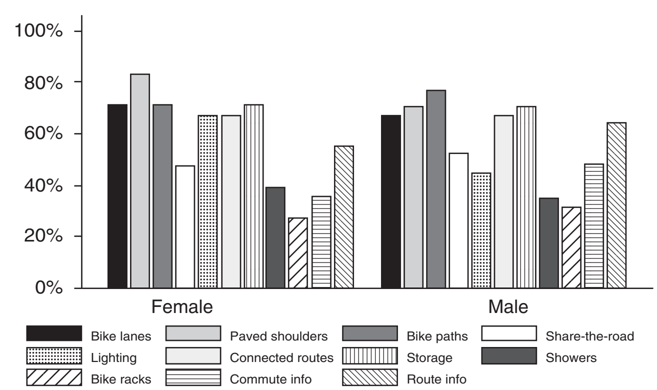

FIGURE 1 Importance of cycling facility infrastructure characteristics to current and potential commuting cyclists by gender (percentage that rated characteristic as very important to commuting by cycle).

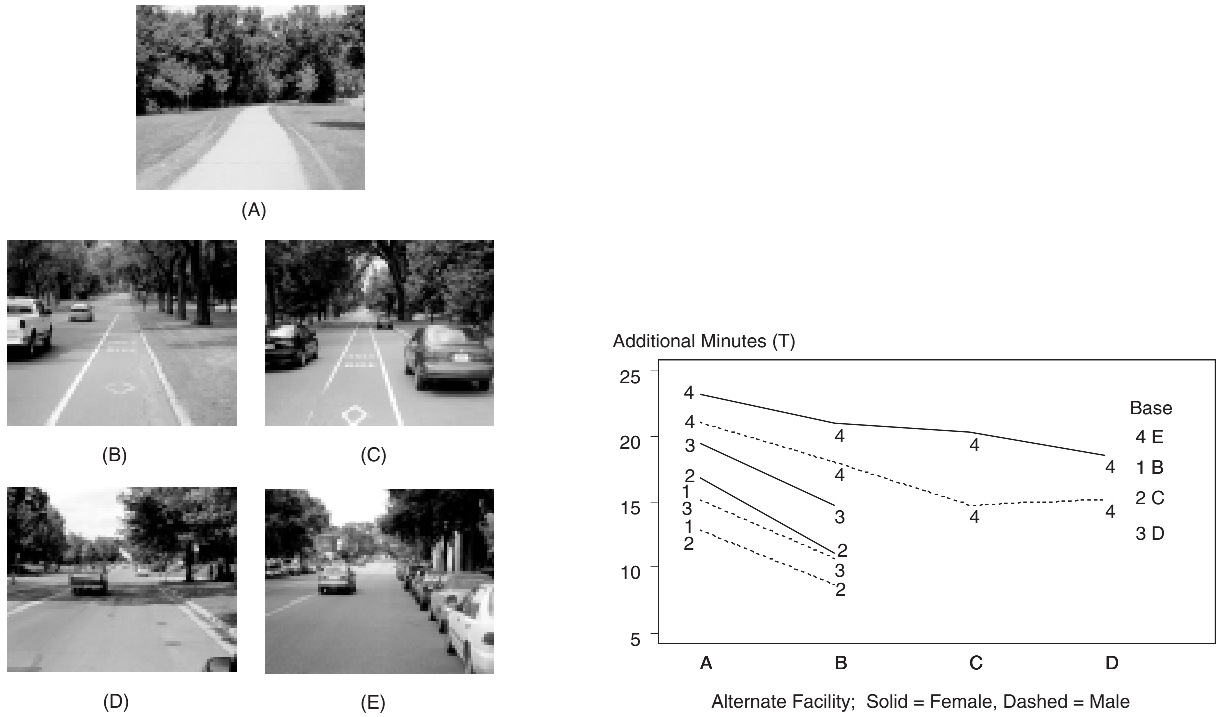

FIGURE 2 Types of facilities and average additional time willing to travel for alternate facilities by gender: A, off-road facility; B, bike lane, no parking; C, bike lane with parking; D, no bike lane, no parking; E, no bike lane with parking.

TABLE 4 Parameter Estimates of Mixed-Effects Regression Model

Linear mixed-effects model fit by maximum likelihood

AIC	BIC	logLik
8119.567	8190.147	–4045.783

Random effects
Formula: ~1 subject

	(Intercept)	Residual
StdDev:	8.385928	7.230089

Fixed effects: $T_i \sim W + P + B + O + \Delta P + \Delta B + A + S + H + I + C$

	Description		Value	Std. Error	*t*-stat	*p*-value
(Intercept)			10.709	4.013	2.669	0.0077 **
W	Season	Winter = 1				
		Summer = 0	–5.087	1.561	–3.260	0.0014**
P	Base parking?	Yes = 1				
		No = 0	4.441	0.526	8.437	0.0000 ***
B	Base bike lane?	Yes = 1				
		No = 0	–6.663	0.526	–12.658	0.0000 ***
O	Alternate off road	Yes = 1				
		No = 0	7.742	0.967	8.006	0.0000 ***
ΔP	Alternate has no parking,	Yes = 1				
	base has parking	No = 0	2.252	0.832	2.706	0.0069 **
ΔB	Alternate has bike lane	Yes = 1				
	Base does not	No = 0	3.328	0.832	3.890	0.0001 ***
A	Age		0.095	0.076	1.255	0.2120
S	Sex	Male = 1				
		Female = 0	–5.427	1.673	–3.243	0.0015 **
H	Household size		–1.281	0.667	–1.919	0.0574 †
I	Household income					
	(=annual/1000)		0.051	0.022	2.266	0.0252 *

Significance ***0.001 **0.01 *0.05 †0.1

commute, men are willing to divert 5.43 fewer minutes (95% CI = 2.13, 8.17) than women for any facility compared in the survey. For example, the uppermost solid line in Figure 2 connects the average additional time women would travel when the Base Facility E was compared with alternate Facilities A, B, C, and D, respectively. The corresponding dashed line shows the same comparison for men. In all cases the solid line is above its dashed counterpart, indicating that the average additional travel time that women are willing to expend for a better facility is higher than that for men. The data also suggest that within gender groups, Base Facility E leads to a greater willingness to travel on any other alternate route than when the base is D, followed by when the base is C and B, which suggests a hierarchy in preference for these facilities.[10, 11]

Interpretation and Summary

An extensive body of literature identifies gender as an important predictor of travel patterns; little of this research, however, examines how cycling patterns and preferences differ between men and women. The research presented here serves to reinforce many expectations of differences between men and women, challenge others, and provide an empirical foundation on which to base future work. It reinforces some expectations by documenting that in general, overall rates of cycling for women are less than those for men both in absolute terms and after the number of trips is controlled for. It is shown that rates of cycling across gender differ by type of trip; in particular, women are more likely than men to cycle for shopping and errands or visiting friends. With reported behavior from three different surveys, it is shown that the prevalence of commuting by bicycle is less for women. Furthermore, the bulk of the stated-preference work presented suggests that when only risk is considered, women perceive risks differently from men (*12*); in particular, women demonstrate a stronger preference for safer forms of cycling infrastructure.

In some respects, however, this work challenges or clouds other assumptions or expectations, namely, that women have shorter distances between home and work. Some work suggests that this might not be the case (*20*). Some of the descriptive statistics presented show that the difference in commute distance between men and women is not statistically significant. Furthermore, some of the prevailing literature suggests that women make fewer recreational trips (*21*, *22*). The descriptive analysis hints that women may have lower rates of commuting; they may pass men in terms of recreational use, particularly in suburban environments. This finding tends to support those of other studies showing that women have higher rates of leisure travel (*8*).

The findings reported here, however, need to be considered in light of several study limitations. First, the samples used were relatively small, especially after stratification on gender and household location. All summary characteristics must therefore be viewed with caution since small changes in any given value could change the described patterns substantially. Second, data sets except for the NHTS are subsets from larger data sets, none of which is representative of cyclists in the Twin Cities metropolitan area.[12] Third, it is difficult to compare cyclists across subsamples of the data analyzed.

However, this study provides empirical documentation of an often-glossed-over but important phenomenon—women's cycling. The paper therefore contributes to the planning, transportation, and public health (physical activity) literature by providing a quantitative valuation of how women demonstrate different patterns of cycling, may prefer different bicycle facilities, and have different safety considerations. These findings—in concert with more refined investigation—will inevitably aid policy discussions. For example, they draw attention to the fact that different infrastructure decisions likely have varying impacts on difference audiences in terms of making cycling environments safer (*23*) or more attractive to different users. From a practical standpoint, such information may be useful for marketing or for directing segmented and targeted policies. If women have different use patterns, make different route choice decisions, or prefer different cycling facilities, these factors are likely to have important implications for provision of different facilities and the use that planners and other policy officials can expect from them. For example, women may prize lighted paths and paved shoulders more than do men.

Future research could be oriented toward understanding how these patterns play out by age and location and moreover what the underlying behavioral reasons for these patterns are. This study could be done through a combination of more extensive and focused analysis of available data sets (e.g., the NHTS) and direct questionnaires to both current and potential women cyclists. It would be interesting to learn whether such relationships hold true across metropolitan settings. This work could be used in combination with conceptual frameworks (*14*) to further refine future research. This study therefore offers a first step in describing gender differences in cycling behaviors and preferences. Such an understanding can be incorporated into the planning process and contribute to policy dialogues regarding optimal investment decisions on bicycle facilities for different market segments.

Acknowledgments

The authors are grateful to Gary Barnes, who assisted with the analysis of the NHTS data for this project, and to Robin McWaters, who assisted with diligent editing. Financial support was provided in part by the National Cooperative Highway Research Program and by the Minnesota Department of Transportation.

Notes

1. The Twin Cities of Minneapolis and St. Paul provide a suitable setting for such research. The metropolitan area enjoys an unparalleled system for off-street bicycling, and the city of Minneapolis ranks among the top cities in the percentage of workers commuting by bicycle.
2. NHTS data are collected from 60,282 persons in 26,038 households that make up the national sample. The survey asked respondents (or their adult proxies) to report all trips taken during a specified 24-h travel day. The response rate was approximately 41%, and weighted results were used here to reflect the travel behavior of the whole sample population.
3. The TBI data were originally collected through 24-h travel diaries and household telephone interviews from randomly selected households across the seven-county metropolitan area and 13 surrounding counties. All subjects from the TBI database that were residents of the seven-county metropolitan area and were age 18 years or older were selected. The variables of interest in this application represent bicycle use in one 24-h period, including cycle trips (number of cycle trips in 24 h); trip types—work trip (any cycle trip to work, yes or no), commute trip (any cycle trip to work or school, yes or no), recreation or fitness trip (any cycle trip for recreation or fitness, yes or no)—and the distance cycled—total kilometers cycled in 24 h.
4. Authors' calculation using weighted sample of NHTS respondents (not including add-on areas) aged 17 or more: 87,385,641 total trips and 3,904,365 total bicycle trips.
5. In the TBI sample cyclists are predominantly men (34% women versus 66% men) and nearly two-thirds (62%) are central city residents (Minneapolis or St. Paul) whereas 38% live in the suburbs. Specifically, Twin Cities women cyclists are less likely to have a college degree but more likely to be employed than are male cyclists. In the suburbs, women cyclists are more likely to have a college degree but less likely to be employed than their suburban male counterparts.
6. Two other criteria were applied to ensure applicability of these data. First, residents of the seven-county metropolitan area were selected to best comport with analysis from the other data sources, which were mostly from urbanized areas. Second, the data included individuals from all walks of life, many of whom never cycle. Uncovering why such individuals never cycle is important. However, the nature of the questions prompted the retention of individuals who indicated that they had used a bicycle in the past year ($n = 146$). Their responses were more in tune with the nature of the questions.
7. This analysis is performed by using a mixed-effects regression model, which provides a relative measure of attractiveness of the attributes of cycling facilities.
8. However, this travel time will still be higher than a travel time the subject has found acceptable in a previous trade-off.
9. If the base facility had parking, individuals would be willing to add additional minutes to avoid that base facility. However, if the base facility has a bicycle lane, individuals are only willing to travel 1.08 additional minutes for the alternative off-road facility. Similarly, individuals are willing to bicycle an additional 3.24 min (95% CI = 1.61, 4.86) if an alternate route provides a bicycle lane as compared with a facility that has no parking and no bicycle lane. If the base facility has parking, the additional minutes they are willing to travel for the alternate bicycle lane facility increases by 4.44 min (95% CI = 3.41, 5.46). In addition, if the alternative also provides a parking improvement, they are willing to add another 2.25 min (95% CI = 5.85, 9.63).
10. For the ASP survey, there are multiple responses from each person, which requires an additional step to account for the within-person correlation. Thus, a linear mixed-effects model was used, which allows for the specification of an additional variance component in the form of a random effect. The mixed-effects analysis was conducted with the NLME library in R statistical software (*19*).
11. The additional time that an individual is willing to travel also differs across demographic and economic variables. Household income and household size were also statistically significant. As income levels increase, individuals are willing to travel longer on the alternate facility. An increase in household size is associated with an unwillingness to trade time for alternate facilities.
12. Because the TBI and the Omnibus data sets were random samples obtained by means of complex sampling strategies designed to produce representative samples of the Twin Cities metropolitan area population, the subset of cyclists used in this study cannot be assumed to be representative.

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Gender Differences in Automobile Choice Behavior

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Automobile ownership plays an important role in determination of travel behavior. In contrast, gender difference is shown to be a significant factor in automobile choice behavior. The primary objective of this study was to identify influential factors that affect gender differences in automobile choice behavior. This study presents the process of developing mixed logit discrete choice models that control for gender to predict automobile type choice behavior. A variety of explanatory variables were used to provide a good model fit. Overall, the models demonstrate that gender-specific automobile type choice behavior is influenced by a wide variety of explanatory variables, including automobile attributes and household and individual characteristics.

Automobile ownership plays a critical role in determination of travel behavior. The decision to buy a vehicle is one of the most important decisions made by a household. Automobile ownership has a dramatic effect on mobility and access to new opportunities such as employment and social services.

During the past few years, increasing attention has been paid to the use of microsimulation modeling approaches to activity-based travel forecasting. Some of the earliest applications of microsimulation in the transportation field involved dynamic modeling of automobile ownership (Miller 1996), and the majority of new travel demand models include explicit modules that simulate household automobile choice behavior, for example, those of Salvini and Miller (2003) and PB Consult (2002). Furthermore, it is clear that understanding the factors driving vehicle ownership and choice behavior is important in addressing a range of environmental issues.

Analyses of household travel survey data have shown differences in travel demand across households that vary with family type and gender of the household members. It has been shown that women behave differently from men when it comes to their travel patterns. Women travel for shorter distances between work and home and make more trips because of their special role in the household (Wachs 1997). Wachs also reports that lower-income women are more likely to use public transit. Mokhtarian (1997) found that women are more likely than men to change their travel behavior as a result of congestion. Furthermore, it seems that women are more willing than men to reduce car use (Matthies et al. 2002). One can postulate the same tendency for gender differences in automobile ownership and utilization behavior. Gender difference is shown to be a significant factor in automobile ownership behavior, and this difference persists across all ages (Prskawetz et al. 2002). Automobile ownership in female-headed households tends to be less than that in male-headed households, and this difference can increase dramatically for households with older members. One reason to explain this tendency can be the lower female labor-force participation rate and the higher rate of single-person, female-headed households.

However, the overall percentage of female drivers is rising, whereas the overall percentage of male drivers is decreasing. According to the U.S. Department of Transportation, the percentage of female drivers grew from 44% in 1972 to 49.7% in 2000 compared with the percentage of male drivers, which fell from 56% in 1972 to 50.3% in 2000 (FHWA 2004). It has been also shown that women have influential buying power. Almost half of the new vehicles are purchased by women, and Ford Motor Company marketing research shows that women influence 80% of car-buying decisions and tend to have different preferences compared with their male counterparts.

The way individuals and households make decisions with respect to automobile ownership has been the subject of numerous studies across many disciplines. Transportation planners are interested to know how many and what type of automobiles are owned by households and how people utilize their vehicles. Several studies have been conducted in this area. One of the early disaggregate studies, by Manski and Sherman (1980), developed multinomial logit models for the number of vehicles owned and vehicle type choice. Separate models for automobile type choice were developed for households with one or two vehicles in their fleet. Mannering and Winston (1985) attempted to model number of vehicles, vehicle type, and vehicle usage in an interrelated framework. They estimated separate models for single- and two-vehicle households. Hensher and Le Plastrier (1985) used a nested logit structure to model a household's automobile holdings and composition choice. Brownstone et al. (1996) developed an automobile choice model using stated-preference data. In their study six hypothetical alternatives were presented to respondents with a number of randomly distributed attributes within certain ranges. Yamamoto et al. (1999) developed a competing risk duration model of household vehicle transactions by estimating a hazard model for each type of transaction separately, assuming the independence of unobserved heterogeneity across the hazards. More recently Mohammadian and Miller (2002b, 2003a, 2003b) developed a series of dynamic automobile transaction and type choice models using nested logit, mixed logit, and machine learning methods. Some of the models reviewed here have dummy variables to specify gender in the model specification, but to the best of the author's knowledge, no other study in the transportation literature has modeled gender-segmented automobile choice behavior.

The primary objective of this study was to develop econometric models of automobile type choice and to identify influential factors that affect gender differences in automobile choice behavior. Two different mixed logit models were developed for male and female decision makers while heterogeneity effects on choice behavior were accounted for. These models were then compared on the basis of the values of their fixed and random parameters. This procedure provides an opportunity to investigate the effects of gender-specific factors that drive vehicle choice behavior and will offer scientific evidence to policy makers for further policy direction. In addition, the models developed here can be used to examine a wide range of scenarios and policy analysis interests.

Data

The data set used in this study was obtained through the Toronto Area Car Ownership Study (TACOS), which was a retrospective survey (Roorda et al. 2000). The data set contained information on household vehicle transactions for up to 9 years from 1990 to 1998 in the Greater Toronto Area. Vehicle characteristics for each automobile in the sample were obtained from the Vehicle Specifications System of the Canadian Association of Technical Accident Investigators and Reconstructionists (CATAIR) (1999). The Fuel Economy Guide database of the Environmental Protection Agency (EPA) (2002) provided fuel consumption information, and vehicle market values at time of purchase were gathered from Canadian Red Book, Inc. (1990–1998a, b). Thus, the prices that are used in the models are not the individual sale prices of the specific vehicles reported in the sample (which would be subject to potential self-selection biases or reporting errors because of the retrospective nature of the survey) but rather the average market values for each given make, model, or vintage of vehicle in the sample.

Many variables are used in the literature to explain the difference in utility between different models. These variables include the turning circle, braking distance, axle ratio, revolutions per minute, horsepower, luggage space, head room, leg room, length, width, fuel efficiency, engine size, and weight. In order to keep the model as simple as possible, only those characteristics were chosen that are judged to be the most important in representing variation in utility. Several vehicle characteristics such as weight, engine displacement, fuel intensity, luggage capacity, and wheelbase were chosen. These vehicle characteristics present a special difficulty when a model is estimated. For technological reasons, many of these variables are highly correlated. This high multicollinearity between variables might create problems of identification of the influence of car characteristics on vehicle utility. Principal components analysis was used to solve this problem (Mohammadian and Miller 2002a). As a result of the principal components analysis, two factors were identified that explain 89% of the total variance in the sample: vehicle performance (dominant variables include vehicle weight, engine displacement, and fuel intensity) and vehicle space (dominant variables include size, luggage capacity, and wheelbase). These two composite factors were used as two independent variables in the utility functions of the model.

The final sample used in the modeling effort of this study includes 597 automobiles for which all the required explanatory variables were available. Variables in the model were selected on the basis of prior experience with this type of model (Mohammadian and Miller 2003a, 2003b). The sample means and standard deviations for the explanatory variables used in this study are presented in Table 1.

MIXED LOGIT MODEL

Random utility–based discrete choice models have found their way into many disciplines. The multinomial logit model is the most popular form of discrete choice model in practical applications. It is based on several simplifying assumptions such as independent and identical Gumbel distribution (IID) of random components of the utilities and the absence of heteroscedasticity and autocorrelation in the model. It has been shown that these simplifying assumptions limit the ability of the model to represent the true structure of the choice process. Recent research has contributed to the development of closed-form models, which relax some of these assumptions to provide a more realistic representation of choice probabilities. Mixed logit (ML) and generalized extreme value (GEV) models are examples of these alternative structures, a detailed discussion of which may be found elsewhere (Bhat 2002).

The ML model was introduced by Ben-Akiva and Bolduc (1996) to bridge the gap between logit and probit models by combining the advantages of both techniques. A growing number of empirical studies implement the ML method, including those by Revelt and Train (1998), Bhat (1997, 2000), Brownstone et al. (2000), and Mohammadian and Miller (2003a). Consider the following utility function:

$$U_{int} = \alpha_{in} + \gamma_i W_n + \beta_{in} X_{int} + \varepsilon_{int} \tag{1}$$

where α_{in} is a constant term and captures an intrinsic preference of decision maker n for alternative i, $\gamma_i W_n$ captures the systematic preference heterogeneity as a function of sociodemographic characteristics, and X_{int} is the vector of attributes describing alternative i for decision maker n in the choice situation t. The vector of coefficients β_{in} is assumed to vary in the population, with probability density given by $f(\beta|\theta)$, where θ is a vector of the true parameters of the taste distribution. If the ε's are IID Type I extreme value, the probability that decision maker n chooses alternative i in a choice situation t is given by

$$P_{nt}(i \mid \beta_n) = \frac{\exp(\alpha_{in} + \gamma_i W_n + \beta_{in} X_{int} + \varepsilon_{int})}{\sum_{j \in C_{nt}} \exp(\alpha_{jn} + \gamma_j W_n + \beta_{jn} X_{jnt} + \varepsilon_{jnt})} \tag{2}$$

where C_{nt} is the choice set available to decision maker n in choice situation t, and j represents individual choices within choice set C_{nt}. The probability in Equation 2 is conditional on the distribution of β_{in}. A subset of all of α_{in} alternative-specific constants and the parameter β_{in} vector can be randomly distributed across decision makers. An important element of these random parameter models is the assumption regarding the distribution of each of the random coefficients. A more detailed treatment of preference heterogeneity may be found elsewhere (Bhat 2000).

Since actual tastes are not observed, the probability of observing a certain choice is determined as an integral of the appropriate probability formula over all possible values of β_n weighted by its density. Therefore, the unconditional probability of choosing alternative i for a randomly selected decision maker n is then the integral of the conditional multinomial choice probability over all possible values of β_n:

$$P_{nt}(i \mid \theta) = \int_{\beta} P_{nt}(i|\beta_n) f(\beta|\theta) d\beta \tag{3}$$

In general, the integral cannot be analytically calculated and must be simulated for estimation purposes. Since exact maximum likelihood estimation is not available, simulated maximum likelihood is to be used by

TABLE 1 Sample Mean and Standard Deviations for Explanatory Variables

	Male		Female	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Vehicle performance factor	4.96	0.84	4.93	0.82
Vehicle space factor	0.44	0.30	0.46	0.28
Vehicle purchase price (×$1000)	15.21	11.80	13.99	6.45
Vehicle ownership and operating cost (×$1000)	7.74	2.32	7.07	2.06
Vehicle is a used car	0.52	0.50	0.50	0.50
Household income (×$1000)	59.10	22.39	60.00	22.28
Driver age	43.30	13.94	40.55	13.69
Home owner	0.25	0.43	0.18	0.39
Driver is employed	0.73	0.44	0.67	0.47
Number of observations	350		247	

drawing pseudorandom realizations from the underlying error process. A detailed discussion of this method may be found elsewhere (Louviere et al. 2000; Bhat 2000).

Model Estimation

Decision makers (defined by survey respondents) in this study are faced with the decision of what class of automobile to purchase. The choice set contains six alternatives: subcompact, compact, midsize, full size, special purpose vehicle [sport utility vehicle (SUV) and pickup truck], and van (van and minivan). The data set extracted to develop this model contains 597 automobile class choice observations. It is assumed that all choices are available to all decision makers.

Variables representing automobile attributes and individual and household characteristics are used in utility functions. In ML models, heterogeneity can be accounted for by letting certain parameters of the utility function differ across decision makers. It has been shown that this formulation can significantly improve both the explanatory power of models and the precision of parameter estimates. Ben-Akiva and Bolduc (1996) and Bhat (2000) provide detailed discussions of the ML models and their estimation method.

In this study 1,000 repetitions are used to estimate the unconditional probability by simulation. This method will improve the accuracy of the simulation of individual log-likelihood functions and will reduce the simulation variance of the maximum simulated log-likelihood estimator. Two important aspects of modeling strategy that need to be considered before estimation of an ML model are the identification of parameters with and without heterogeneity and the assumption regarding the distribution of each of the random coefficients. These two aspects must be selected on the basis of prior information, theoretical considerations, or some other criteria. Random parameters in this study are estimated as normally distributed parameters in order to allow parameters to get both negative and positive values. Both observed attributes of the decision makers and alternatives (explanatory variables) and their unobserved attributes (alternative-specific constants) were introduced as random parameters.

Tables 2 and 3 show the results of the model for male and female decision makers in detail. These tables present statistically significant parameters and a good model fit—given the capability of the data set and model—especially since the focus of the work is to define gender differences in automobile choice behavior and to identify factors that define that difference, not how each individual selects the best alternative in a choice situation. In reviewing the results, one can observe consistency in the signs of coefficients across the models. Parameters of both models are statistically significant at the 95% confidence level or better. The signs of all utility parameters seem to be correct and unambiguous. Furthermore, estimated standard deviations of the random parameters of variables representing vehicle price, income, and alternative-specific constants are statistically significant in the model. The significant *t*-statistics for these standard deviations indicate that they are statistically different from zero, confirming that parameters indeed vary in the population. Results of the model estimation strongly imply that heterogeneity is a significant factor in the model developed here.

Discussion of Modeling Results

The vehicle performance factor has a significant positive coefficient in all utility functions of male decision makers. The vehicle performance factor is a composite factor representing physical and operational attributes of the vehicle, including weight, engine displacement, and fuel intensity. This finding conforms with the notion that male automobile owners prefer more power and performance in their vehicle. In the second model, the vehicle performance factor has a significant negative coefficient in all utilities, suggesting that female automobile consumers probably tend to prefer practicality and safety of the vehicle over its performance. This finding is probably due to disparities in women's injury and crash rates compared with those of men as well as their key responsibilities in the household and their concerns for children's welfare.

The vehicle space factor, another composite factor representing luggage capacity, wheelbase, size, and cargo features of the vehicle, has the expected significant negative coefficient for small-sized vehicles (subcompacts, compacts, and mid-sized cars) and a significant positive coefficient in the utility function of large-sized vehicles (vans and minivans) in both models. Furthermore, the value of the coefficient of the space factor for sedan-class vehicles in the model developed for female decision makers is greater than the value of the coefficient in the male model, which suggests that female automobile customers are more sensitive to space-related attributes of sedan-class vehicles. They seem to prefer better safety features and more storage and other room in their vehicles. This finding confirms the notion that women prefer practicality and safety, as discussed earlier. This difference can be attributed to differences in activity needs and travel behavior between the two genders, which require further analysis and can lead to the need to design different vehicles for men and women.

Modeling results suggest that both male and female decision makers are responsive to vehicle price. It is

TABLE 2 ML Model Estimation: Male Decision Makers

	Subcompact		Compact		Mid-Size		Full-Size		Special Purpose		Van	
Variable	Coeff.	*t*-Stat	Coeff.	*t*-Stat	Coeff.	*t*-Stat	Coeff.	*t*-Stat	Coeff.	*t*-Stat	Coeff.	*t*-Stat
Vehicle characteristics												
Performance factor	0.29	1.62	0.29	1.62	0.29	1.62	0.29	1.62	0.29	1.62	0.29	1.62
Space factor	–4.97	–8.06	–4.97	–8.06	–4.97	–8.06					4.74	4.25
Log (purchase price)	–0.85	–3.46	–0.75	–3.06			0.81	2.76	0.83	3.14		
Std. dev.	0.33	0.91	0.37	1.42			0.20	1.59	0.17	1.14		
Used car	–1.73	–4.45	–1.73	–4.45							–1.19	–2.70
Household attributes												
Log (income)							0.76	1.77			0.84	1.69
Std. dev.							0.29	1.15			0.37	1.79
Home owner					–0.68	–1.83			–0.82	–2.01		
Individual attributes												
Log (driver age)					1.32	2.40						
Driver employed					1.09	2.59	–0.92	–2.49				
Constants	4.15	1.89	3.74	1.71	–5.52	–1.83	–1.99	–0.86	0.73	0.34		
Std. dev.	2.53	1.08	0.95	1.24	1.12	1.62	0.62	1.67	0.22	0.99		
Number of observations			350									
Chi-squared			360.29									
Log-likelihood at convergence			–446.97									
Log-likelihood at constants			–623.62									
Log-likelihood—no coefficients			–627.12									
Log-likelihood ratio			0.27									

TABLE 3 ML Model Estimation: Female Decision Makers

	Subcompact		Compact		Mid-Size		Full-Size		Special Purpose		Van	
Variable	Coeff.	*t*-Stat	Coeff.	*t*-Stat	Coeff.	*t*-Stat	Coeff.	*t*-Stat	Coeff.	*t*-Stat	Coeff.	*t*-Stat
Vehicle characteristics												
Performance factor	–1.41	–4.81	–1.41	–4.81	–1.41	–4.81	–1.41	–4.81	–1.41	–4.81	–1.41	–4.81
Space factor	–6.95	–7.45	–6.95	–7.45	–6.95	–7.45					4.24	1.98
Log (purchase price)	–2.44	–5.29	–0.13	–2.01			1.94	2.24	1.52	2.15		
Std. dev.	1.01	1.33	0.09	1.26			1.79	2.32	1.16	1.60		
Used car	–0.97	–2.03			1.49	3.46			1.32	2.37		
Household attributes												
Log (income)			–0.49	–1.54							–1.07	–1.53
Std. dev.			0.47	1.51							0.66	1.43
Home owner					–0.89	–1.72			–1.29	–1.59		
Individual attributes												
Log (driver age)					1.54	2.80						
Driver employed									0.80	1.44		
Constants	–1.80	–0.58	–4.19	–1.39	–14.37	–3.96	–12.94	–3.90	–9.22	–2.67		
Std. dev.	0.90	1.44	1.36	1.18	2.83	2.12	2.14	1.48	1.62	1.08		
Number of observations			247									
Chi-squared			349.96									
Log-likelihood at convergence			–267.58									
Log-likelihood at constants			–408.59									
Log-likelihood—no coefficients			–442.56									
Log-likelihood ratio			0.38									

expected that the purchase price would present negative effects on the utility of the alternatives. This assumption is supported by negative significant coefficients for subcompact and compact vehicles in both models. However, modeling results suggest that both female and male automobile customers tend to consider the purchase price as a positive factor when they choose full-size or special purpose vehicles. This finding is somewhat as expected given the luxury and exclusive features often found in full-size vehicles and SUVs that make them more fashionable. The coefficient of vehicle purchase price has a larger magnitude in the women's model, suggesting that female decision makers are more sensitive to price than their male counterparts are. This finding confirms that disparities in the financial capacity of men and women could lead to different choices. This confirmation was somehow expected since women have lower labor-force participation, which can affect their access to credit or may influence their buying power. In order to account for heterogeneity, parameters of vehicle price are entered into the utility functions as random parameters with normal distribution. Modeling results confirm that standard deviations of these parameters are statistically different from zero, suggesting that the parameters vary in the population.

Used cars purchased by women drivers are less likely to be subcompacts and have a higher probability of being a mid-size or special purpose vehicle. Results presented in Table 2 also suggest that male car buyers are less likely to purchase a used subcompact, compact, or van.

With regard to individual-related characteristics, the variable for driver's age has significant positive coefficients in the utility functions of the mid-size alternative in both models. This finding suggests that older drivers are more likely to purchase mid-size automobiles. The magnitude and *t*-statistics of this parameter are more significant in the model developed for women drivers. Employment status was found to be important in both models. The utility of purchasing an SUV is higher for an employed woman. In contrast, male decision makers who are employed have a higher utility to purchase mid-size vehicles and are less likely to buy a full-size automobile.

Two additional factors related to household characteristics were also explored. Male car buyers from households with higher incomes are more likely to purchase vans and full-size vehicles. Female members of high-income households are less likely to purchase vehicles that are either vans or compacts. The household income variable was also introduced to both models as a random parameter variable with normal distribution. The standard deviations of income parameters were found to be significantly different from zero, suggesting that these parameters are in fact random. Both male and female decision makers who are members of households that own their homes are less likely to purchase mid-size and special-purpose vehicles. Model results suggest that female car buyers are more sensitive to this variable than their male counterparts are. Other household-level variables that may play an important role in automobile choice behavior include the presence of children and the household structure and lifestyle. Assessing the impacts of these variables on the structure of the model and explaining choice behavior remain as tasks for further research in this area.

Alternative-specific constants that account for unobserved attributes of the decision maker and alternatives were also introduced into the models as random parameters with normal distribution. This method will allow accounting for heterogeneity of unobserved attributes. The results of the simulation with 1,000 draws confirm the importance of parameter heterogeneity in all alternative-specific constant terms introduced to utility functions of both models.

Conclusions

This study presents the process of developing ML models to simulate vehicle class choice by male and female decision makers based on attributes of the alternatives and characteristics of the decision makers and their households. Models developed for male and female decision makers are compared on the basis of the sign and the value of their parameters as well as the value of mean and standard deviation of their random parameters. Interpretation of the effects of each explanatory variable in the model led to several interesting insights. These findings were consistent in models developed for both male and female decision makers, so it is clear that personality characteristics deserve further attention.

It is shown that gender difference is a significant factor in automobile type choice behavior. Female automobile consumers are found to prefer practicality over performance. They usually tend to prefer better safety features and more storage and other room in their vehicles, probably because of their responsibilities in the household and concerns for the children. At the same time, male decision makers tend to prefer more power and performance in their vehicles. It was also shown that female car buyers are more responsive to the price of automobiles than their male counterparts are, probably because of issues related to their buying power and access to credit. Several other factors explaining gender differences were also explored and discussed. A few other factors that were worth further examination were identified, including driver behavior, activity needs, presence of children, and household structure and lifestyle. Overall, what can be confidently concluded from this first attempt to explicitly account for gender-specific attributes is that such factors play an important role in the decision-making process and that these interactive effects are deserving of further attention in future analysis.

The results of the study presented here can facilitate addressing a range of social and planning issues. It is hoped that these results provide scientific evidence to policy makers for further direction. These models—given the capability and limitations of the data set and the models—can be used to examine various scenarios of technology design and policy analysis. Variations in vehicle technology, pricing, financing, and demographic assumptions are among the factors that can be explored. This study will lead to a better understanding of what mechanisms and programs should be designed to facilitate meeting long-term goals of equitable and sustainable transportation systems more effectively.

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Differences in Trip Chaining by Men and Women

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Men's and women's commuting behavior continues to be distinctly different. The difference may be most apparent in the tendency to trip-chain—that is, to link short stops in the trip to or from work. As more women entered the workforce and went from higher education to professional careers, it was widely assumed that aspects of women's and men's travel behavior would converge. However, research has found persistent gender differences in distance to work, mode of travel, and automobile occupancy and in the propensity to trip-chain. This study examines whether trends in trip-chaining behavior show convergence or the continued persistence of gender differences. Trends show that trip chaining during the commute increased from 1995 to 2001, and men's trip chaining increased nearly twice as much as women's. The growth in men's trip chaining is robust, but a large amount of that growth is for stops to get a meal or coffee on the way to work, called the Starbucks effect. Clarifying trends in the incidence of trip chaining and, more important, the details in terms of the direction, time of day, and purpose of the stops during commuting helps in the understanding of the persistence of gender roles in travel behavior. Such an understanding is vital to policy directives that aim to change travel behavior to ease congestion, reduce emissions, and save fuel.

Women's travel is distinctly different from that of men. Overall, working-age women make more trips but travel fewer miles and minutes than their male counterparts do. During their commutes, women make more short stops and stop for different reasons than men. In addition, the occupations and job locations of working women are different from those of men—women work closer to home than men, even within the same general occupation categories.

The focus of this study is to examine trends in trip chaining between men and women. Levinson and Kumar (1995) reported an increase in trip chaining. They related the increase to higher family incomes and less time as women entered the workforce and the fact that dual-career households buy services (such as daycare) that were formerly conducted in the home. McGuckin and Murakami (1999) determined that trip chaining was predominantly the domain of women rather than men in the household, even as women entered the workforce. Bianco and Lawson (1997) found specifically that the work trip was becoming more complex as workers incorporated personal, household, and child-care activities into their commutes. Likewise, Nishii et al. (1988) discovered that an important secondary role for the work trip was to provide an opportunity to link nonwork travel.

Few researchers have examined trends in trip-chaining behavior. Definitions of what constitutes an incidental stop between destinations such as home and work can complicate the comparisons between years or areas, or both. In this study, trends are derived from the 1995 Nationwide Personal Transportation Survey (NPTS) and the 2001 National Household Travel Survey (NHTS). Both data sets were processed by using the same definitions, which identify an incidental stop during the commute as one of 30 min or less. The similarities in survey design and the definition of variables allow comparison between the two years, although the short time frame between the surveys gives an indication of a direction rather than a trend. However, the findings suggest that there has been an increase in trip chaining during the weekday commute from 1995 to 2001.

From 1995 to 2001, women made more short stops on the way to or from work than did men to perform household-sustaining activities, such as shopping and family errands, and working women in two-worker families were twice as likely as men to pick up and drop off school-age children at school during their commute.

In the same period (1995 to 2001), men added more stops to their commutes for child care and household errands, especially men in families with young children. But a substantial part of the growth in men's trip chaining was to make a short stop for a meal or coffee on the way to work.

To the extent that trip chaining is a more efficient use of time and fuel, increasing such behavior is good. But what if the increase in trip chaining is for the kind of activities that were previously done at home, such as breakfast and coffee, but now are an added trip during the morning commute? If adding a trip changes the travel route or departure time, it complicates the forecasting of travel demand. Since adding a trip may add an engine start (or, for drive-through windows, idling time), such stops may not bode well for air quality.

Clarifying trends in the incidence of trip chaining and, more important, the details of trip-chaining behavior in terms of the direction, time of day, and purpose of the stops during commuting helps the understanding of the persistence of gender roles in travel behavior. Such an understanding is vital to policy directives that aim to change travel behavior to help ease congestion, reduce emissions, and save fuel.

Definition of Trip Chaining

The NHTS, like most household travel surveys, collects travel information about trips—movement from one address to another. In this way, every movement by any mode for any distance is reported for all respondents.

A trip chain is a sequence of trips linked together between two anchor destinations, such as home and work. Economists, geographers, and transportation planners have recognized trip-chaining behavior since the 1960s, but even then the conceptualization of a trip chain was easier to agree on than the definition (Thill and Thomas 1987).

Today there is still no formal agreement on the definition of a chained trip, and little empirical research has been published on the incidence of or trends in trip-chaining behavior within comparable travel markets or with comparable data for the same market. Different terms and expectations exist as to what types of trips should be considered as part of a chain—only trips for certain purposes (e.g., dropping off a passenger) or only trips with certain dwell times (e.g., 15 min or less). Some of the earlier national research used no time or purpose constraints at all (Strathman and Dueker 1995; McGuckin and Murakami 1999), so direct comparison with that earlier work is difficult.

Trip chaining may be difficult to define, but this common behavior complicates the understanding of commuting. As in the example in Figure 1, persons can make a total of four separate trips but two chained trips during their commute—from home to a coffee shop to work and then from work to a daycare center and then home. If these are considered separate trips, the trip from home to the coffee shop would not normally be seen as part of the commute. But linked together with the next trip, from the coffee shop to work, it can be seen as part of the chain of trips from home to work.

Stops made during a commute may be regular daily activities, weekly scheduled activities, or infrequent and unscheduled. The stops may take the traveler well out of his or her way or be close to home or work. Since the NPTS-NHTS data series obtains travel for a sample day, the frequency of stops during an individual worker's weekly commute is not known. Destinations in the national data sets are not geocoded to latitude and longitude, so the proximity to home and work is also not known.

However, using a common definition (trip chains include stops of 30 min or less) allows analysis of the change in incidence and purpose of short stops during the commute from 1995 to 2001. The analysis presented here describes the trends in trip chaining with this definition.

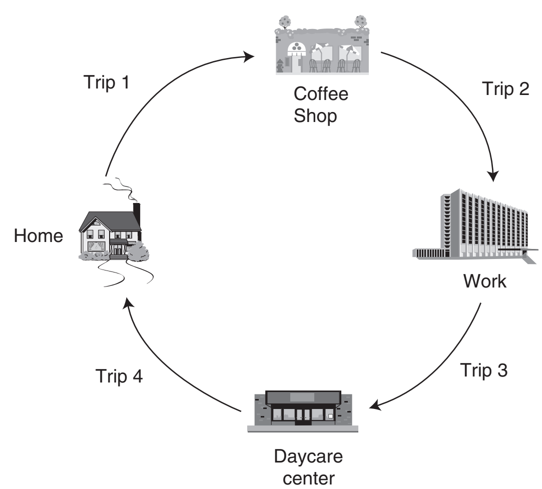

FIGURE 1 Example of four trips and two trip chains.

DIFFERENCES IN WORK LOCATION AND OCCUPATION

During the last several decades, women have increased their driving and have their own vehicles, better education, and professional careers, and as a result women's travel has grown immensely and the nature of their travel has radically changed. These changes have had a permanent effect on travel behavior analysis and transportation planning and policy.

Working women make more trips than working men (110 more trips per year), but the trips are shorter on average. The largest differences are found in households with small children, in which women make 5.2 trips to men's 4.7 but travel on average 12 fewer miles a day (Table 1).

One of the reasons for the difference in travel miles is that women have traditionally held jobs closer to home than men did. In 2001, women reported working about 11 mi from home compared with 15 mi for men. Wachs (1998) notes that although women have moved into the labor force, they are overrepresented in what is called the secondary work force, consisting of part-time and seasonal workers. The NHTS shows that women are twice as likely to be part-time workers (12% of women but only 6% of men work part time).

Second, Wachs says that women are concentrated in occupations such as clerical and sales work. These positions pay lower wages, and it is argued that women do not search for jobs farther away because they gain no wage advantage in these traditional occupations.

Third, Wachs argues that women may work closer to home because the suburbanization of service and retail activity has resulted in more even distribution of women's jobs than of the professional and technical jobs typically held by men. Spain (1999) asserts that the jobs in which women are concentrated (teaching, clerical work, and nursing) differ in that they are closer to home and require less travel.

Figure 2 shows the distance to work measured as the crow flies [the great circle distance (GCD)]. These data demonstrate that even within the same general occupational category, women choose jobs closer to home. Women in professional, managerial, and technical jobs work, on average, 2.6 mi closer to home than do men in the same occupations (9.9 mi versus 12.5 mi). Because these occupational categories are large and inclusive, it would be interesting to analyze differences in distance to work from an establishment or workplace survey to see if directly comparable occupations in the same location showed the same differences in trip length to work.

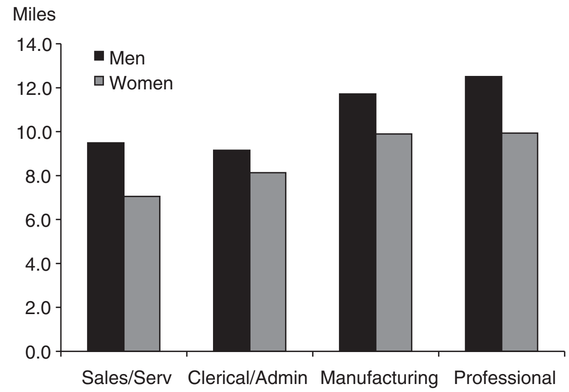

FIGURE 2 Distance to work (GCD) by occupational category.

Another explanation offered in the literature focuses on family commitments (child and elder care). For example, Gordon et al. (1989) postulate that women may work closer to home to minimize their work-related travel time and maximize the time they have for non-work-related trips and activities.

Single women work closer to home than do single men, but the difference in distance to work becomes more pronounced in two-adult families with children. Some evidence of the amount of time women spend in household-sustaining activities comes from the recent American Time Use Survey (Bureau of Labor Statistics 2003). The 2003 results show that employed adult women (18 and over) spend about an hour more per day than employed adult men doing household activities and caring for household members. Twenty percent of men reported doing housework on the survey day compared with 55% of women, and 35% of men did food preparation or cleanup compared with 66% of women.

TABLE 1 Miles and Minutes of Travel per Day for Men and Women Workers, 2001

		Trips/Day	Miles/Day	Minutes/Day
Men	No child	4.6	62	103
	Small child (<6 years)	4.7	58	104
	Middle child (6–15 years)	4.8	63	105
	Teen child (16–21 years)	4.8	52	98
Women	No child	4.7	50	94
	Small child (<6 years)	5.2	46	90
	Middle child (6–15 years)	5.4	47	93
	Teen child (16–21 years)	5.0	45	90

Trends in Men's and Women's Trip Chaining

Almost 2 million more workers stopped during their commutes in 2001 compared with 1995—overall, 9% more workers trip-chained during their commute. This statistic compares with an 8% growth in civilian employment in the same time period, according to the U.S. census.

Men's and women's stops both increased, especially in the home-to-work direction, but for men the increase was dramatic: 24% more men stopped during their home-to-work commute in 2001 than in 1995 (Table 2).

The typical demographic variables used to forecast travel demand (e.g., age, income, and geography) did little to explain differences in trip-chaining behavior as found by Cao and Mokhtarian (2004) and by Li et al. (2004). Especially disappointing was the failure of the geographic variables available in the NHTS to show descriptive differences. Instead, the starkest differences in trip-chaining behavior, such as the number and purpose of stops, were related to life cycle, especially combined with sex and the presence of children.

Twenty percent of men in families with two adults and small children trip-chained, more than any other group of men, and the change since 1995 is noteworthy (see Figure 3). Men in households with teenaged children or no children also showed increases in trip-chaining behavior.

More than 40% of the women in two-adult households with small children chained nonwork trips into their commutes, a percentage that grew little between 1995 and 2001 (see Figure 3). However, as with men, women who have teenaged children in the household or those with no children increased their trip chaining.

The proportion of men and women stopping during their commutes to or from work varied within race and ethnicity, as shown in Figure 4. Hispanic men are the least likely to report stopping for any purpose during their commutes, whereas Hispanic women were almost as likely as whites and African-Americans to trip-chain. African-American workers, women in particular, are more likely to stop during their commutes than any other group.

Reasons for Stops During Commute

The most common purposes for stops in the commute to work are to drop off or pick up a passenger, to do family or personal errands, or to buy a meal or coffee. However, the most common stops after work are to shop, serve a passenger, or run family errands.

TABLE 2 Percentage Change in Number of Workers Who Trip-Chained in 1995 and 2001

		1995	2001	% Change 1995–2001
Chain home–work	Men	4,378,082	5,441,096	24.3%
	Women	6,060,274	6,553,425	8.1%
Chain work–home	Men	5,942,466	6,076,712	2.3%
	Women	6,471,233	6,767,123	4.6%

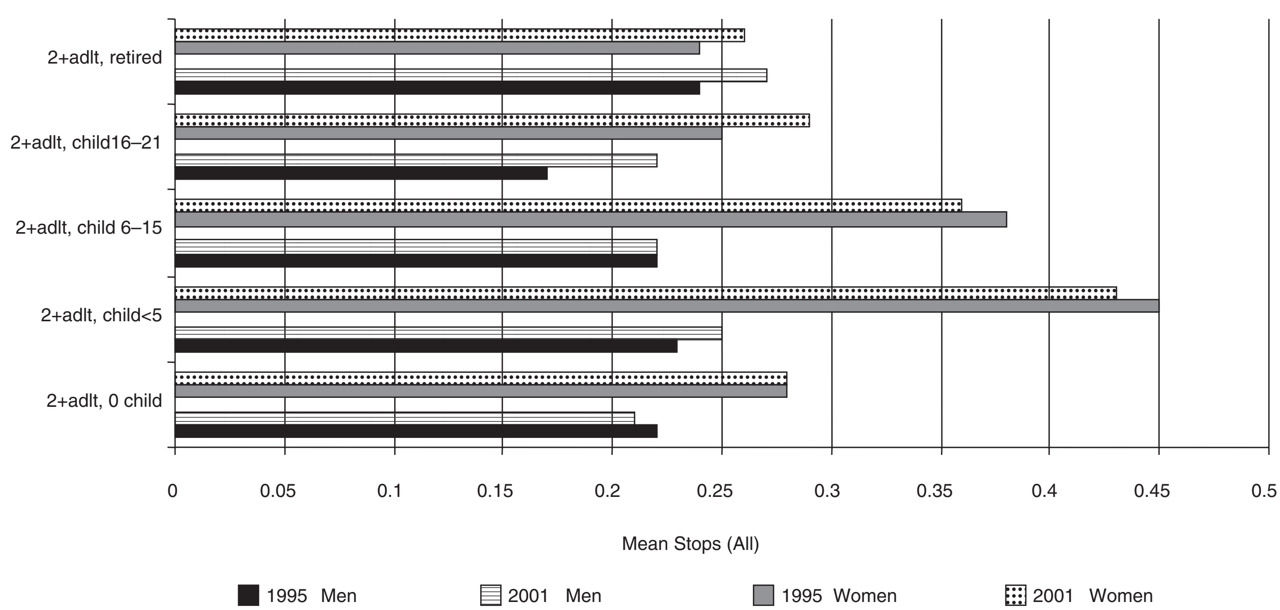

FIGURE 3 Mean number of stops by life cycle.

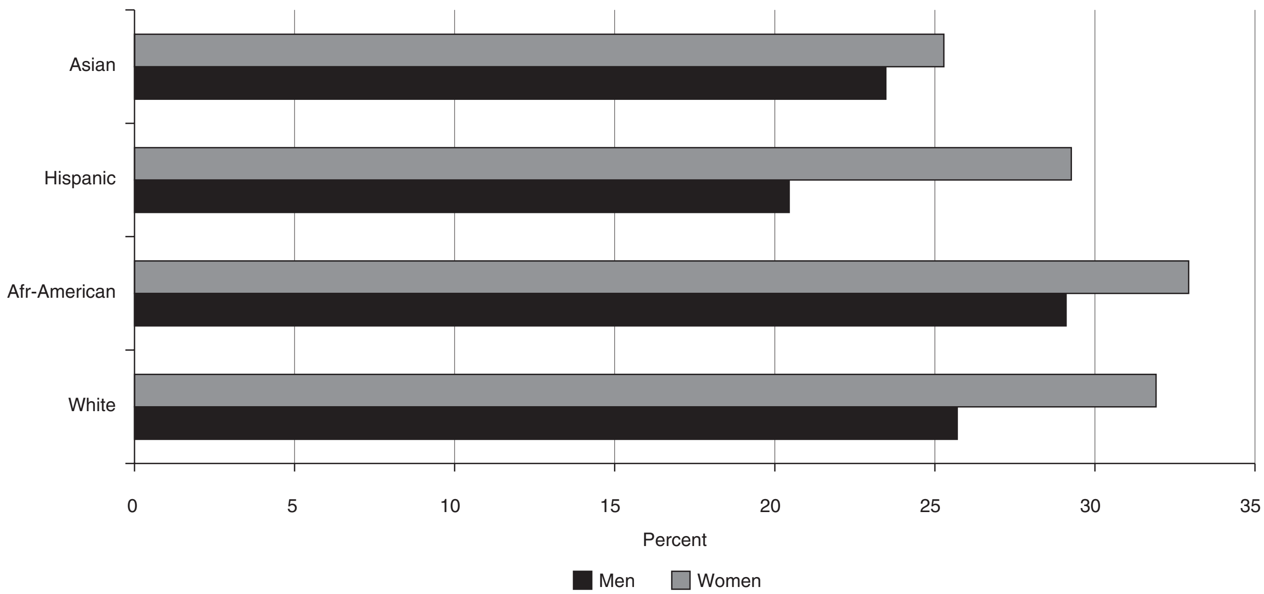

FIGURE 4 Percentage of workers who made stops during commuting.

Dropping off and picking up a passenger are common stops in both directions. Of all the multioccupant vehicle trips to and from work, three-fourths were "fam-pools" (all occupants were from the same household) and women drove 60% of those. Of the remaining fourth of carpools with nonhousehold members, men drove 64%.

Many of the passengers in fam-pools are children being dropped at daycare or school or other activities by parents. This discovery is compatible with the finding by Lee and Hickman (2004) that the presence of children in households positively affects the duration of out-of-home activities. The recently released American Time Use Survey (Bureau of Labor Statistics 2003) indicates that the average woman in the United States spends 84 h a year picking up and dropping off household children (in the American Time Use Survey all women are averaged, not just families with children).

To understand this common type of stop during the commute, serve-passenger trips to drop off or pick up children (less than 14 years old) were examined further. According to the 2001 NHTS, more than 7 million families with two working parents drop off or pick up their children (less than 14 years old) during a weekday commute. In total, 2.7 million men and 4.3 million women insert a drop-off or pickup trip (or both) into their work trip.

When two working parents commute to work, twice as many trips to drop off or pick up a child are made by women (66% compared with 34% for men). Eighty percent of the drop-off trips occur before 9:00 a.m. on weekdays, but perhaps because of "after-care" and after-school activities, the pickup trips are not so clustered.

Another common reason to stop during a commute is to shop and conduct family errands, especially on the way home from work, and Figure 5 shows that women make more of these stops than men.

There is dramatic variation by race or ethnicity in the trends for stopping to shop during the work-to-home commute, as shown in Figure 6. Between 1995 and 2001, the number of shopping stops by Hispanic commuters increased more than 20%, whereas the number of stops to shop by African-American commuters declined by 12%.

As the research presented here has shown, men have increased their incidence of trip chaining, and the types of trips that women traditionally insert into their commutes, such as serving a passenger, running errands, and shopping, have increased modestly.

One trend is intriguing and accounts for a surprising amount of the growth in men's trip chaining: the increase in the number of stops to get a meal or coffee on the way to work, as shown in Figure 7. In just a 6-year span, more than 1.5 million more stops were added to get a meal or coffee (1995 to 2001). There was a large increase in the number of such trips by both women and men workers, but especially by men. This effect is called the "Starbucks effect."

Conclusions and Further Research

The analysis presented here relied on a definition of a trip chain as a sequence of trips bounded by stops of 30 min or less. This operational definition facilitates a rich

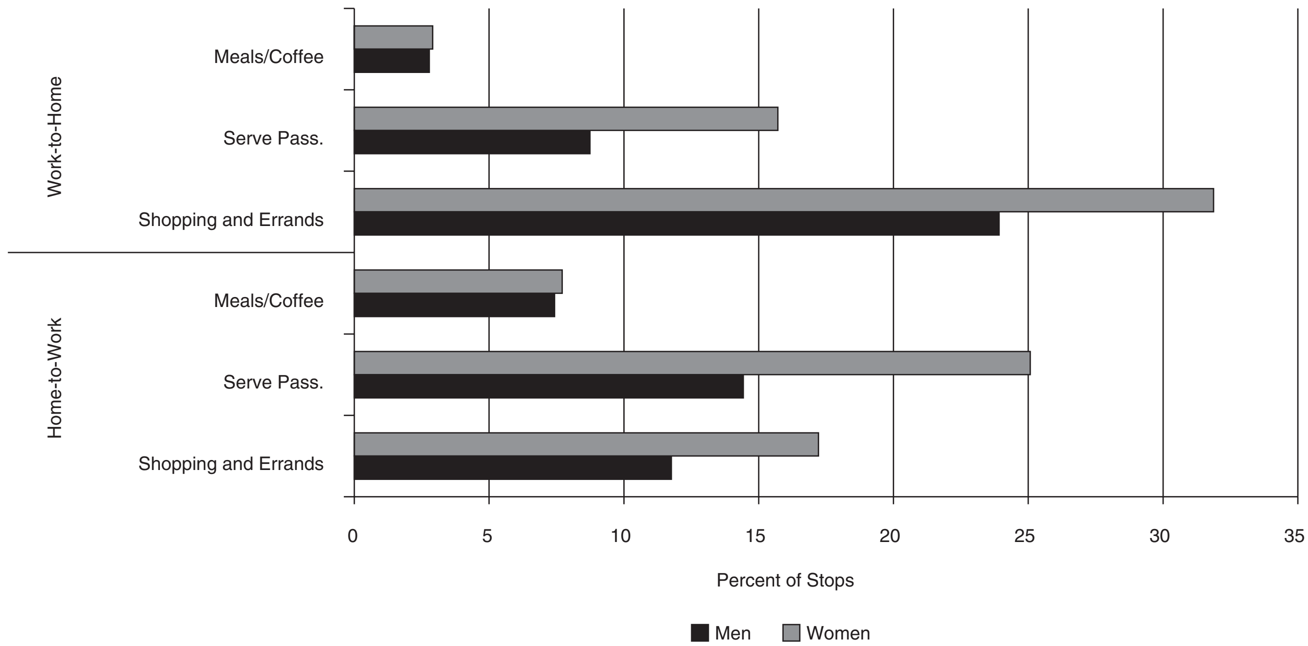

FIGURE 5 Percentage of stops by men and women by selected purpose.

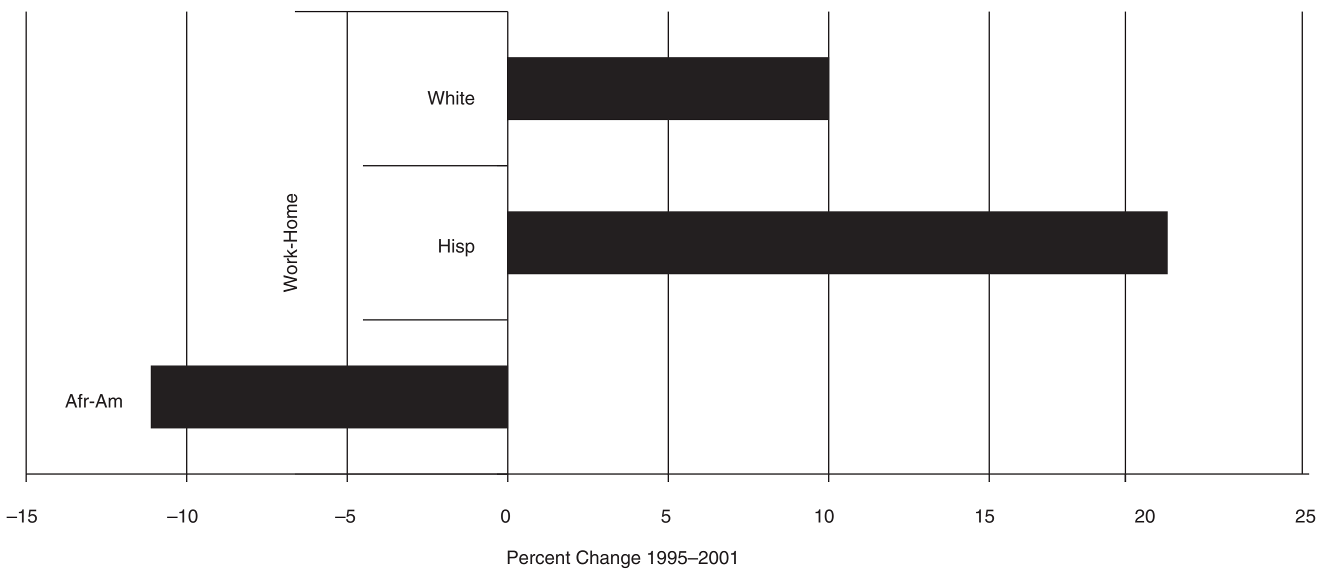

FIGURE 6 Percentage change in stops for shopping by race and ethnicity, 1995–2001.

analysis of trip-chaining behavior, and thus the authors invite other travel researchers to use it. The chained files for the 1995 NPTS and the 2001 NHTS are publicly available for researchers and analysts on the NHTS website (nhts.ornl.gov/2001/index.shtml).

An important finding is that the presence of children continues to affect women's travel patterns more than men's. Overall, women work closer to home than men, even within the same occupational categories. This characteristic is especially marked when young children are present in the household.

Women are twice as likely as men to drop off or pick up children in two-worker households. Further, such trips are highly constrained within the morning and evening peaks. This finding suggests that women may have less flexibility in departure time than men since school and daycare start and end times may influence the commute times of women workers more than those of men.

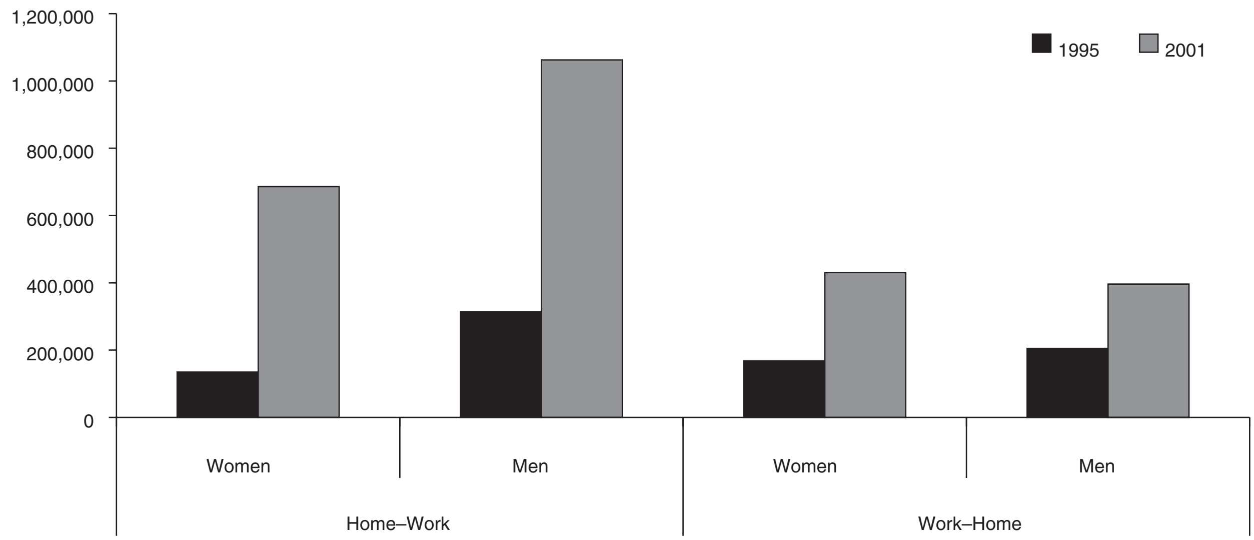

FIGURE 7 Number of stops to get meals or coffee, 1995–2001.

The evidence continues that travel is a gender-related activity. The household and child-care responsibilities of women make it likely that women will chain some of those tasks into the commute.

One surprising finding from the trends shown here is that in-home activities, such as cooking meals, are being replaced with activities requiring travel—picking up a meal. This finding is true even for a cup of coffee in the morning, no longer brewed at home but purchased at the local coffee shop on the way to work.

Many researchers expected an effect on travel linked to the growth of the Internet, and congestion relief from telecommuting continues to be sought, but the apparent substitution of travel for what was traditionally an in-home activity (breakfast and coffee) needs further study.

One of the biggest questions for the future is how household dynamics, social roles and expectations, and perhaps market and lifestyle changes will affect the travel behavior of both men and women.

Although women have made great strides and accomplishments in the last quarter-century, change in societal expectations is slow. Differences in travel related to gender roles persisted over the short time frame studied, although there are indications that men in households with small children have increased their trip chaining for household- and child-related purposes. Perhaps there is a cohort effect in the coming generation.

More research is needed. Especially interesting questions have been raised on the effect of geographic factors and commuting distance on the probability of trip chaining. Nishii et al. (1988) also raised the importance of incorporating more information about the travel environment into the analysis of trip chaining. The clear next step is analysis with a geographic component.

In addition to these questions about the conditions of the travel environment that encourage or discourage trip chaining, further research into the conditions of the traveler, specifically looking at demographic factors as this study looked at gender and life cycle, would be useful.

Data Used in This Research

An NHTS has been conducted by the U.S. Department of Transportation periodically since 1969 to obtain an inventory of daily travel for the nation. Details about the survey methods, questions, and weighting can be found at nhts.ornl.gov/2001/index.shtml.

Most important for trend analysis, the 2001 NHTS and the 1995 NPTS were processed simultaneously with the same rules and logic streams to develop the trip chains analyzed in this research. Changes in trip-chaining behavior found during comparison of the 1995 NPTS and the 2001 NHTS, when statistically significant, are not artifacts of differences in scope, methodology, or question wording.

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Transportation, Access, and Community Design

Gender as a Determinant of Car Use
Evidence from Germany

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The determinants of car use in Germany are explored by analyzing a panel survey of travel diary data collected between 1994 and 2001. The analysis is conducted against the backdrop of two questions: Do women have more constrained access to cars than men, and if so, how is this constrained access mitigated or exacerbated by other determinants of car use such as community design, socioeconomic circumstances, and the demographic composition of the household? A cross-cutting issue is whether the existence of gender discrepancies in car use reflects the outcome of objective reasoning or of patriarchal constraints. Answers to these questions are pursued by estimating a probit choice model of the determinants of car utilization on weekdays. Although it is found that women are characterized by a lower likelihood of car use than are men, the magnitude of the discrepancy is influenced by several intervening variables including age, number of children, and time spent in out-of-household activities. The presence of children, in particular, is found to play a significant role in reducing disparities between men and women with respect to car use, whereas urban form variables generally play an insignificant role. It is concluded that although car use decisions may be made on the basis of objective reasoning, this reasoning often emerges from patriarchal constraints that dictate traditional gender roles.

The determinants of motor vehicle use are significant to a range of themes that have relevance for the study of mobility behavior. Private cars not only contribute to air and noise pollution but are also major sources of congestion and injuries and fatalities on the public roadways. The behaviors that give rise to these negative external effects emerge largely from decision making undertaken at the household level, including choices pertaining to the allocation of both household resources and responsibilities among individual members. These choices, in turn, give rise to in-home and out-of-home activity patterns, from which the demand for travel by various modes is derived. In Germany, as elsewhere in the industrialized world, the demand for motor vehicle travel is of particular interest because of its strong growth in the years following Germany's reunification, with the number of newly registered vehicles increasing by 15.2% between 1995 and 2003 (*1*). Understanding the preferences and constraints underlying such trends can be useful in several policy applications, including assessments of the provision of public transport infrastructure, forecasting of trends in air pollution, and the evaluation of zoning and other land use measures.

One important area of research has focused on the role of gender in car use decisions. An often-cited observation emerging from this work is that although women tend to have more complicated activity patterns and make more serve-passenger trips than men, they have unequal access to the car and conduct more of their travel by public transportation or on foot (*2–9*). Consensus on female subordination in car access, however, is far from universal, and empirical evidence varies widely over both time and space. For example, whereas Hanson and Johnston (*6*) point to a survey in Baltimore showing that women are far more reliant on public transportation for commuting, Gordon et al. (*10*) find little difference between men and women in private automobile and public transport use. They point to statistics from the 1983 Nationwide Personal Transportation Survey (NPTS) showing that the proportion of women who drive to work (62.2%) in the United States is slightly higher than that of men (61.7%). Likewise, Rosenbloom (*11*) presents statistics from the 1990 Public Use Microdata Sample (PUMS) indicating that 89.5% of all women's trips are by car compared with 89.1% for men, with both groups having increased car usage substantially over the previous decade. A more recent survey from the United Kingdom notes that despite a strong growth in license holding among women, men undertake on average 15% more car trips as the driver than women do (*12*). In another U.K. study, Dargay and Hanly (*13*) find no significant effect of gender in a probit model of the likelihood of using the car as a commute mode.

Regarding German mobility behavior, Preissner et al. (*8*) analyze data from 1991 to conclude that women are often "captive riders" of public transport, noting that only 55.6% of them are licensed drivers compared with 84.1% of men. Nevertheless, the authors concur with Buhr (*14*), who stresses the role of the car in helping women to manage both household and family duties, that motorization of women will catch up in the future. Heine et al. (*9*) found in their qualitative study of German families that children are the most important factor in increasing women's car use. In addition to women's using the car for shopping and escorting duties, the necessity of car access is explained by security aspects of caring for the child in the case of emergencies.

On the whole, the literature presents a mixed picture of the nature and sources of disparities in car use between women and men. Moreover, the existing body of evidence provides little insight into whether differences in car reliance are primarily a function of access or of other factors such as preferences. Although it is true that the question of access has been addressed at the household level in analyses of car ownership, few studies have addressed the issue of access at the intrahousehold level among households that own cars. In such situations, Pickup (*15*) suggests that car use decisions are generally not made on the basis of objective reasoning (i.e., as would be characterized by a logical assessment of mobility needs) but rather that the "general pattern is for husbands to have first choice of car-use, usually for commuting, and for wives to rely on public transport or receiving lifts to meet travel needs." Gordon et al. (*10*) take the opposite view, rejecting the notion that "patriarchal constraints"—as rooted in traditional gender roles—determine car access. Rather, they suggest that the diffusion of automobile ownership has been a strong equalizing force in the United States. A strong empirical case for either argument, however, is difficult to produce given the complex confluence of individual preferences, household power relations, and external socioeconomic and geographical factors that jointly determine mode choice decisions.

The issue of access among households that own cars is addressed here by employing an econometric analysis of car use from a panel of travel diary data collected in Germany between 1994 and 2001. The analysis is conducted against the backdrop of the following two questions: Do women have more constrained access to the car than men, and if so, how is this constrained access mitigated or exacerbated by other determinants of car use such as socioeconomic circumstance and the demographic composition of the household? A cross-cutting issue is whether the existence of gender discrepancies in car use reflects the outcome of objective reasoning or of patriarchal constraints. The answers to these questions are pursued by estimating a probit choice model of the determinants of car utilization on weekdays.

Data

The primary data source used in this research is drawn from the German Mobility Panel (MOP), a representative multiyear travel survey financed by the German Federal Ministry of Transport, Building and Housing. The survey, which is ongoing, was initiated in 1994 and includes a total of roughly 7,000 households. In its initial years, from 1994 to 1998, the MOP focused exclusively on the former West German states, but in 1999 its scope was broadened to include the new federal states.

The panel is organized in overlapping waves, each including a group of households surveyed for a period of 1 week for three consecutive years. Households that participate in the survey are requested to fill out a questionnaire eliciting general household information and person-related characteristics. In addition, all relevant aspects of everyday travel behavior are recorded, including distances traveled, modes used, activities undertaken, and activity durations. Despite the high demands made on the survey respondents, the average attrition rate is relatively low, about 30%. As a consequence, the sample size for a given year includes about 750 households (*16*). The data used here are from the first six waves of the panel, spanning a total of 8 years, from 1994 to 2001.

The analysis here focuses exclusively on those households that owned at least one car, roughly 85% of the sample. The analysis is further limited to household members who are at least 18 years old and who possess a driver's license. Finally, since one of the explanatory variables of interest in the study is employment status, weekends were excluded from the sample. The resulting sample size is 2,620 individuals—observed over the 5 days of the work week and the 3 years of the survey—from 1,493 households. Overall, 28,059 individual person-day observations of both workers and nonworkers are included in the sample on which the model is estimated.

With the exception of a few neighborhood descriptors obtained from the respondents themselves, the MOP lacks sufficiently detailed geospatial information to derive measures of community attributes. Moreover, the MOP includes no direct measures of household-level income. To redress these features, the data were augmented with additional information obtained from Infas GEOdaten GmbH and NavTeq, two commercial data providers. The Infas data are from 2001 and are measured at the level of the zip code, the median size of which is roughly 27 km^2. Two variables are used in the current analysis from this data set: average household income and population density of the zip code. The second data source, NavTeq, is a vector layer of the road network in Germany from 2003. With this layer, an algorithm was written to calculate the total length of paved roads in each zip code, from which density measures of roads per square kilometer could be calculated.

Empirical Specification and Methodological Issues

In the data used, roughly 28% of the individuals who possess a license and live in a car-owning household do not use the car on a given day, of which 59% are women. To assess the determinants of this pattern, a structural model describing the probability of car use is specified:

$$y_i^* = \beta' x_i + \varepsilon_i \qquad (1)$$

where

x = vector of explanatory variables,
ε = error term,
β = vector of estimated coefficients, and
i = observation.

The variable y_i^* measures the utility associated with car use and is therefore unobservable. However, the outcome of whether the car is used is observed. This outcome can be denoted by the dichotomous variable y_i, whereby

$$y_i = \begin{cases} 1 \text{ if } y_i^* > 0 \\ 0 \text{ otherwise} \end{cases} \qquad (2)$$

In the current analysis, y_i equals 1 for individuals who use the car as a driver and zero for nonusers or passengers. Returning to Equation 1, if the error term is assumed to have a normal distribution, the parameters β can be estimated by using the probit maximum-likelihood method, expressed as follows:

$$P(y_i = 1) = \Phi(\beta' x) \qquad (3)$$

where Φ is the standard normal distribution (*17*). Given the panel nature of the data set, the model can either be estimated as a random effects probit, in which case the correlations between successive error terms for the same individual are restricted to be constant, or as a pooled probit, which involves simply pooling the data and ignoring the correlation structure. The current analysis employs the latter approach. This approach not only eased the computational burden associated with the implementation of a simulation exercise and the calculation of marginal effects (both discussed later) but also ensured the estimation of consistent parameter estimates under the standard assumption of zero correlation between the individual effects and the regressors (*18*). The primary cost in pooling the data is a loss in efficiency relative to the random effects model, but this cost was of small concern given the large sample size.

The explanatory variables x included in the model, the selection of which was guided by a review of the literature, can be conceptually grouped into four broad categories: individual attributes, household socioeconomic characteristics, community characteristics, and activity pattern indicators. The values for all variables other than those measured at the zip-code level are self-reported; descriptive statistics and definitions are presented in Table 1.

In addition to the variables in Table 1, the model includes binary variables indicating the year, to control for autonomous shifts in macroeconomic conditions that could affect the sample as a whole. A model with dummy variables was also estimated for each day of the week, but it was found that these variables were statistically insignificant and hence they were not included in the model. To correct for nonindependence emerging from the repeated observations of individuals during the course of the week over each of the 3 years of the survey, the model is specified to account for clustering on the individual. The presented measures of statistical significance are thus robust to the appearance of individuals over multiple time points in the data, though it is noted that this feature of the model has no effect on the magnitude of the coefficient estimates.

Finally, the model includes squared terms to allow for nonlinearities as well as interaction terms to test for differential effects of gender according to individual, household-level, and community attributes. Although several specifications with interaction and squared

TABLE 1 Definitions and Descriptive Statistics of Variables Used in Model

Variable	Definition	Mean	Standard Deviation
female	1 if female, 0 otherwise	0.481	0.500
ed	Education of respondent (1–4, 1 = grade school; 4 = college degree)	2.886	0.936
age	Age of respondent	47.808	15.072
parttime	1 if part-time employed, 0 otherwise	0.157	0.364
fulltime	1 if full-time employed, 0 otherwise	0.432	0.495
kids	Number of children in household	0.548	0.895
adults	Number of adults in household	2.192	0.770
numlic	Number of driver's license holders in household	1.924	0.685
numemply	Number of employed household members	1.180	0.867
carhh	Number of cars owned by household	1.489	0.666
popdens	Population density of zip code in 1000s per km^2	1.371	2.126
pcinc	Per capita income of zip code in 1000s of euros	16.750	3.936
walktime	Walking time to nearest public transport	5.538	4.411
center	1 if household located in an urban center	0.274	0.446
strdens	Street density of zip code in kilometers per sq kilometer	11.537	6.869
strpark	1 if street parking at residence, 0 otherwise	0.103	0.304
diswork	Distance to work in kilometers	8.246	14.645
totstop	Total number of trips made during the day	2.441	1.547
maintenance	Total hours spent in out-of-home maintenance activities (e.g., shopping)	0.719	1.170
leisure	Total hours spent in leisure away from home	1.034	1.769
work	Total hours spent in work away from home	3.976	4.158

terms were tested, the final specification presented includes only those that were statistically significant or that contributed to the overall fit of the model.

Because of the nonlinearity of the probit model, some care must be taken with regard to the interpretation of the interaction terms. As Ai and Norton (*19*) show, the interaction effect for two variables in nonlinear models requires computing the cross-derivative $[\partial^2\Phi(\beta'x)/\partial x_1\partial x_2]$, whereas the standard output from most computer software gives the marginal effect, equal to $[\partial\Phi(\beta'x)/\partial(x_1x_2)]$. Computation of the marginal effect is shown to often result in false inferences with respect to both the sign and significance of the interaction term. The authors have written a program for calculating the cross-derivative, adapted in the current study, that uses the delta method (*19, 20*). The program only works for the interaction between two variables that do not have higher-order terms. Hence, a separate program using the Stata software was written for this study to calculate the interaction of the variables involving quadratic terms (the program is available from the authors upon request).

To further facilitate interpretation of the interaction effects, predicted probabilities and associated 95% confidence intervals were plotted over a range of values for particular variables of interest. The predicted values are generated on the basis of statistical simulations by using a method and programming code developed by King et al. (*21*) and Tomz et al. (*22*). The programming code, called CLARIFY, employs a sampling procedure akin to Monte Carlo simulation in which *m*-values of each estimated parameter are drawn from a multivariate normal distribution. By taking the vector of coefficient estimates from the model as the mean of the distribution and the variance-covariance matrix as the variance, the program uses the simulated parameter estimates to generate predicted values, first differences, and the associated degree of uncertainty around these and other quantities of interest.

RESULTS

Table 2 shows the results from the probit analysis of the determinants of car use. Two models are presented. Model II is distinguished from Model I by its inclusion of only those interactions found to be statistically significant. Discussion of the results focuses primarily on the former, more parsimonious specification, though comparisons with the latter are occasionally drawn when of interest. Columns 2 and 4 contain the coefficient estimates of the two models, and Columns 3 and 5 contain transformed coefficients showing the marginal change in probability from a unit change in an independent variable.

Most of the variables are statistically significant and have signs that are consistent with intuition. With respect to the respondent attributes, education has a negative and highly significant effect on the probability of car use, a possible reflection of more pronounced environmental consciousness among the more highly educated. The indicator for part-time employment status, "parttime," increases the probability of car use by 0.06 in Model II but interestingly that for full-time employment is not significant. This result may be due to the fact that part-time employed workers, unlike their full-time and nonemployed counterparts, have schedules that require greater flexibility in their mobility behavior. The nonsignificance of the interaction terms in Model I suggests no differences in the effect of employment status by gender. Age, which is specified as a quadratic, has a significant and nonlinear effect on the

TABLE 2 Probit Model of Determinants of Automobile Use (*n* = 28,059)

	Model I		Model II	
Variable	Coefficient Estimate	Marginal Effect	Coefficient Estimate	Marginal Effect
female	–0.2141 (0.2770)	–0.0663	–0.2966 (0.0780)	–0.0918
ed	–0.0544 (0.0060)	–0.0168	–0.0541 (0.0060)	–0.0167
age	0.0311 (0.0000)	0.0096	0.0312 (0.0000)	0.0096
agesq	–0.0003 (0.0000)	–0.0002 (0.0008)	–0.0003 (0.0000)	–0.0002 (0.0000)
female*age	–0.0053 (0.0710)	–0.0015 (0.1079)	–0.0048 (0.0970)	–0.0014 (0.1317)
parttime	0.3377 (0.0280)	0.0952	0.2066 (0.0040)	0.0605
fempart	–0.1531 (0.3290)	–0.0311 (0.4164)		
fulltime	0.0974 (0.2610)	0.0299	0.0596 (0.4100)	0.0184
female*full	–0.0675 (0.5280)	–0.0169 (0.5752)		
kids	–0.0383 (0.2520)	–0.0118	–0.0390 (0.2390)	–0.0121
female*kids	0.1373 (0.0040)	0.0396 (0.0038)	0.1397 (0.0030)	0.0404 (0.0032)
adults	–0.1980 (0.0000)	–0.0612	–0.1981 (0.0000)	–0.0612
numlic	–0.2704 (0.0000)	–0.0835	–0.2703 (0.0000)	–0.0835
numemply	–0.0582 (0.1580)	–0.0180	–0.0569 (0.1670)	–0.0176
carhh	0.7268 (0.0000)	0.2245	0.7263 (0.0000)	0.2244
popdens	–0.0614 (0.0000)	–0.0190	–0.0614 (0.0000)	–0.0190
pcinc	–0.0091 (0.1000)	–0.0028	–0.0092 (0.0930)	–0.0029
walktime	0.0056 (0.3310)	0.0017	0.0068 (0.0900)	0.0021
female*walktime	0.0026 (0.7480)	0.0009 (0.7058)		
center	–0.0265 (0.7280)	–0.0082	–0.0456 (0.4090)	–0.0142
female*center	–0.0369 (0.7250)	–0.0116 (0.7041)		
strdens	0.0048 (0.3630)	0.0015	0.0037 (0.3930)	0.0011
female*strdens	–0.0023 (0.7370)	–0.0004 (0.8089)		
strpark	–0.0534 (0.5450)	–0.0167	–0.0872 (0.1540)	–0.0276
female*strpark	–0.0599 (0.6020)	–0.0311 (0.4164)		
diswork	0.0228 (0.0000)	0.0070	0.0224 (0.0000)	0.0069
disworksq	–0.0001 (0.0000)	–0.0001 (0.0005)	–0.0001 (0.0000)	–0.0001 (0.0001)
female*workdis	–0.0009 (0.8120)	–0.0003		
totstop	0.3956 (0.0000)	0.1222	0.3957 (0.0000)	0.1222
totstopsq	–0.0245 (0.0000)	–0.0203 (0.0000)	–0.0245 (0.0000)	–0.0200 (0.0000)
maintenance	0.2806 (0.0000)	0.0867	0.2805 (0.0000)	0.0867
maintensq	–0.0255 (0.0000)	–0.0193 (0.0000)	–0.0253 (0.0000)	–0.0192 (0.0000)
female*maintenance	–0.0817 (0.0000)	–0.0151 (0.0697)	–0.0833 (0.0000)	–0.0160 (0.0286)
leisure	0.0942 (0.0000)	0.0291	0.0944 (0.0000)	0.0292

(*continued on next page*)

TABLE 2 (*continued*) **Probit Model of Determinants of Automobile Use (n = 28,059)**

	Model I		Model II	
Variable	Coefficient Estimate	Marginal Effect	Coefficient Estimate	Marginal Effect
leisuresq	–0.0066	–0.0042	–0.0066	–0.0042
	(0.0010)	(0.0013)	(0.0010)	(0.0012)
female*leisure	–0.0323	–0.0064	–0.0333	–0.0068
	(0.0190)	(0.1504)	(0.0160)	(0.1070)
work	0.0232	0.0072	0.0255	0.0079
	(0.0010)		(0.0000)	
female*work	0.0267	0.0090	0.0211	0.0074
	(0.0090)	(0.0031)	(0.0340)	(0.0096)
Summary Statistics				
Log-likelihood	–13565		–13571	
χ^2	1959		1969	
Pseudo R^2	0.191		0.191	

P–values in parentheses. Year dummies omitted from table.

probability of car use, with the probability initially increasing until an age of about 52 and then tapering downward into retirement years. Moreover, though just out of the range of significance at the 10% level, the interaction term suggests that the effect of age may be mitigated by gender. Further insight into this effect can be gleaned from Figure 1, which shows the simulated probabilities of car use over a range of ages for men and women while the other variables are held fixed at their mean values. Women have lower predicted probabilities of car use over the entire range. Moreover, the observed gap increases slightly as age increases, suggesting that gender differences become more pronounced in older age cohorts.

With respect to the household sociodemographic characteristics, the model results confirm the importance of children as a determinant of car use. Although the coefficient estimate on the variable "kids" is negative and statistically significant for men, as given by a joint chi square test on "kids" and the gender interaction (χ^2 = 10.12; p = 0.006), it is positive and significant for women, a possible reflection of the greater number of serve-passenger trips associated with child care. As indicated by the plots of the predicted probabilities in Figure 2, the influence of children is actually seen to decrease the gender disparities with respect to the probability of car use. In households with two or more children, statistically significant differences between men and women cannot be discerned, as indicated by the overlap of the 95% confidence intervals.

Consistent with intuition, the demographic variables measuring the number of adults over 18 years of age in the household, the number of license holders, and the number of employed household members all have negative effects, although the last is not statistically significant. Specifically, an additional adult reduces the probability of car use by 0.06, whereas each additional license holder reduces the probability by 0.08. These effects likely reflect both increased competition for the car and greater sharing of responsibilities, such as shopping, that require car use. In a similar vein, the number of cars in the household has a positive effect on the

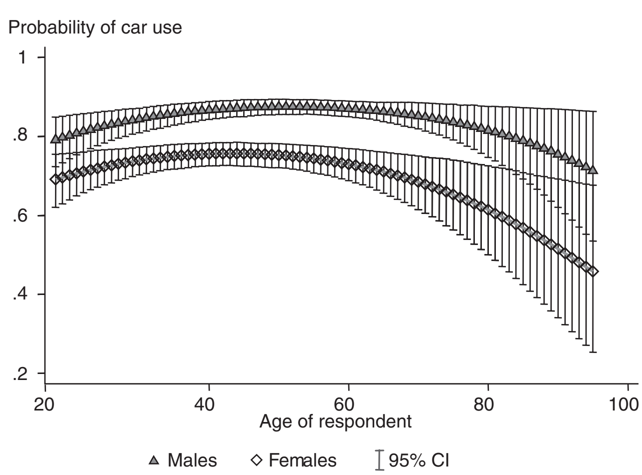

FIGURE 1 Influence of age on probability of car use for men and women.

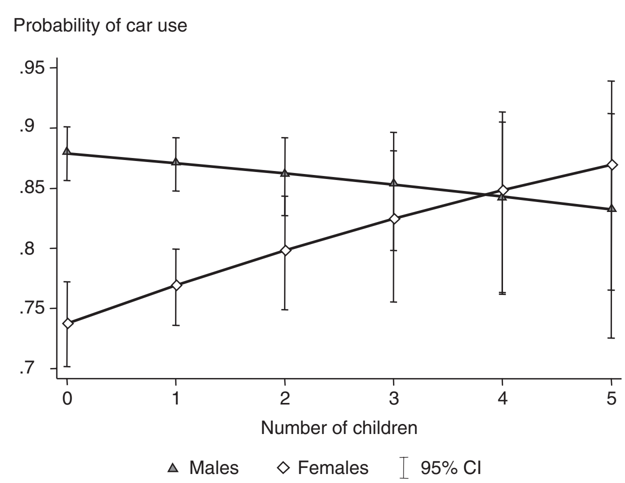

FIGURE 2 Influence of children on probability of car use for men and women.

probability of car use. This finding can again be interpreted as a reflection of the degree of competition—in this case attenuated—among household members.

Among the neighborhood and community design characteristics, population density, average income, and walking time to the nearest public transport are all statistically significant, with the first two having negative coefficients and the last a positive coefficient. To the extent that higher population density is associated with a higher incidence of road congestion, it is expected to deter car use. The negative coefficient on the average income in the postal zone, however, is counterintuitive, and contradicts the emphasis placed by some analyses on income as a positive determinant of car use (*11*). One possible explanation is that land with high accessibility to recreational amenities or services, which could decrease car dependence, is occupied by wealthier households. As would be expected, the higher costs of public transit access, as measured by walking time in minutes, increases the likelihood of car use, though the magnitude of the effect (0.002) is relatively small. The remaining variables measuring urban form are found to be nor statistically significant. Residence in an urban area has no apparent effect on the probability of car use, either on its own or in interaction with the female indicator. Similarly, the variables measuring road density and street parking, although they have the expected positive and negative signs, respectively, are not statistically significant.

Finally, all five of the activity pattern indicators are highly significant. Among these, the variables measuring the commute distance, the total number of stops, the time spent in out-of-home maintenance activities, and the time spent in out-of-home leisure activities were all found to have significant nonlinear effects characterized by probabilities that increase at a decreasing rate. Some caution is warranted in the interpretation of the last three of these, given the potential for endogeneity; to the extent that activity patterns are determined by car access rather than vice versa, the coefficient estimates for these variables could be biased. For the case of the commute distance, the peak probability occurs at around a value of 100 km, so a positive effect can be said to prevail over the range of relevant values in the data. With respect to gender differences, a significant effect is evident for the variables measuring the amount of time spent in maintenance activities and outside the home working. With regard to the latter, increases in the variable "work" increase the probability of car use over all values, an effect that is interestingly more pronounced for women. As indicated by Figure 3, longer working hours for women narrows the gap in the predicted probabilities of car use as compared with men, though statistically significant gender differences still remain. Taken together, the results for these variables suggest that more complex and time-consuming mobility patterns encourage greater reliance on the automobile.

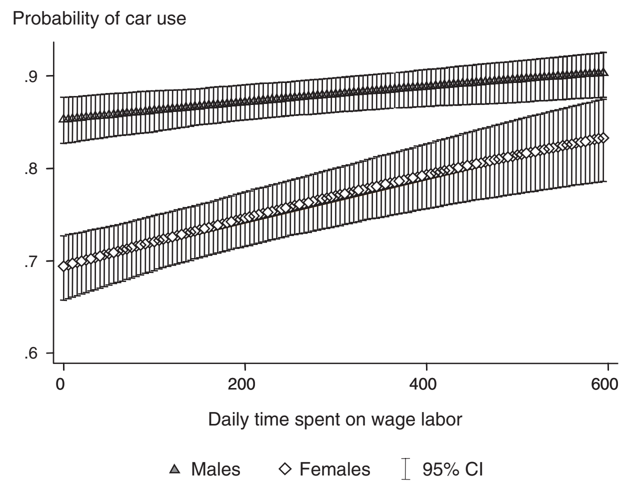

FIGURE 3 Influence of daily time spent in wage labor on probability of car use for men and women.

Discussion of Results and Conclusion

The most fundamental result emerging from the foregoing analysis is that women are characterized by a lower likelihood of car use than men, a discrepancy that is influenced by other sociodemographic and activity-based determinants. In this regard, the analysis of simulated probabilities generated from the model suggests differences between men and women that are statistically significant for several intervening variables. This finding is especially true for the variables "age" and "work." Although it is not possible to identify statistically significant differences in the predicted probabilities with respect to the variable "kids" beyond one child, the estimates of the slope coefficients reveal clear distinctions in the marginal effects, which are positive for women and negative for men.

Drawing inferences as to whether the identified gender discrepancies reflect the outcome of objective reasoning or patriarchal constraints is tricky, but a few tentative observations can be offered. The first of these relates to the role of children. The presence of children often figures as a critical factor in research on male-female mobility disparities. Women are said to bear a greater share of the responsibility for child care, a burden that is often used to explain other observed aspects of their mobility behavior, such as shorter commute distances, relative to those of men. The results presented here suggest that children reduce disparities between men and women with respect to car use, but whether children thereby represent an equalizing force in men's and women's mobility behavior is more questionable. It is unlikely, for example, that car access for child care and pickup services would substantially relax whatever other constraints underlie women's shorter commute distances. Hence, although car access decisions may, given the presence of children, be made on the basis of objective reasoning, this reasoning potentially emerges from a traditional division of responsibilities that dictates a preeminent role for women in child care. A more definitive conclusion concerning the possible existence of objective reasoning can be drawn with respect to the variables measuring employment. Although the analysis finds employment-related variables to have a positive effect on the probability of car use, it finds no evidence that this effect is weaker for women. To the contrary, the positive impact of time spent working is actually slightly stronger for women. Moreover, the absence of gender differences for the variables "parttime," "fulltime," and "diswork" would seem to suggest the absence of a male bias with respect to the effects of employment status and workplace proximity.

A final conclusion to draw from the foregoing analysis relates to the role of community design. With the exception of walktime, the remaining community design variables—"strprk," "strdens," and "center"—were found to have insignificant effects on the probability of car use, both on their own and in interaction with gender. These findings may partly reflect the possibility that the supply of transportation services, as captured by the measures of street density and proximity to public transit, is relatively homogeneous across the country. For example, given that less than 5% of respondents reported being more than 20 min by foot from the nearest public transport stop, it is possible that the variability of "walktime" is insufficient to elicit a measurable behavioral response. It also bears noting that the geographic resolution of the MOP data is rather course; the smallest geographical unit within which the household is situated is the zip code, which precluded a detailed characterization of the land immediately surrounding the household. To the extent that it would allow for the generation of variables capturing the land use pattern, future research into household decision making surrounding car use could greatly benefit from data of higher geographic resolution. Rigorous analysis of such data, however, would also require models that address the simultaneity of mode choice, residential location, and employment location in order to disentangle correlation from causation.

Acknowledgment

The authors thank May Boggess of Stata Corporation's Technical Support for her assistance with the program code used for the calculation of marginal effects.

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Does Residential Density Affect the Travel "Gender Gap"?

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Research has shown that women with children have different travel patterns from those of their male counterparts, and thus there is a travel "gender gap." Women are more likely to make linked trips and to make trips solely to meet their children's travel needs, leading women to make more trips than men. A separate body of literature has shown significant, but moderate, influences of the built environment on travel behavior. This study tests the hypotheses that (*a*) there is a travel gender gap and (*b*) mothers make fewer trips for their children in densely populated places because their children are better able to meet their own travel needs. Analysis using the 2001 National Household Travel Survey shows that women make 77% more trips with children than their husbands do. This provides strong evidence for the existence of a gender gap when travel with children is considered. However, there is no evidence that the maternal travel burden declines as density increases, because children's travel options are not necessarily better in urban areas. Although children in urban areas walk and ride transit more than their rural counterparts do, they are less likely to have school bus service or to drive themselves. These two effects tend to cancel each other out, and the result is no reduction in mothers' travel burdens as density increases.

Research has shown that women with children have different travel patterns from those of their male counterparts, creating a travel "gender gap." Women are more likely to make linked trips and to make trips solely to meet their children's travel needs, which leads women to make more trips than men (*1*, p. 792; *2–5*). These researchers concluded that women's household and chauffeuring responsibilities largely account for the observed differences in travel behavior between men and women. A separate body of literature has shown significant, but moderate, influences of the built environment on travel behavior. However, little research has been done on how urban form differentially affects women, particularly women with children. The strong connection between women's and children's travel suggests that as children have more travel options, the travel burden on the mother is reduced. This study tests the hypotheses that (*a*) there is a travel gender gap and (*b*) mothers make fewer trips for their children in densely populated, accessible places because their children are better able to meet their own travel needs.

Previous Research

Two separate but well-developed bodies of literature underlie this research: household travel and the effects of the built environment on travel patterns. Studies of household travel have consistently shown that women's travel patterns and activities are most affected by the presence of children in the household (*6–10*; *11*, pp. i, 49). Women are more likely to chain trips (*2–4, 12*). For example, 65% of women with children under 6 linked trips to work; 42% of comparable men did so (*3*). These patterns were seen in Sweden, the Netherlands, the

United Kingdom, and France (*1*, p. 792; *3*; *13*). Differences in trip purpose have also emerged. Analysis of U.S. survey data shows that women make two-thirds of trips to drop off or pick up someone (*14*). Other research has suggested that community characteristics may have a role in shaping observed gender-based differences in travel. In a study of dual-earner households in the Boston metropolitan area, Barnett and Reisner (*15*) found that the availability of transportation and community resources (e.g., public transit, school buses, after-school programs) greatly affected parental work schedules and chauffeuring responsibilities. The lack of quality and affordable after-school programs coupled with poor public transportation forced one parent, usually the mother, to reduce her work hours and spend more time transporting the children.

Researchers are beginning to compile a better understanding of the factors influencing children's mode choice and travel patterns. Several factors appear to be important in mode choice, particularly for the school trip: distance, urban form, age, gender, household car availability, safety, and children's travel preferences. Several authors identify the distance to school as an important factor (*16–20*; *21*, p. 187; *22–24*). Urban form appears to have a significant but modest impact on travel behavior, particularly walking (*16*, *24*, *25*). Age and gender are strongly related to whether children are allowed to travel by themselves and how far they are allowed to travel (*21*, p. 187; *26*).

The 1990s saw an explosion of work on the effects of the built environment on travel patterns [reviews may be found elsewhere (*27*; *28*; *29*, pp. x, 224; *30*)]. The message from a majority of the studies is that the built environment matters, but it may only have a marginal impact on the choice of travel mode or the amount of trip making. The major separations among these studies are in how they measure the built environment. Some authors have opted to look only at density to understand the relationship between travel patterns and the environment. Dunphy and Fisher (*31*) found a negative correlation between density, measured at the zip-code level, and vehicle miles of travel per capita. They also found a corresponding increase in transit and walking trips at higher densities. Cervero and Kockelman (*32*) found that density encourages walking trips and reduces total trip making, but that the effects are "fairly marginal."

Another branch of the literature on travel and the built environment has focused on understanding differences in travel patterns between automobile- and pedestrian-oriented neighborhoods. Many of these studies used matched neighborhood pairs and generally found walking to be more common in pedestrian-oriented neighborhoods (*33–37*). However, Cervero and Gorham (*35*) and Handy (*34*) also showed that the regional context limited the impacts of the neighborhood environment. A final set of studies has focused on measuring specific elements of urban form, such as street connectivity, average block length, and slope, with a mix of electronic mapping and field surveys so that regression techniques and factor analysis can be used to sort out the influences of each element on travel (*29*, pp. x, 224; *38–42*). The results from these studies have been mixed. For example, Cervero (*40*) found that measures of land use density and diversity were stronger predictors of mode choice for commuters from Montgomery County, Maryland, than were urban design variables. In contrast, Boarnet and Crane (*29*, pp. x, 224) found little direct influence of the built environment on nonwork automobile trips. However, there are still many unanswered questions about how the geographic scale of environmental measures affects results and how statistical issues, such as multicollinearity and endogeneity, affect analyses.

Data

The National Household Travel Survey (NHTS) provides an opportunity to assess the differential impacts of density on parental travel for a large sample of households across the United States. Nearly 70,000 households were surveyed between March 2001 and May 2002 (*43*). For this analysis, only those households are included that reported ages for all household members, completed travel-day records for all household members, have married or partnered adults 19 and older in the household, and have at least one child (18 and under) living at home. Given these requirements, the sample includes 13,316 households and 126,397 trips. The mean number of children per household is 1.9. Of the households included, 51% have children under 5; 43% have children between 6 and 10; 37% have children between 11 and 15; and 19% have children between 16 and 18.

Methodology

This analysis uses descriptive statistics to compare the travel behavior of married (or partnered) men and women with children 18 and under. The emphasis is on understanding the differential effects of density on parents' overall trip rates and trips taken with children. Confounding factors such as income, age, number of children, race, and so on, are controlled by testing the influence of these variables and, when appropriate, comparing parents with similar characteristics. The unit of analysis is the unlinked trip. Because women are more likely to trip-chain and to have more complex trip chains than those of men, the use of linked trips might obscure some of the gender-based differences in travel patterns. One methodological issue common to large, stratified samples such as the NHTS is the influence of sample weights. Because the focus of this study is on a specific subpopulation (married men and women) rather than the entire U.S. population, sample weights were not used. Ignoring the weights avoids statistical problems common in weighted data, particularly correlations across error terms (*44*).

Another issue, rather unique to the NHTS data, is that very large samples confound most statistical tests (*45*). In other words, if sample sizes are large, even tiny differences between populations can be statistically significant but have little practical significance. For this reason, other measures of difference, such as percentage differences, are often considered to identify substantial differences in behavior. In this paper, measures of significance, for example, *t*-tests and associated probabilities, are not reported because they are significant unless otherwise noted.

One drawback of the NHTS is that it is difficult to do more than look at broad measures of place, mainly population density. There is a large body of literature discussing the shortcomings of only using density, mainly that density represents so many aspects of place that it is difficult to identify the critical underlying factors (*30*, *46*). However, because so little is known about the differential impacts of the environment on men, women, and children, looking at density-based measures is actually quite helpful precisely because density reflects so many aspects of place. However, it is clear that future research should use more detailed environmental measures.

In particular, tract- and block-level residential density and a Claritas measure of location in the region, for example, rural or urban, were tested. The results were similar with all measures, and the analysis with the Claritas variable was chosen to be shown here. This measure is based on residential population density at the block level with a correction factor for the densities of the surrounding areas (*43*, *47*). This "contextual density" is based on overlaying a grid onto the United States and converting density into centiles (0 to 99). Certain designations were defined simply on the basis of the centiles, for example, rural (0 to 19) and small town (20 to 39). In more urbanized areas, the designations relied on the cell's density relative to the nearest population center. Urban areas consist of population centers with centiles greater than 79. Second city areas were defined as population centers of lower density, that is, with centiles less than 79. Suburban designations are areas outside of population centers with centiles greater than 39. Because there is significant variation within areas categorized as urban or suburban, any estimate of the effect of the environment on parental travel will represent a lower bound.

Findings

In the following discussion, whether a travel gender gap exists and how it is affected by characteristics of the parents (work status), children (age, number of children), household (race, income, number of vehicles), and trip purpose are investigated. Finally how the gender gap varies with density is evaluated.

Establishing Travel Gender Gap

Overall, married women with children make slightly more trips than married men with children do (see Table 1). What is truly striking, however, is how much more women travel with their children than men. Women make 77% more trips per day with their children than men and 19% fewer trips without children.

	Women	*Men*	*Difference (Women – Men)*	*Percent Difference*
Trips with children	2.3	1.3	1.0	77
Trips without children	2.6	3.2	–0.6	–19
Total	5.0	4.5	0.5	11

Parental Characteristics

Analyses into the behavior of married couples must always contend with the influence of economic variables versus gender roles. This analysis finds that although the gap in travel with children narrows as women work more (and presumably earn more), it only comes close to zero when women work full time and their spouses are not in the labor force (see Table 1). For example, in households in which only the father works, mothers make 1.6 (or 122%) more trips per day with children. This gap narrows to 0.7 trip per day when both parents work full time and disappears when women work full time and their spouses do not work. These findings suggest that although economic variables are important, gender roles also have a strong impact on how much each parent travels with children.

Children's Characteristics

Not surprisingly, the children's characteristics also influence how much parents travel with them. The age of the youngest child in the household has a particularly strong

TABLE 1 Trip Rate Differences Between Married Women and Men by Parental Work Status

	Parental Work Status			
	Dad Full-Time Worker	Dad Full-Time, Mom Part-Time Workers	Dad Full-Time, Mom Full-Time Workers	Mom Full-Time Worker
Trips with children	1.6	1.3	0.7	0.2
(% difference)	(122%)	(102%)	(56%)	(11%)
Trips without children	–1.1	–0.3	–0.4	0.3
(% difference)	(–37%)	(–10%)	(–11%)	(13%)
Total trips	0.5	1.0	0.4	0.5
(% difference)	(11%)	(21%)	(8%)	(12%)

Differences are calculated as (women – men). Percentage differences are (women – men)/men.

effect on adult trip making. Both men and women make more trips with younger children, presumably because young children are either not able or not allowed to travel alone. When there is a child under the age of 5 in the house, mothers make an average of 2.4 trips with children per day and fathers make 1.5 trips (in households where both parents work full time). These trip rates decline by nearly half when the youngest child in the house is a teenager (becoming 1.2 for women and 0.8 for men). However, these results also highlight a paradox in the data. Men with young children make more trips—in absolute numbers—with their children than men with older children. The gap between men's and women's travel with children is also the largest when there are young children at home. This finding probably reflects the fact that young children place the heaviest travel burden on parents, causing both parents to make more trips with their children. However, because this travel burden is not evenly distributed between mothers and fathers, the difference in men's and women's travel is most exaggerated when there are young children in the house.

The total number of children in the household might also be expected to influence the gap between men's and women's travel with children. Individually both men and women make more trips as the number of children in the household grows. For example, men working full time make 1.0 trip per day with children when they have one child but 1.6 trips per day when they have at least three children. The pattern is similar for working mothers. However, because the patterns are so similar, the gap between men's and women's travel shows no statistical difference as the number of children in the household varies.

Household Characteristics

Household characteristics such as race, income, and the number of household vehicles are relatively poor predictors of how much parents travel with children. When race and automobile ownership are controlled for, income shows no effect on the travel gender gap. Similarly, having at least one car per driver tends to increase the gap, but the effect is not significant. Finally, travel gaps are similar across racial and ethnic groups, with women making between 0.6 and 0.8 more trips with children per day than their spouses. This finding suggests that parental work status, children's ages, and gender roles have the strongest impact on how parents split responsibility for children's travel.

Trip Purpose

The data show that women travel more with children than comparably situated men. What is not known is why women travel more with children. Are women making more trips with children because they have responsibility for dropping them at school, sports, and other activities and must align their own schedules around their children's? Or are children traveling more with women because mothers have more child-care responsibilities and must bring children with them as they run errands and grocery shop? Unfortunately, the NHTS data were not collected in a way that makes it easy to analyze this problem. Aside from obvious cases like serve-passenger trips, it is often difficult to distinguish who is the primary beneficiary of a trip. For example, when the trip purpose is shopping, it is impossible to know whether Mom took Joey to buy sneakers or if Joey accompanied Mom when she bought shoes. The data do not distinguish between these two types of trips. Future versions of the survey might consider incorporating questions about which household member was the primary beneficiary of the trip. In the interim, one can look at reported trip purposes to get some insight into this issue and to understand the different types of trips that mothers and fathers make with children.

With regard to parental trip purposes, it is clear that although women make more trips with children across all trip purposes, the distribution of trip purposes is remarkably similar between mothers and fathers (see Table 2). The major differences occur because mothers are more likely to make shopping trips with children and fathers are more likely to make sports trips with them. This analysis also

TABLE 2 Percentage Distribution of Trips with Children by Parental Trip Purpose

	Mom	Dad	Both
Serve passenger	36	38	9
Shop	27	22	29
Visit friends/family	7	8	17
Meals	7	7	18
Personal	4	4	3
Sports	4	6	4
Work	3	4	1
Medical	3	1	1
Church	2	2	6
School	2	2	2
Gas	2	2	2
Other	4	5	6
Total	100	100	100

If trip purpose was "Home," then the trip purpose for the previous trip was used.

shows that when trip purpose is considered, it is important to separate out trips in which mothers and fathers travel together. Because men make a higher proportion of their trips with children in the company of their spouse than women do, the distribution of trip purposes can look very different if this factor is not accounted for. When the whole family makes a trip, it is usually for shopping, visiting friends or family, and eating out.

Density Effects

Many researchers have studied the effects of density on the travel behavior of adults. However, this literature has not addressed whether density has differential impacts on men, women, and children. Because women make many more trips with children than men do, the effects of density on children's travel may have a large impact on women's travel. For example, Rosenbloom (*3*) found that Dutch mothers made fewer chauffeured trips than American mothers, which Rosenbloom partially attributed to children's ability to get around by themselves in Holland. If children in certain environments are better able to meet their travel needs, this aspect should be reflected in their parents' making fewer trips and, perhaps, a decline in the travel gender gap. This mechanism relies on children's ability to meet their own travel needs. For that reason, density is expected to matter only for older children whose parents allow them to travel alone. Analysis of the NHTS data shows that children begin to walk and bike by themselves between the ages of 8 and 10. Therefore, this analysis will be restricted to those households in which the youngest child is at least 8, which results in a sample of 5,312 households.

The research hypothesis posited that mothers' travel with children would decline as density increases. The data show that after income and age of the youngest child are controlled for, the effect of location depends heavily on maternal work status. In households where both parents work full time, mothers make 15% fewer trips in urban as opposed to rural places. The travel gender gap narrows slightly as density increases (see Figure 1). When women do not work full time, they make 18% more trips with children in urban areas, and the gender gap is largest in urban areas. However, once confidence intervals are calculated, it becomes impossible to conclude that density has any effect on maternal trip making or the travel gender gap. This finding suggests that although household location may affect women's travel, the effect is relatively small and, if it exists at all, is highly dependent on maternal work status.

One final way of testing the connection between mothers' and children's travel and density is to switch

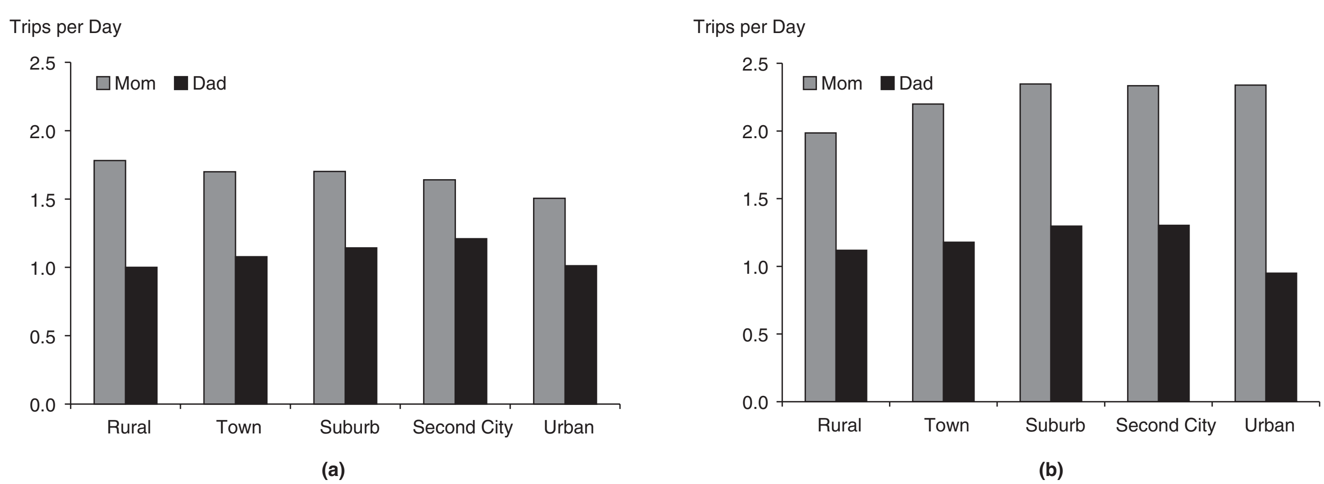

FIGURE 1 Trips with children by location in region and maternal work status: (*a*) both parents work full time; (*b*) mother works part time or is a homemaker. (Includes households in which men work full time, household incomes are between $40,000 and $100,000, and youngest child is 8 or older.)

perspectives to the child. What becomes clear is that children in urban areas are not better able to meet their own travel needs. In fact, the odds of traveling without a parent decline by 17% from rural to urban areas, whereas the odds of traveling with a mother increase by 28%. So as places become more urban, children do not take advantage of increasing accessibility levels to travel without parents and thereby do not reduce the travel burden on parents, particularly mothers. The primary explanation for this finding is that the benefits of density—that is, the presence of transit, more walkable environments, and shorter trip lengths—are more than offset by lower levels of school bus provision in urban areas and lower levels of teen automobile access (*18*, *48–50*). Because school buses and teen drivers are effective at reducing the travel burden on parents, parents in urban areas must actually make more trips with their children. The data show that when children in rural areas are traveling without their parents, they use the school bus for 27% of trips (see Table 3). In contrast, children in urban areas use school buses for only 10% of trips without parents. Similarly, 75% of rural children aged 16 to 18 drove themselves when they traveled without parents. This number was 42% for teens in urban areas.

Conclusion

This research provides strong evidence for an unequal distribution of responsibility for children's travel between married men and women. Although maternal work status has a strong influence on the division of trips, it does not completely explain the observed differences, suggesting that gender roles still strongly influence which parent takes responsibility for children's travel and activities. The effect of density on household travel is more complex than previously hypothesized. Rather than having more opportunities to travel by themselves in urban areas, children still rely heavily on their mothers in these settings. Although other travel options are available to children in urban areas, children and their parents opt not to use them, which leads some mothers to make more trips with their children than they do in rural areas. Further research is needed to establish why parents do not allow their children to use alternative modes—whether the reason is safety concerns or time constraints—to help transportation planners understand whether necessity or choice drives mothers' behavior.

These analyses suggest that the environment does matter, but its effects are mixed because of two opposing factors. In high-density areas, children have the options to walk or ride transit without adults. In lower-density areas, these options do not exist and children are observed to use school buses and drive themselves more. This combination means that children's ability to travel by themselves is certainly no worse in rural areas and might actually be better than it is in cities. Therefore it can be seen that women make slightly fewer or about an equal numbers of trips with children across space. Perhaps the most important conclusion that can be drawn from this work is that since mothers are so responsible for children's travel, any efforts to improve children's travel options should reduce the burden on mothers. These connections ought to be considered during policy debates about the elimination of school bus transportation and funding of Safe Routes to School programs.

This research also highlights many deficiencies in the understanding of intrahousehold travel dynamics. Although this subject has received significant academic attention over time (*51*; *52*, pp. 470–474; *53–55*), it has proved to be difficult to attack because of the inherent complexities. Future research, particularly that concerned with environmental impacts on household travel, should consider using natural experiments such as the projects designed to increase the walkability of communities to better understand the relationships. Researchers should also consider how the activities available to parents and children differ with the environment and how this characteristic might affect travel patterns.

Acknowledgments

Susan Liss and Nancy McGuckin at FHWA were incredibly knowledgeable and patient sources of information

TABLE 3 Percentage of Children's Mode When Traveling Without Parents

Mode	Rural	Town	Suburb	Second City	Urban
Drive self	32	28	23	29	13
School bus	27	26	23	15	10
Walk	14	18	22	22	37
Bike	5	6	8	8	4
Transit	0	1	2	1	11
Other	22	21	23	25	25
Total	100	100	100	100	100

Includes households where men work full time, household incomes are between $40,000 and 100,000, and the youngest child is 8 or older.

on the NHTS. The author appreciates their assistance. This research was completed with support from the U.S. Department of Transportation Eisenhower Fellowship and a University of California Transportation Center Dissertation Fellowship.

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Gender Differences in Travel Behavior of 13-, 14-, and 15-Year-Olds and Role of Built Environment

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A substantial body of research documents significant differences in the travel behavior of men and women. For example, women make more trips to chauffeur family members and others to their destinations than men do. Differences in household responsibilities offer some explanation for observed differences in behavior by gender, but it is possible that gender differences emerge much earlier, before adult responsibilities come into play. In particular, differences might first emerge when children are old enough to travel on their own, generally in the early teen years. Gender differences in travel behavior for 13- to 15-year-olds are examined by using two data sources: the 2001 National Household Travel Survey (NHTS) and a qualitative study of the travel behavior of pre-driving-age teens in Austin, Texas. The role of the built environment in explaining gender differences for this age group is also explored. Data from the 2001 NHTS used for this analysis included 21,091 trips by 5,735 young teens, divided about evenly by gender and age. These data show a difference by gender in trip purposes and modes even for 13- to 15-year-olds, and they show that gender differences vary for urban and rural locations. In urban areas girls make a higher share of trips to hang around and a lower share of trips for exercise and sports than boys, and in rural areas the reverse is true; in both urban and rural areas, girls make a higher share of shopping trips than boys. In urban areas, girls make a much higher share of trips by privately owned vehicles than boys do and a lower share by walking, though girls make a higher share of trips by walking in rural areas. In both areas, boys make a higher share of trips by bicycle than girls do. These results suggest that significant gender differences exist even at this age and that the built environment influences the nature of these differences. It is important to note, however, that the data collection instrument used in the NHTS is geared toward adults, and nearly 98% of trips by young teens were reported by their parents or other proxies. A qualitative study of this age cohort in Austin reveals some of the reasons for differences in travel behavior. As a part of a study of independent travel of young teens conducted between March and August 2003, 31 young teens filled out specially designed travel diaries for 3 days. After filling out the diaries, the teens were interviewed about their travel behavior. According to the travel diaries, the girls generally participated in more socializing activities, whereas the boys were involved in more sports activities; these activity differences contributed to differences in travel behavior. In the interviews, girls and boys both discussed their preference for being with other people (preferably friends) when walking, biking, or riding the bus. They also described frustrations with parental restrictions on their travel, although in some cases the restrictions were self-imposed. For both boys and girls, characteristics of the built environment sometimes contributed to travel restrictions. However, only young women mentioned fear of kidnapping as a reason to avoid traveling by bike, foot, or bus independently of their parents. These results point to the possibility of early differences in travel behavior by gender, partly influenced by the built environment, and to the need for further research into the roots of gender differences observed in adults.

Abstract prepared by Susan L. Handy, University of California, Davis.

Connection Between Travel and Physical Activity
Differences by Age and Gender

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Concern over declines in physical activity among Americans has grown in response to increasing rates of obesity and related health problems. One possible explanation for the decline in physical activity is that driving has almost entirely replaced walking as a means of getting places. However, for a portion of the population, driving enables exercise by allowing quick travel to locations away from home at which people engage in their chosen physical activity. It is possible that the average benefits per unit time of driving to a health club and working out exceed those of walking and biking to work or other destinations. With only 24 h in the day, the limited time available for physical activity might be better spent driving to the health club. Little is known about the trade-offs between time spent walking and biking as a mode of transportation and time spent driving to and exercising at health clubs or other places and even less about how these behaviors differ by age and gender. With data from 60,282 persons in 26,038 households in the 2001 National Household Transportation Survey, this study compares exercise obtained through travel (walking and biking) and exercise made possible by travel (derived from the time spent at destinations whose purpose is exercise) for men and women of various ages. The analysis addresses three questions: (*a*) Do the number and length of trips made by walking and biking, and thus the exercise these forms of travel provide, vary by age and gender? Middle-aged men were the group least likely to engage in 30 min or more of walking or biking per day, though younger men and men over age 60 were more likely to walk or bicycle more than 30 min a day than were similar-aged women. For women, trip numbers and length increase through middle age but decline again after age 45. The differences between men and women are primarily in trip length (both miles and minutes), with women making shorter trips, beginning in middle age. (*b*) Do the number of trips and travel time to physical activity vary significantly by age and gender? Travel to physical activity was a significant share of total travel, accounting for more than 3% of all trips. Trips to exercise are not evenly distributed across men and women of all ages, however. The largest numbers of trips to exercise are made by male children. The second-highest number of such trips is by women between the ages of 30 and 44. Interestingly, a higher proportion of trips by the latter group is made on foot. Trips to exercise by women 45 and older are even more likely to involve walking or biking to the exercise place rather than driving. (*c*) How does the amount of time spent exercising compare with time spent driving to get to exercise, and does this relationship differ by age and gender? Women spend more time traveling to exercise than men or less time exercising at their destinations than men, or both. Exercise time increases relative to travel time with age as women approach late middle age, either because travel time declines or exercise time increases, or both. This finding holds true until ages 45 to 59, and reverses again thereafter. Although walking and biking burn more calories than driving a car, exercise that involves a vehicle trip may result in more physical activity overall: exercise reached through travel yields about 2½ times the MET-minutes of all walking and biking trips, based on the analysis in this study (METs are a measure of intensity of physical activity). When people choose to travel by car to get to a place to exercise, the higher

value of the exercise at the chosen destination outweighs the time and monetary cost of driving for them, and the net value exceeds that of exercising in or around home. The fact that many people do make trips to exercise suggests that opportunities away from home are attractive, perhaps because of specialized facilities, opportunities for socializing, and other factors. If so, the obstacles to travel so well known to planners—inability to afford transport, congestion, facility locations with poor accessibility to users, lack of mode choice options, and dangerous travel—are also obstacles to exercise. Efforts to reduce these obstacles may prove effective in increasing overall physical activity.

Abstract prepared by Susan L. Handy, University of California, Davis.

Gender Differences in Walking Behavior, Attitudes About Walking, and Perceptions of the Environment in Three Maryland Communities

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Pedestrian behaviors and attitudes toward walking have recently become a focus of interest for researchers in a number of disciplines, including public health, transportation planning, and recreational studies. The potential gender differences regarding not only walking behavior but also attitudes about walking and perceptions of the environment, including safety, are of particular interest to planning researchers. To address these issues, the research design utilizes a survey instrument devised to capture respondents' perceptions about the physical environment, attitudes about walking, and self-reported pedestrian behaviors. These data were collected in three Maryland communities with different walkability and socioeconomic characteristics as part of a study to understand connections between the built environment and walking. These data are analyzed to examine how the subjective measures contribute to the understanding of gender differences in revealed pedestrian behaviors, attitudes, and perceptions. Lessons learned from this project, potential contributions to the understanding of the walking environment for both sexes, and future avenues of research are discussed.

Recent studies showing connections between health outcomes and the built environment have sparked interdisciplinary efforts to understand the connections between pedestrian activity and the built environment (Berrigan and Troiano 2002; Craig et al. 2002; Ewing et al. 2003). Interest in pedestrian behaviors is not a new endeavor for transportation researchers, who have long sought to understand the link between travel choices and land use (Crane 2000). However, research collaboration between public health, urban planning, and recreational studies has revived this debate and interjected new approaches, both methodological and theoretical (Hoehner et al. 2003). Within this line of inquiry, there is increasing recognition that subjective factors shape behavior and mediate actions. Attitudes, perceptions, and lifestyle goals are increasingly incorporated into empirical studies of human behavior in the built environment. In some cases, these subjective factors have had better explanatory power in models of travel behavior than land use characteristics have (Kitamura et al. 1997).

Understanding the role of these subjective factors becomes important as policy makers attempt to design interventions that encourage walking, either for health or for mobility reasons. Effective interventions also require consideration of how these perceptions and resulting behaviors vary by different demographic or population groups, such as between the sexes. There is a substantial body of work that reveals the differences between the travel patterns of men and women (Matthies et al. 2002; Rosenbloom 1997); however, little of this work is focused specifically on pedestrian activity. Studies on women's travel that have focused on walking tend to show that women walk farther than men (Carlsson-Kanyama et al. 1999) and make more walking trips (Root et al. 2000). Some of the differences that exist in pedestrian behavior between the sexes have been explained by gender roles and household responsibilities, but gender differences in attitudes, perceptions, and other subjective factors may also be key. Although land use and urban form may affect aggregate levels of pedestrian activity, it is not clear that attributes of the built environment are perceived and, ultimately, affect the behaviors of men and women in the same ways.

The differences in pedestrian activity, attitudes about walking, and perceptions of the environment between men and women are explored here. On the basis of a study of walking and the built environment conducted with residents in three Maryland communities, the study examines how these subjective measures contribute to the understanding of gender differences in revealed pedestrian behaviors. In particular, the gender differences in perceptions of safety and purposes of walking are of interest. Lessons learned from this project, potential contributions to the understanding of the walking environment for both sexes, and future avenues of research are discussed in the conclusion.

Background

Existing research regarding gender differences in pedestrian issues comes from a number of disciplines. The most important and complete line of research involves women's travel behaviors. Almost all existing research about gender and travel focuses on motorized transportation (Matthies et al. 2002); the automobile and the journey to work especially are the subject of a large body literature (Blumen 1994; Blumenberg 2004). Pedestrian activity, in contrast, is often only mentioned in passing. The increasingly limited focus of women's travel research has been recently criticized by a number of researchers. For instance, Law (1999) stated that women's travel literature has come to focus on a relatively limited range of research problems (notably journey-to-work travel) at the expense of other relevant issues. The lack of attention to pedestrian issues is now coming to the forefront, since walking has become more of a focus both in the planning and public health fields.

Public health research tends to focus largely on the health benefits of walking. As such, cumulative walking behaviors are the data of interest and are very useful in ascertaining aggregate levels and types of physical activity. For instance, Zepf (2003) compared walking with vigorous exercise for heart health in women. Recent interest in the relationship between the built environment and physical activity have resulted in an increasing number of studies that deal with the determinants and correlates of walking and physical activity.

Recent studies (Moudon et al. 1997) have shown that there is a relationship between physical activity and environmental conditions, although the variables describing the physical environment are limited (Berrigan and Troiano 2003). This link between environment and walking behavior has encouraged policy makers to make physical changes in the environment to increase walking, which have achieved some success (Sallis et al. 1998). This policy change is of particular importance for women, who generally have fewer available areas for physical activity than men do (Brownson et al. 2001). Despite the increasing interest in the role of environmental variables, women's issues remain underrepresented in the current research agenda.

Sociopsychological characteristics are a key factor to fully understanding gender differences in pedestrian activity. Perceptions, attitudes, and lifestyle preferences all have an effect on walking behavior, but they also influence each other over time. Much of the existing research regarding subjective assessment of the environment focuses on visual preference of a number of aspects of the environment, from enclosure (Stamps and Smith 2002) to aesthetics (Stamps 2000) to safety (Fisher and Nasar 1995). A number have analyzed differences in perceptions of these environmental features (Hoehner et al. 2003; Humpel et al. 2004). Some have examined these perceptions specifically by gender. For instance, there has been substantial research on gender differences in perceptions of safety, showing that women tend to be more sensitive to environmental clues and more likely to limit their walking behavior because they feel unsafe (Bianco and Lawson 1997). However, understanding the gender differences in these sociopsychological qualities and, ultimately, their effect on behavior requires additional research.

The research presented here fills some of the gaps in the existing literature and confirms some hypotheses previously postulated by researchers. To support the research performed here, a conceptual framework showing the hypothesized relationships between the neighborhood pedestrian environment, individual and household characteristics, sociopsychological characteristics, and walking behavior is shown in Figure 1. The direction and magnitude of many of these relationships are still unclear. From this general framework, a few more specific concerns are also tackled. One hypothesis of interest here, discussed by Bianco and Lawson (1997), is the impact of gender differences in safety perceptions on pedestrian behaviors. Another interest is to test whether the sexes differ in the general purpose of their common walking trips, given that women tend to have less access to areas of physical activity yet they tend to make more nonwork trips than men (Sarmiento 1997).

Methodology

The study presented was designed to capture perceptions about the environment and attitudes about walking and self-reported measures of aggregate pedestrian

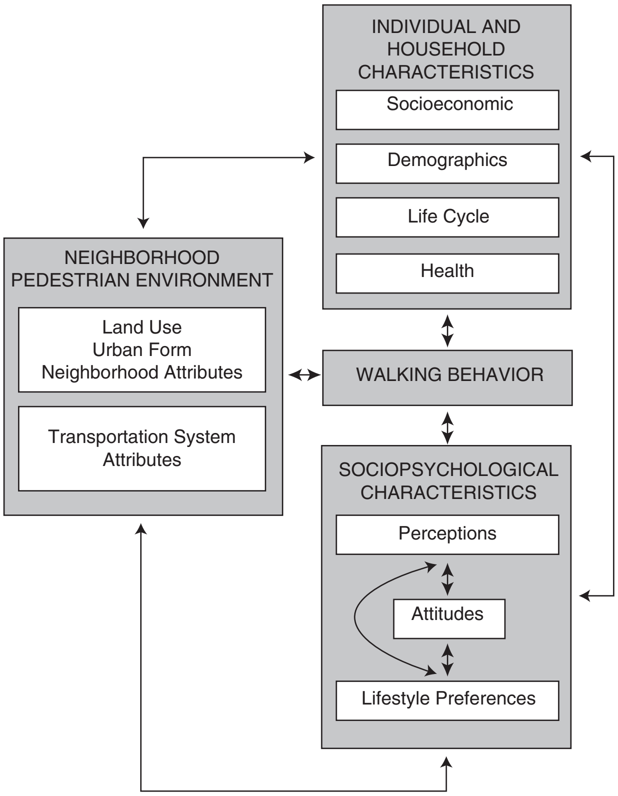

FIGURE 1 Conceptual framework.

activity. Analysis of gender differences in all these aspects of pedestrian activity can lead to a more comprehensive and thorough understanding of what motivates walking for each gender. For this analysis, surveys and focus groups were conducted in three Maryland communities (College Park, Bel Air, and Turner Station) from 2003 to 2004.

Survey Design

The goals of the survey were articulated from the limitations of previous research and results:

- Evaluating perceptions of neighborhood walkability,
- Assessing attitudes about walking and the environment, and
- Capturing measures of pedestrian activity.

The survey was short—two typed pages that required less than 10 min to administer—to maximize response rates and respondent motivation and to minimize respondent burden. Questions were mostly multiple choice, except perceptual questions, which were on a five-point Likert scale. The survey aimed to capture cumulative daily pedestrian activities by using a comprehensive questionnaire of recalled behavior with complementary questions about motivations for walking and the relative importance of a variety of physical environmental factors. Each community used volunteers to administer the door-to-door survey with a sampling scheme that attempted to survey every fifth residential unit in the community.[1] Surveyors were given training on survey administration, including the sampling procedure, instrument questions and responses, potential problems or issues, probing, and conduct. To ensure a random sample, the survey was administered to the person (over the age of 12) who had had the most recent birthday at home at the time of survey administration. The survey was administered in the summer and early fall of 2003. The response rate for each community is found in Table 1.

Focus Group Design

By drawing on survey respondents, focus groups were held with members of all three communities to identify factors that contribute to participants' walking behavior. In each focus group, all participants first filled out a short background survey and completed consent forms. The participants were recorded on both video- and audiotapes in order to aid transcription.

The focus groups explored physical impediments (e.g., poor lighting, condition or availability of sidewalks) and psychological (fear of walking alone or at night) or other impediments (e.g., disincentive of having to carry groceries for a family of five). Information culled from the focus groups was intended to identify actions that could be taken to address some of these issues, including changes to the physical environment (e.g., new lights or sidewalks), the psychological environment (increased policing or escort services), or social environment (e.g., making loaned pushcarts available at the grocery store), and items on which to focus for a public outreach and promotion campaign.

Study Area

The three communities—Bel Air, College Park, and Turner Station—were selected for their interest in pedestrian issues and willingness of community leaders to participate in this project. The locations of these communities are shown in Figure 2, and community characteristics are summarized in Table 2.

As the county seat, Bel Air is the government and commercial hub of Harford County. Located north of

[1] In Turner Station, every third residential unit was surveyed.

TABLE 1 Response Rates and Gender Distribution for Survey and Focus Groups

	Walking Survey					Focus Groups		
	Refusal Rate	Response Rate	Male	Female	Total	Male	Female	Total
Bel Air	25.50%	36.60%	78	121	199	3	6	9
College Park	23.80%	46.30%	126	129	255	3	3	6
Turner Station	6.20%	73.90%	70	134	204	2	9	11
Total			274	384	658	8	18	26

FIGURE 2 Study areas.

Baltimore, this suburban town of 10,000 is relatively wealthy and largely white. Bel Air also has a sizable elderly population and high vehicle access. The suburban nature of the development, consisting primarily of low-density single-family neighborhoods, explains the almost complete reliance on automobiles for the work transit mode.

Turner Station, the oldest African American community in Baltimore County, lies at the southern edge of Dundalk. Originally settled by workers of Bethlehem Steel, this fairly densely populated community has struggled with economic problems. The community is over 80% African American and residents have a median income and automobile ownership rate significantly below those of the other two communities in this study. Turner Station residents have higher rates of public transportation use. A negligible portion of the population of this town walks to work, probably because of the isolated and homogenous residential nature of the development. Turner Station by far has the youngest population and the smallest percentage of owner-occupied housing of the three communities in this study.

College Park, located in Prince George's County, is the home of the University of Maryland. Traditionally a college town with more than 54.4% of its population enrolled in higher education (as calculated from the 2000 U.S. census Summary File 3), College Park has a

TABLE 2 Community Characteristics from 2000 U.S. Census

	Bel Air	College Park	Turner Station
Total population	9,924	24,590	3,301
Age			
<5	5.6%	2.7%	7.7%
5 to 15	14.0%	7.1%	20.6%
16 to 64	63.2%	83.2%	55.8%
65+	17.2%	7.1%	9.9%
Median income	$44,135	$50,168	$28,324
Household living in poverty	6.4%	19.9%	24.5%
Race/ethnicity			
White	91.8%	69.2%	18.0%
Black	4.7%	16.2%	80.9%
Asian	2.4%	9.1%	0.0%
Hispanic	1.5%	5.5%	1.9%
Other	1.0%	5.5%	1.1%
Vehicle access	90.4%	89.8%	74.6%
Mode to work			
Private auto	94.0%	63.0%	80.9%
Drove alone	84.9%	53.8%	66.7%
Carpool	9.1%	9.2%	14.2%
Public transportation	0.9%	8.9%	18.1%
Bus	0.9%	1.4%	16.5%
Subway	0.0%	7.1%	0.0%
Bicycle	0.1%	2.1%	0.0%
Walk	2.5%	22.6%	0.6%
Work at home	2.5%	2.8%	0.3%
Owner-occupied housing	65.8%	58.0%	36.2%

large population of pedestrians and bicyclists and two major rail transit stations. Similarly, the University of Maryland is clearly instrumental in contributing to the diverse ethnic distribution. However, the city currently lacks adequate sidewalks in many areas, and pedestrian connectivity to the campus is rather poor.

RESULTS

Analysis of the data by sex reveals interesting trends: women tend to be more sensitive to safety issues, frequent different destinations, and have different amounts of pedestrian activity compared with men.

Survey Results Analysis

Results from the survey clearly show significant differences between the sexes regarding walking behavior, perceptions of the environment, and attitudes about walking.

Differences between the sexes in the amount of pedestrian activity were noteworthy, as shown in Table 3.[2] Women were more likely to engage in some level of walking activity, but men were more likely to walk longer distances, as shown with the walk distance distribution. Overall, the distribution of walk distance for women was considerably more concentrated than that for men: they were less likely to be completely sedentary but also less likely to walk more than 1 mi per day. A larger percentage of women (25%) than men (22%) walked 5 days a week, which may indicate that more physical activity for women is related to the work week, although this finding was not statistically significant. All of these variables seem to indicate that more women are involved in healthy walking (10 continuous minutes or more) on a regular basis. This tendency may indicate that walking behavior is more conducive to good health in a larger number of women than men.

Walking destinations also varied significantly by sex. Women were much more likely to walk at the mall (31% versus 19% for men) and, to a lesser degree, use walking trails (16% versus 11% of men). Destinations such as churches and stores were also accessed more on foot by women. However, women walked less to and from parking lots (34%) than men (40%), perhaps because of less access to vehicles. They were also less likely to walk as part of their work.

Most reasons for walking seem to be shared by both men and women. The convenience of walking was cited by considerably more men (31%) than by women (25%). In contrast, significantly fewer women than men gave alternative kinds of exercise as a reason not to walk more. This finding would indicate that for many health-conscious women, walking is one of their routine exercise options.

When asked if improvements to the environment would change their walking behavior, women were less likely to respond in the negative, as shown in Table 4. This finding suggests that women are more aware of and more strongly influenced by their environment than men are. This apparent heightened sensitivity is in line with findings of previous research (Bianco and Lawson 1997).

As expected, the main differences between men and women relate to safety. This statement is true not only for behavior but also for perceptions and attitudes. Regarding walking behavior, women were much less likely than men to walk at night: only 54% of women reported walking at night, whereas 63% of men reported doing the same. The particular issue of walking at night also proved significant in specific perceptions of the environment. When asked what would be most likely to encourage them to walk more, 33% of women cited better lighting, whereas only 25% of men did the same.

The importance of safety for women was demonstrated by their walking with others. Women are significantly less likely than men to walk alone and correspondingly reported walking with friends and family much more often than men (49% of women reported walking with friends and family while only 36% of men reported doing the same). In addition to safety concerns, this response may suggest that women prefer to walk as a social activity or that they walk as part of their household responsibilities, such as accompanying children to school or the elderly on walks.

In addition to safety related to personal security, women are more sensitive to traffic safety. This finding was reflected, in part, in their larger emphasis on lighting, as mentioned earlier. Women showed more concern with specific traffic-related safety issues, such as automobile speed. Again, this finding emphasizes that women tend to be more conscious of safety measures, with regard to both crime and traffic issues.

Regression Models

So far this analysis has shown important associations among gender, perceptions, and behavior. To analyze the effect of perceptions and other factors on behavior, multivariate regression models, segmented for men and women, were specified and analyzed. These models were devised to explore the relationship between walking behavior and perceptions of the environment. Therefore, the goal was to use not the most efficient model but the

[2] The differences between the distribution of responses for men and women were tested by using a Pearson's chi-square test.

TABLE 3 Pedestrian Activity

Variable	Male	Female	Signif. (2-tailed)
Walk Distance per Day			0.0069*
Less than 1/4 mile	25.2%	20.8%	
1/4 to 1/2 mile	20.4%	20.3%	
1/2 to 1 mile	16.1%	24.3%	
More than 1 mile	38.3%	34.6%	
Walk Time per Day			0.298
No walking at all	3.6%	5.7%	
Less than 10 minutes	15.7%	11.0%	
11–20 minutes	21.5%	23.2%	
21–60 minutes	32.1%	34.7%	
More than 1 hour	27.0%	25.3%	
Days per Week Walked More Than 10 Minutes			0.771
None	8.9%	7.9%	
One	5.9%	5.5%	
Two	10.0%	9.2%	
Three	12.9%	11.1%	
Four	9.6%	10.6%	
Five	22.5%	24.8%	
Six	7.4%	8.9%	
Seven	22.9%	20.8%	
Primary Mode of Transportation			
Car	71.2%	69.6%	0.462
Bicycle	4.0%	2.6%	0.310
Walking	19.7%	24.7%	0.128
Transit	6.6%	12.0%	0.021**
Passenger (in car)	12.4%	14.6%	0.424
Walk at night	63.2%	54.6%	0.027**
Able to walk to work	37.2%	32.1%	0.185
Do walk to work	8.2%	14.5%	0.154
Walk Alone/With Others			
Walk alone	64.2%	53.6%	0.007***
Walk with friends and/or family	36.1%	48.7%	0.001***
Walk with organized group	1.1%	1.3%	0.811
Walk with pet	8.4%	12.2%	0.147

Variable	Male	Female	Signif. (2-tailed)
Primary Areas of Walking Activity			
Home	84.3%	83.9%	0.876
Mall	19.3%	31.3%	0.001***
Walking trails	11.3%	15.9%	0.096*
Work/school	39.8%	33.6%	0.103
Gym	19.3%	15.1%	0.152
Primary Walking Destinations			
Work	21.5%	18.2%	0.293
Park	25.9%	21.9%	0.229
Neighbor's house	50.7%	48.4%	0.562
No destination	36.1%	41.1%	0.194
Car/parking lot	40.5%	33.6%	0.069*
School	24.1%	21.9%	0.505
Bus stop	16.4%	16.1%	0.924
Post office	5.5%	6.5%	0.584
Church	9.9%	15.4%	0.039**
Library	10.2%	10.4%	0.935
Store	25.9%	33.1%	0.048**
Primary Reasons for Walking			
Health/exercise	48.0%	53.4%	0.172
Enjoy nature	32.5%	27.9%	0.202
Pet	10.9%	14.1%	0.238
Primary mode of transportation	19.0%	22.1%	0.325
Inexpensive mode	16.8%	14.1%	0.337
Relaxation	31.4%	36.2%	0.200
Accompany family	23.7%	25.5%	0.598
Most convenient mode	31.4%	25.0%	0.071*
Impact of Seasonal Changes in the Weather			
No change	39.1%	32.3%	0.125
Reduce walking	42.0%	44.3%	0.557
Walk indoors	8.4%	9.1%	0.748
Change exercise type	5.5%	4.9%	0.764
Stop walking	12.8%	14.6%	0.507

Note: The differences between the distribution of responses for men and women were tested using a Pearson's chi-square test.
*Significant at 90% confidence interval.
**Significant at 95% confidence interval.
***Significant at 99% confidence interval.

most inclusive one. The total distance walked per day was estimated by using an ordered logit model. The ordered logit model was chosen because the dependent variable is sequential categorical data. The number of days walked per week was estimated by using a Poisson regression. The models' specification and estimation results can be found in Table 5.

Reasons for walking were important in the amount and distance that women walk. Walking as a mode of exercise had a significantly positive impact for women in the distance walked and for both sexes in days walked per week. This finding shows that a concern for health increases the likelihood of walking regularly. Walking as a means of transport and walking for relaxation were significant and positive for women but not for men in both models, further emphasizing the gender differences in reasons for walking found in earlier analyses.

Subjective interpretation of the built environment revealed interesting results in both models. The presence of commercial areas in the neighborhood had a positive impact on distance walked for both sexes but did not have a significant impact on the days walked per week. This finding might indicate that the presence of neighborhood stores results in walking trips but that these destinations are not part of a daily or weekly routine. The presence of curb cuts had a significant and positive influence for women in both models but did not for men. This finding may be due to the fact that women are more likely to use strollers and therefore more likely to be aware of this feature.

TABLE 4 Pedestrian Attitudes and Perceptions

Variable	Male	Female	ANOVA Signif. (2-tailed)	Variable	Male	Female	Chi-Square Signif. (2-tailed)
Perceptions (in Neighborhood)				*Impediments to Walking*			
Drivers drive at safe speeds	3.09	2.91	0.620	No time/too busy	46.0%	45.8%	0.969
Drivers yield to pedestrians	3.51	3.42	0.333	Health reasons	12.4%	15.1%	0.326
There are enough traffic signals	3.41	3.30	0.235	Extreme weather	22.3%	27.6%	0.121
Traffic signals allow time to cross	3.38	3.17	0.034**	Not enough destinations	12.8%	17.2%	0.122
Sufficient curb cuts	3.35	3.28	0.470	Get enough exercise elsewhere	9.5%	4.4%	0.010***
Sufficient street lighting	3.05	2.91	0.167	Don't think about it	32.8%	30.5%	0.517
Feel safe	3.88	3.71	0.064*	Feel unsafe	6.2%	9.6%	0.114
Dogs are kept on leash	3.66	3.53	0.120				
Sufficient sidewalks	3.06	3.06	0.992	*What Would Increase Your*			
Sidewalks are in good condition	2.98	2.97	0.928	*Walking Behavior*			
Sidewalks are clean	3.14	3.19	0.630	Lighting	25.2%	33.1%	0.029**
Sidewalks are kept free of snow	2.75	2.69	0.593	Improved signals	6.6%	7.3%	0.720
There are places to sit	2.36	2.23	0.213	Better police enforcement	15.7%	16.9%	0.674
There are trees	3.62	3.52	0.387	Cleaner streets	10.6%	9.6%	0.690
There are walking trails	2.85	2.75	0.406	More bus stops	4.4%	2.6%	0.212
Neighborhood is attractive	3.79	3.70	0.362	More parks and trails	29.9%	28.9%	0.777
There are commercial areas	3.35	3.27	0.499	Better/more sidewalks	29.6%	32.3%	0.456
There are people walking	4.07	4.09	0.835	Better/more crosswalks	13.5%	12.5%	0.705
Overall rating	3.94	3.94	0.967	More trees	9.1%	8.6%	0.813
				More stores	20.8%	18.8%	0.513
				Nothing	30.3%	24.0%	0.070*

Note: ANOVA = analysis of variance.
*Significant at 90% confidence interval.
**Significant at 95% confidence interval.
***Significant at 99% confidence interval.

Surprisingly, the model results did not find any significant effects of feeling safe on walking for men or women. However, seeing people walk in the neighborhood has a positive association with the number of days that men walk. Having places to sit in the neighborhood was negatively associated with the number of days women walk, perhaps because persons may be perceived as loitering and suspect by women.

Finally, as expected, the demographic variables of age and presence of children in the household had a negative impact on women's walking.

Focus Group Results

The focus groups conducted in all three communities further emphasized the gender differences in walking behavior, perceptions of the environment, and attitudes about walking found in the survey questionnaire.

Comments made during the focus groups confirmed the safety concerns of women. Most men did not even engage in the conversations that centered on safety issues. In Turner Station, all comments related to safety were made by women. They noted both problems in lighting and lack of infrastructure such as sidewalks:

> I think the lighting would help in certain areas. We have certain areas where there's no lighting in the back, like the back of the houses, and I think that more should be put into that project in Turner Station because there are some dark areas and we're not going through those areas, and we might as well face it, there are drugs and other transactions and, you know, illegal things going on.

The emphasis on safety was also made by women in Bel Air: "And I think that if we had more areas that felt safer to walk, there would be more walking in Bel Air." Reflecting the findings of the survey, many women spoke at the focus groups about walking with friends and family rather than alone.

In contrast, safety concerns did not seem to have much of an impact on men's walking behavior, as evidenced by this comment from a male College Park resident: "Come on! What is going to happen in the city? This is a really quiet place . . . same thing with walking, I just go out and do it."

The distribution of walking activity by sex was also further emphasized in the focus groups. Very few women reported being completely sedentary. Many women in all three communities had some kind of exercise regimen that they said they tried to keep going. One woman in Turner Station, for instance, said, "I walk for exercise. I have a car and I use it a lot. I like to walk on the track, I have a track a couple blocks away from my house." However, with the exception of one woman in College Park, none of the women said that they walked more than one mile on a typical day. In

TABLE 5 Regression Models for Distance Walked per Day and Days Walked per Week

	Distance Walked per Day: Ordered Logit				Days Walked More than 10 Minutes Per Week: Poisson			
	Men		Women		Men		Women	
	Coef.	Z	Coef.	Z	Coef.	Z	Coef.	Z
Reasons for Walking								
Health/exercise	1.622	4.566	0.624	2.343***	0.242	3.111***	0.180	2.662***
Enjoy nature	0.258	0.625	0.205	0.672	0.016	0.166	0.154	2.088**
Pet	0.015	0.024	0.593	1.469	0.168	1.205	0.163	1.568
Means of transport	0.486	1.076	0.714	2.004**	0.037	0.339	0.208	2.331**
Inexpensive mode	0.225	0.549	0.209	0.515	0.097	0.983	–0.045	–0.473
Relaxation	–0.350	–0.887	0.826	2.920***	0.040	0.434	0.215	3.039***
Accompany family	0.222	0.597	–0.182	–0.627	0.017	0.189	0.060	0.857
Most convenient mode	0.688	1.825*	0.001	0.004	0.061	0.687	0.025	0.311
Perceptions of the Environment								
Drivers drive at safe speeds	0.177	1.173	–0.095	–0.732	–0.008	–0.227	0.016	0.524
Drivers yield to pedestrians	–0.256	–1.431	–0.204	–1.452	–0.006	–0.151	–0.038	–1.121
Sufficient traffic signals	–0.452	–2.713***	0.150	1.186	–0.040	–1.100	0.013	0.423
Traffic signals allow time to cross	0.101	0.594	0.070	0.573	0.031	0.808	0.017	0.575
Sufficient curb cuts	0.199	1.196	0.257	1.908*	–0.022	–0.554	0.055	1.647*
Sufficient street lighting	–0.085	–0.634	–0.053	–0.498	–0.027	–0.850	–0.035	–1.295
Feel safe	0.118	0.630	0.072	0.552	–0.037	–0.868	–0.029	–0.898
Dogs are kept on leash	–0.106	–0.657	–0.108	–0.863	0.001	0.015	–0.009	–0.289
Sufficient sidewalks	0.243	1.502	–0.077	–0.610	0.084	2.349***	–0.051	–1.631
Sidewalks are in good condition	0.032	0.168	0.134	0.829	–0.041	–0.952	0.028	0.696
Sidewalks are clean	0.093	0.546	–0.195	–1.324	–0.013	–0.321	–0.024	–0.640
Sidewalks are kept free of snow	0.123	0.800	0.032	0.268	–0.006	–0.158	0.016	0.509
Places to sit	–0.060	–0.426	0.047	0.399	–0.001	–0.019	–0.065	–2.230**
Trees	0.009	0.056	0.065	0.450	0.003	0.086	0.023	0.638
Walking trails	0.078	0.680	0.038	0.390	–0.007	–0.269	0.008	0.337
Neighborhood is attractive	–0.039	–0.212	0.196	1.243	0.038	0.917	0.006	0.156
Commercial areas	0.392	3.045***	0.204	1.734*	–0.007	–0.213	–0.008	–0.253
People walking	0.227	1.275	–0.046	–0.316	0.076	1.725*	0.022	0.601
Overall rating	0.032	0.212	0.098	0.828	–0.029	–0.762	0.064	2.010**
Sociodemographic Characteristics								
Child under 5 in household	–0.379	–0.682	–0.769	–2.265**	–0.096	–0.722	–0.143	–1.623
Pet in household	0.426	0.906	–0.014	–0.040	0.027	0.240	–0.054	–0.570
Driver's license	0.350	0.596	0.746	1.577	0.103	0.772	0.165	1.495
Car ownership	–0.030	–0.047	–0.258	–0.558	0.078	0.569	–0.250	–2.273**
Car as primary mode of transport	–0.466	–0.849	–0.435	–0.994	–0.224	–1.830*	0.043	0.408
Age	–0.107	–1.162	–0.170	–2.186*	–0.036	–1.600	–0.051	–2.470**
Constant					1.352	4.654	1.248	5.144
N	221		285		221		285	
Log-likelihood	–243		–335.4		–482.8		–585.3	
Pseudo R^2	0.2		0.1		0.1		0.1	

*Significant at 90% confidence interval.
**Significant at 95% confidence interval.
***Significant at 99% confidence interval.

contrast, a number of the men said they did not walk at all, such as this Bel Air man: "I don't walk. I would like to, but just I work all the way in Pennsylvania, I drive 102 miles a day, I never seem to have the time. Weekends, I've always got so many things to do around the house."

Perceptions of neighborhood destinations seemed to be different by sex in all three communities. Generally, women spoke much more about the existence and accessibility of stores and other attractions along their walking routes. In contrast, the men hardly spoke of store accessibility. Instead, they spoke of walking almost exclusively in the contexts of work, transportation (as part of an intermodal trip involving car or bus), or exercise. The lack of destinations was only mentioned by women, like this one in Turner Station: "Destinations. We don't have anywhere to walk to. I walk to church which is really not that far from where I live. But we don't have any stores."

Overall, the focus groups conducted in the three communities punctuated the findings of the survey. This similarity was particularly true for safety issues, regarding both crime and traffic. Women were much more invested in these issues than men. Perceptions of the environment were also very different by sex, as they were in the survey.

Discussion of Results

The study described shows that there are a number of significant gender-related differences in walking behavior, perceptions of the environment, and attitudes about walking. Clearly, the three issues are related, since behavior is influenced by attitudes and perceptions, and (perhaps) vice versa. Regarding safety in particular—related to both traffic issues and crime—women tend to be more concerned with these factors, more sensitive to safety risks in the environment, and more likely to alter their walking behavior to conform to their assessment of their walking environment. Behavior also differs among the sexes in destinations for walking and, to a smaller extent, reasons for doing so.

These results point to possible policy implications: by creating safer environments, or environments that feel safer, and providing destinations for walking, walking behavior could be increased. For instance, improving lighting, adding sidewalks, and increasing eyes on the street might make women feel safer and consequently more likely to walk. Increased destinations of interest, such as stores, would strengthen that effect even more. Conversely, by educating women on environmental conditions—without necessarily an intervention in the environment—perceptions might be changed and walking increased. Indeed, the relationship between perceptions and walking might exist in both directions. This relationship would mean that interventions not only directly on the environment but also indirectly through education could be successful in increasing walking.

This study illustrated some of the gender differences surrounding pedestrian issues, with an emphasis on subjective factors. Further examination of the relationships among perceptions, attitudes, and behaviors would benefit by the addition of objective measures of the built environment. As well, women are not a homogenous group, and more disaggregate analysis of women's perceptions by age, race, and life cycle is needed.

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Women's Travel Behavior and Land Use
Will New Styles of Neighborhoods Lead to More Women Walking?

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Many travel behavior researchers have explored the links between land use characteristics and travel patterns. Several of them have demonstrated that certain patterns, such as density, mixed uses, and street connectivity, are associated with fewer or shorter vehicle trips, or both. There is also a considerable body of literature demonstrating the differences between men's and women's travel patterns. Yet less effort has been devoted to examining how land use may interact with sex to influence travel outcomes. If land use does affect travel, does it affect men's and women's travel differently? In particular, will both women and men take advantage of the walkable features of new urbanist neighborhoods? This study examines these questions in more detail through empirical analysis of land use and travel data. The relationships between walking behaviors, land use, and sex are emphasized. The findings reveal that women in new urbanist neighborhoods may walk more than do women in less walkable environments. However, men appear more likely to respond to these environments and walk more than their female counterparts. Land use and urban design may also remove some of the current barriers to women's walking, particularly safety concerns; however, the results indicate that women's ability or inclination to walk may be rooted in other reasons, such as family responsibilities.

Many travel behavior researchers have explored the links between land use characteristics, the built environment, and travel patterns. Several of them have demonstrated that certain features, such as higher densities, a mixture of uses, and increased street connectivity, are associated with fewer or shorter vehicle trips, or both, and more pedestrian trips. Many of these features are incorporated into the concepts of smart growth, new urbanism, neotraditional development, transit-oriented development, and a host of similar trends that share the objective of reducing the use of automobiles for travel in favor of walking, bicycling, or transit. These new styles of development draw heavily on concepts from pre–World War II development, when automobiles were a less dominant mode, and include higher residential densities, a mix of land uses often centering on commercial centers, a gridlike street network, and more accommodation for alternative modes. The research linking these neighborhood styles to travel often compares those who live in neighborhoods with characteristics such as high density and mixed land uses with those who do not. Thus far, the focus has been on overall differences in travel with and without those characteristics. More recent research is examining why people choose to live in these new types of neighborhoods and how attitudes may also influence travel.

At the same time, there is a considerable body of literature demonstrating the differences between men's and women's travel patterns. Less effort has been devoted to examining how land use may interact with sex to influence travel outcomes. Examining these interactions is useful for several reasons. The purported benefits of these new styles of development are both personal and societal. For example, personal benefits may include increased physical activity and improved health. A recent summary of the literature on physical activity and the built environment was conducted by the Transportation Research Board and the Institute of Medicine (*1*). The collection of studies reviewed consistently shows that women in general tend to be less physically active than men. It is important to understand why this is the case and if the built environment presents barriers to or opportunities for women and men differently.

Societal benefits may include reduced pollution, energy use, and infrastructure costs, among others. Without a better understanding of such travel issues as why people are traveling differently and who is traveling differently, it is difficult to make informed policy and planning choices. If research conclusions are based on the general population yet the demographics of those who actually live in the new types of neighborhoods differs from those of the general population, the societal benefits may also differ. In addition, studying different subgroups, such as men and women, can help the understanding of why travel behavior may differ. If one sex is affected more than the other, it would be enlightening to look deeper at the factors that influence that sex's travel decisions; those factors might help explain why travel differs on the basis of the built environment. Therefore, in this study these questions are asked: If land use does affect travel, does it affect men's and women's travel differently? In particular, will both women and men take advantage of the walkable features of new urbanist and similar styles of neighborhoods? These questions will be examined in more detail through empirical analysis of land use and travel data, emphasizing the relationships between walking behaviors, land use, and sex.

Literature Review

The volume of research linking land use and travel patterns has increased in the past decade with the interest in applying land use policies (e.g., new urbanism and smart growth) to reduce motor vehicle travel and its negative impacts. The results of this research are mixed. Several studies have looked at residential neighborhoods, trying to relate travel to combinations of land use patterns and design elements. For example, Cervero and Kockelman (*2*) found that land use characteristics were a stronger predictor of mode choice for nonwork trips compared with commute trips and concluded that "higher densities, diverse land uses, and pedestrian-friendly designs, we believe, must co-exist to a certain degree if meaningful transportation benefits are to accrue" (*2*, p. 217). Other studies also support the notion that neotraditional types of land use measures are related to lower levels of personal vehicle travel or higher levels of walking (*3–11*) or higher levels of transit use (*12–15*).

Studies supporting the link between land use patterns and reduced vehicle use are not without critics. Some of these studies—for example, the one by Newman and Kenworthy (*9*)—are criticized for not controlling for factors such as income, gasoline prices or other user fees, and transit service (*16*). Crane (*17*) hypothesized that most of the elements of new urbanism could either increase or decrease vehicle trips, vehicle miles of travel, and mode split, particularly when all elements are combined. For example, if trip lengths (and therefore times) decrease because of a grid street pattern, the number of trips may increase because automobile trips are a normal good (i.e., demand increases with resources, including time). In addition, several studies fail to support certain neotraditional land use concepts (*18*, *19*).

Although there is a fair amount of research exploring differences between men's and women's travel, there is little research on whether land use may affect men's and women's travel patterns differently. Most of the research on land use and travel uses sex as a control variable. There is general agreement that women's travel patterns differ significantly from those of men (*20*). Some of the differences stem from family roles and household structure. For example, by using the 1990 Nationwide Personal Transportation Survey, Rosenbloom (*20*) found that the presence of children in the household affected women's travel far more than men's. In addition, women tend to trip-chain more than men (*21*). Spain (*22*) concluded that because women are more likely to work part time, to be responsible for household chores and child care, and to work in interruptible spaces and jobs, they need more travel flexibility than men. Cars provide that flexibility, along with enhancing a sense of safety often not found with transit.

Some research has examined the interactions between sex, land use, and travel. Using data from the Atlanta region, Helling (*23*) found that individuals and households living in more accessible areas spent fewer minutes traveling but that among individuals the effect was seen primarily for employed men. In a study examining walking and physical activity, De Bourdeaudhuij et al. (*24*) found that walking was positively correlated with diversity of land use, ease of walking to a transit stop, access to local shopping, and emotional satisfaction with a neighborhood but not with presence of sidewalks or satisfaction with neighborhood services. With data from neighborhoods in Austin, Texas, Handy (*25*) found that women walked to the store fewer times per month than men. She attributed this finding as perhaps due to women's greater household responsibilities and time constraints. Both men and women living in a traditional neighborhood walked more than those living in more modern, suburban neighborhoods, though household type and attitudes played a large part as well. For example, women without children walked to the store more often than other women did. Handy concluded that creating accessible environments would help both men and women by allowing them to drive shorter distances or walk more often. She also emphasized the need to create safer environments, both in fact and in perception.

The literature reveals that three factors may distinguish men's and women's travel with respect to land use. Two of these are related to time. The direction of the impact of these factors on travel is perhaps less clear. First, women, particularly women with children, may have more time constraints brought on by different household responsibilities. This factor leads to more trip chaining. The mixed uses promoted by new urbanism and smart growth could benefit women by locating multiple destinations in one place. This arrangement might enable them to walk instead of drive or to drive shorter distances. However, if time is more constrained for women, walking may not be an attractive option. Increased densities may also reduce travel times. Second, women may need more flexibility in their travel, thus affecting their mode choice. Flexibility can be related to time but also to features of the travel mode, for example, space for passengers and goods. Generally, a private vehicle provides a high level of flexibility. Third, women may be more concerned about personal safety. The question is whether these new styles of neighborhoods can provide the perception and reality of a safe walking environment.

Research Approach and Data Sources

Four elements of land use that are commonly found in new urbanism, smart growth, and related concepts that should promote more walking are examined here: (*a*) a pedestrian-friendly environment; (*b*) higher-density, compact neighborhoods that shorten walking distances to destinations; (*c*) a mix of uses; and (*d*) access to parks within neighborhoods. In addition, many other factors, particularly sociodemographic characteristics, influence travel decisions. These factors are examined in combination with the land use factors.

It is rare that a single, existing data source includes all of the variables necessary to adequately analyze the factors identified. Therefore, four different data sources were relied on. Three of the sources are large-scale travel or activity surveys covering a range of land uses. The fourth is a travel survey of residents in a new urbanist neighborhood. Each of the four elements of new urbanism is examined by using the data sets that include the best matching variables, and different sources are compared when possible.

The first data source is the 2001 National Household Travel Survey (NHTS), conducted by the U.S. Department of Transportation. The survey includes demographic characteristics of households, people, and vehicles and detailed information on daily and longer-distance travel for all purposes by all modes. NHTS survey data are collected from a sample of 26,038 U.S. households and expanded to provide national estimates of trips and miles by travel mode, trip purpose, and a host of household attributes. In an effort to increase information about nonmotorized transport, the NHTS respondents are asked how many walking trips they made in the past week and several attitudinal questions in addition to the trip-level information on the travel day.

In addition to the national sample, a number of jurisdictions were oversampled to provide sufficient numbers for regional travel modeling. In this study, the Baltimore-area NHTS add-on survey was used to analyze pedestrian trips, but data were limited to those 1,536 households residing within the city of Baltimore. These data were enhanced with local land use data at the census-tract level, including population density and percentages of park land, households within ¼ mi of bus transit, and households within ¼ mi of commercial uses.

The third source is the 1994–1995 Portland regional activity survey, conducted by Metro, the regional transportation and land use planning agency for the Portland, Oregon, metropolitan area. The data include 7,784 adults, almost equally split between men and women (3,747 and 4,037, respectively). Household members were asked to record their activities for 2 days. This analysis focuses on activities that involved travel to get to the activity. Each household was categorized by Metro on the basis of the land use characteristics of the transportation analysis zone in which it was located. For the purposes of this analysis, the original 12 categories were collapsed into five land use categories:

1. Multnomah County, urban with transit, good pedestrian environment factor (PEF) and land use mix (LUM): These zones include downtown Portland, the denser parts of northwest Portland, and inner-southeast neighborhoods.
2. Multnomah County, urban with transit, bad PEF: This area includes primarily southwest Portland.
3. Multnomah County, urban with transit, good PEF: These zones include most of the inner north, northeast and southeast Portland neighborhoods, primarily built before World War II.
4. Multnomah County, light rail corridor: These zones include areas around the east-side MAX stations, from Lloyd Center to Gresham.
5. The rest of Multnomah County and region.[1]

[1] Households sampled as park-and-ride users at light-rail stations were excluded.

For the purposes of this analysis, Land Use Categories 1 and 3 (LU 1 and 3) are considered to most closely resemble new urbanist neighborhoods. These are primarily older, pre–World War II neighborhoods.

The final source of data is a survey conducted in 2003 by one of the authors (Dill). The survey included 138 adults living in a new urbanist neighborhood in the Portland region, Fairview Village. Fairview Village includes detached single-family houses, attached town homes and row houses, duplexes, and apartments, along with some neighborhood retail shops, a post office, library, city hall, and Target store. About half of the residential land area is within a ¼-mi walking distance of the central commercial area and nearly all is within ½ mi. The neighborhood exhibits the design features expected in a new urbanist neighborhood, including sidewalks, attractive street furniture, narrow streets, walking paths and bridges, street trees, and crosswalks. Along with demographic information, the survey asked several questions about travel in the past week and overall habits.

FINDINGS

Pedestrian Environment

A good pedestrian environment, including such amenities as sidewalks, easy and safe street crossings, and aesthetically pleasing features, is a common component of new urbanism, smart growth, transit-oriented developments, and related styles of development. Would a good pedestrian environment affect a woman in her choice to walk in a different manner than it would a man? If women are more concerned about personal safety, a good pedestrian environment may have a more significant impact on their decision to walk than it would on men. Two aspects of safety are important here—not being hit by a motor vehicle and not being the victim of a crime. The latter impact might be more significant for women than for men. Infrastructure such as sidewalks, curb extensions, and crosswalks focuses on reducing the incidence of being hit by a motor vehicle. Whether these features also improve the perception of safety from crime is unclear. Some features, such as lighting, can clearly affect both aspects of safety.

In the 2001 NHTS respondents were asked about various problems related to their travel, including the lack of walkways or sidewalks. Respondents were asked whether this was not a problem, a little problem, somewhat of a problem, and so forth, in their day-to-day travel. Overall, the lack of walkways and sidewalks was more of a problem for women (Table 1). The difference in the proportion of women stating that it was very much a problem or a severe problem compared with that of men was statistically significant at the 0.01 level.

Because one of the objectives of these new development styles is to encourage people to switch from driving to walking, it is useful to look at drivers separately. The last four columns of Table 1 divide drivers between those who made a walking trip in the past week and those who did not. Those who have made a recent walking trip may be more familiar with the pedestrian environment. Women drivers who had made a walking trip in the past week were about equally as likely to say that the lack of walkways and sidewalks was very much or a severe problem (18.7%) as women who had not made a walking trip (18.9%). This result compares with 13.3% and 10.7% of the men, respectively. In addition to the data in Table 1, of the women drivers who said that the lack of sidewalks was a severe problem, 30.4% did not make a walking trip in the past week compared with 24.4% of the men. For women stating that the lack of sidewalks was very much a problem, 34.0% did not make a walking trip compared with 22.6% of the men. These findings suggest that the lack of walkways and sidewalks

TABLE 1 Problems with Lack of Walkways and Sidewalks, Women Versus Men: 2001 NHTS, National Sample

	All Adults		Drivers Who Did Not Make a Walking Trip in the Past Week		Drivers Who Did Make a Walking Trip in the Past Week	
	Women	Men	Women	Men	Women	Men
Not a problem	50.2%	57.4%	54.3%	63.3%	48.6%	55.3%
A little problem	16.8	17.6	14.7	15.2	18.3	19.5
Somewhat of a problem	13.4	11.0	11.4	9.5	14.2	11.5
Very much a problem	7.9	5.8	8.3	4.5	7.5	5.9
A severe problem	11.2	7.3	10.6	6.2	11.2	7.4
Very much or severe	*19.1*	*13.1*	*18.9*	*10.7*	*18.7*	*13.3*
Refused	0.0	0.1	0.1	0.0	0.0	0.0
Don't know	0.5	0.7	0.6	1.2	0.2	0.4
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
N (unweighted)			4958	3339	7354	5903

Note: Percentages represent weighted data. Row in italics is total of two previous rows.

TABLE 2 Problems with Lack of Walkways and Sidewalks, Women Versus Men: 2001 NHTS, Baltimore Add-on

	All Adults		Drivers Who Did Not Make a Walking Trip Last Week		Drivers Who Did Make a Walking Trip Last Week	
	Women	Men	Women	Men	Women	Men
Not a problem	63.9%	67.2%	63.5%	65.9%	72.7%	71.4%
A little problem	15.9	16.1	21.8	18.3	4.5	17.9
Somewhat of a problem	9.5	8.8	7.1	8.5	9.1	7.1
Very much a problem	4.0	4.4	1.9	3.7	9.1	0.0
A severe problem	6.7	3.6	5.8	3.7	4.5	3.6
Very much or severe	*10.7*	*8.0*	*7.7*	*7.4*	*13.6*	*3.6*
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
N	252	137	156	82	22	28

Note: Row in italics is total of two previous rows.

may be suppressing women's walking activity more than that of men.

Analysis of the Baltimore NHTS data reveals some similar trends but with smaller or no differences between sexes, as shown in Table 2. Overall, both men and women are more satisfied with the pedestrian environment. This result may indicate that there are more sidewalks in the Baltimore region or that there are differences in the desire for such facilities. Although Baltimore women were less satisfied with the pedestrian environment than the men were, the difference is less pronounced than it is in the national data. Those women who indicated some walking activity the week before the survey were more likely to say that the lack of sidewalks was not a problem compared with those who did not walk the previous week (72.7% versus 63.5%). And women not making a walking trip the previous week were about equally as likely as men to say that the lack of sidewalks was a problem (7.7% versus 7.4%). This lack of a difference between the sexes, compared with the difference in the national data (18.9% versus 10.7%), may indicate that when more sidewalks are provided, this aspect is no longer a bigger barrier for women.

From the fourth data source, the residents in Fairview Village were asked whether they walk more often in their current neighborhood compared with where they used to live. Over three-fourths (75.5%) of the women said that they did compared with 63.4% of the men. Respondents could then complete an open-ended question describing why they walked more (or less). Women were more likely to list safety issues (28.8% versus 15.6%). In addition, 10% of the women listed a reason related to the amount of traffic compared with none of the men.[2] Aesthetic reasons (e.g., "it's prettier") were cited by 16.3% of the women and 11.1% of the men. These differences between men and women were all significant at the 0.05 level. There was no significant difference between men and women listing something about pedestrian infrastructure, such as the presence of sidewalks (21.3% of women and 24.4% of men). The results indicate that these women were more likely to walk more after moving to the new urbanist neighborhood compared with men and that the physical environment was a factor in that behavior change.

Density

Increasing density may increase walking by making destinations closer. However, as many other researchers have noted, density is often a proxy variable that represents other factors. For example, transit service is likely to be higher in higher-density neighborhoods. Neighborhoods of higher residential density may also have a greater mix of land use types, such as shops and services. Unfortunately, good data representing these other factors are not available for the 2001 NHTS nationwide sample. For example, the 2001 NHTS land use data released in January 2004 included a variable "jobs per square mile" that implied it would be a measure of mixed use. However, a recent erratum explained that the variable is really the number of employed people living in the census tract (*26*). The data do include household and population density by census tract and block group.

With the nationwide 2001 NHTS data, Figure 1 shows that the number of walking trips per week is lowest at the middle range of densities and is highest in areas with 5,000 or more housing units per square mile. At all densities, men made significantly more walking trips than women in the previous week ($p < 0.01$). Most new urbanist and similar neighborhoods are unlikely to be built at the highest density level; they are more likely

[2] The "amount" could be higher or lower. The responses were not always specific, though it is likely that the women were walking more because of less traffic.

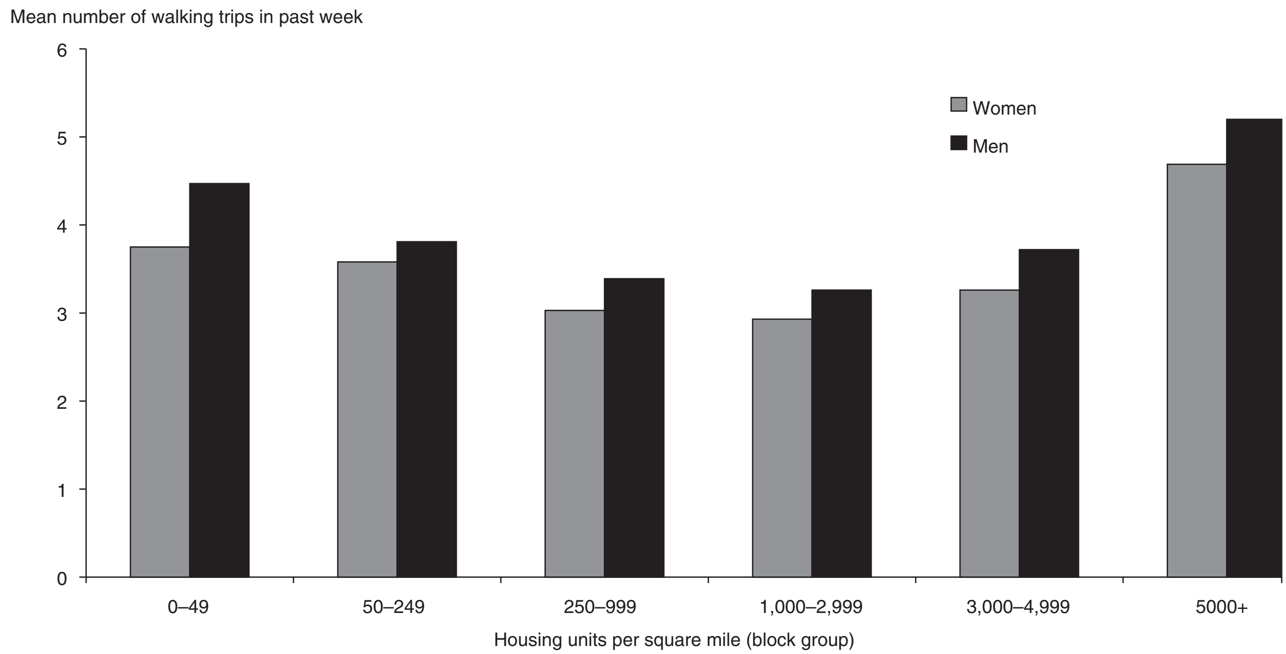

FIGURE 1 Walking and housing density, women versus men: 2001 NHTS, national sample.

to be at the densities in the middle range, which show the lowest levels of walking. This finding may reinforce the conclusions of other researchers that considering only density overlooks many other important factors. For example, the second-highest level of walking occurs at the lowest density range, 0 to 49 units per square mile. In these more rural areas, are people walking more because of a lack of traffic, the proximity of other land uses in a small town, or the presence of natural areas, or because of all three of these features? If the reason is these features, they closely resemble those of some new urbanist developments, although those new developments have higher residential densities.

Land Use Mix

A key feature of new urbanism is a mix of land uses, including everyday activities such as shopping, going to school, and visiting parks. The data from Portland indicate that women in the more walkable neighborhoods are making significantly more walking trips, both for utilitarian and recreational purposes, than women in other neighborhoods (Table 3). However, women living in the "best" walking environment (LU 1), with a good pedestrian environment and land use mix, walk less than men in those neighborhoods. Men appear to be talking more advantage of the walkability of the neighborhoods in LU 1. In particular, they are making more utilitarian walking trips and are making a higher share of their trips on foot.

One question is whether women are not walking as much as men in LU 1 because of safety concerns. Many of these neighborhoods are downtown. Another explanation may be demographic differences. However, Table 3 includes only households with vehicles, eliminating many of the lowest-income households that may live downtown (e.g., men living in single-room-occupancy hotels). In addition, few of these households had children. In LU 3, which also has a good pedestrian environment but not as high a land use mix, women are walking about the same amount as men. These neighborhoods are in the inner suburbs, usually along historic streetcar lines with some commercial activity, which may seem safer than downtown. These neighborhoods may more closely resemble new urbanist developments, which are unlikely to reach the densities of downtown Portland.

Parks and Exercise and Leisure Trips

One principle of new urbanism is to provide a range of types of parks in or near a neighborhood. In Baltimore, men and women revealed similar numbers of walking trips for the purpose of exercise and leisure, with 5.5% of men's walking trips and 5.1% of women's made for this purpose. As the interest in physical activity and the built environment increases, the relationship between walking activity and the provision of parks and other places for this purpose is an important question for investigation. The Baltimore tracts were classified as to

TABLE 3 Differences in Walking Behavior by Land Use: Portland Adults Who Made Trips from Households with Vehicles

	Total # trips	# of walking trips	# utilitarian walking trips	# of rec. walking trips	% trips walking	% that made a utilitarian walk trip	% that made a rec. walk trip	n
1: Multnomah County, urban w/transit, good PEF & LUM								
Women	8.65	**1.64**	**1.29**	0.23	**18.8%**	41.8%	17.9%	184
Men	8.86	**2.38**	**1.90**	0.32	**24.8%**	49.0%	22.6%	208
2: Multnomah County, urban w/transit, bad PEF								
Women	8.79	0.57	0.42	0.12	5.8%	18.8%	7.9%	292
Men	8.23	0.47	0.37	0.08	5.1%	15.7%	5.8%	292
3: Multnomah County, urban w/transit, good PEF								
Women	8.41	0.99	0.80	0.13	11.0%	28.3%	10.9%	515
Men	8.23	0.86	0.72	0.09	10.3%	27.7%	7.4%	447
4: Multnomah County, light rail corridor								
Women	**8.44**	0.60	0.46	0.09	6.9%	18.2%	7.2%	373
Men	**7.57**	0.47	0.38	0.08	5.4%	15.6%	5.7%	366
5: Rest of region								
Women	**7.90**	0.47	0.36	0.09	5.9%	16.1%	7.2%	2054
Men	**7.42**	0.49	0.38	0.09	6.2%	14.7%	6.6%	1893

Bold: difference between men and women significant at 0.05 level. For both men and women, the differences between neighborhoods are all significant below the 0.01 level.

access to parkland as low (0 to 10% of land area), medium (10% to 40%), or high (over 40%). The differences in walking trips between men and women for areas with low and medium park access are similar, as shown in Figure 2. However, in the areas with highest park access, men make an overwhelmingly higher number of daily walking trips than women, perhaps reflecting women's concerns about safety. Men may feel safer walking in or near some parks. In addition, in areas with such a high percentage of land devoted to parks, there may be less of a mix of other land uses, such as commercial, or other correlate with land use, which may suppress women's walking behavior. Closer examination is necessary to determine a satisfactory explanation.

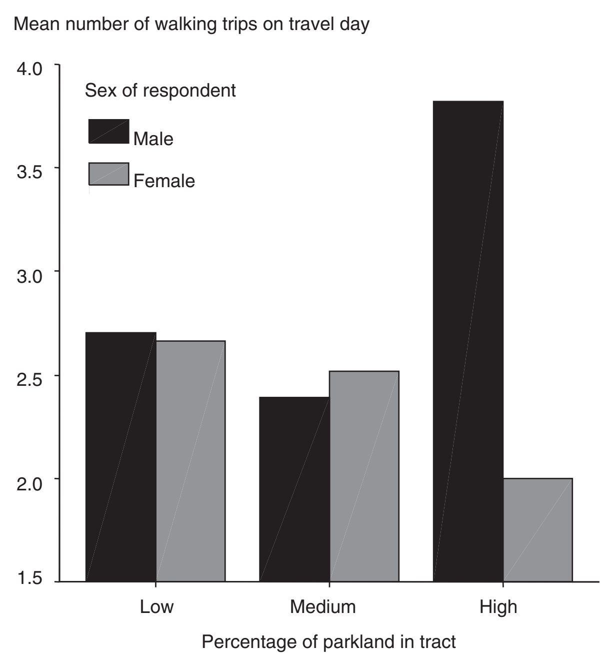

FIGURE 2 Walking and parks: 2001 NHTS, Baltimore Add-on.

Multivariate Models

As most researchers have found, demographic factors (particularly income) can overwhelm, explain, or alter relationships between travel and land use. Therefore, it is useful to perform a multivariate analysis that attempts to control for such factors. For the Portland data, a binary logit model was estimated to predict the likelihood that an adult would make a walking trip for a utilitarian purpose (not for recreation or exercise). As shown in Table 4, several factors decrease the likelihood of taking a utilitarian walking trip for both men and women: having one or more vehicles per adult in the household, higher income, and increasing age. Having one or more children under 16 in the household was only a significant factor for men, decreasing their likelihood of utilitarian walking. In contrast, being a licensed driver was a significant factor for women and not for men. Residing in LU 1 had a significant, positive association (relative to LU 5) with utilitarian walking for both men and women but was slightly higher for men. Residing in LU 3 also had a positive relationship with utilitarian walking, but slightly more so for women.

The finding in Portland that having a child under 16 in the household is not associated with significantly less utilitarian walking for women bodes well for the new urbanism and smart growth concepts. One hypothesis is

TABLE 4 Binary Logit Model of Taking Utilitarian Walking Trip: Portland Adults Who Made Trips

	Women			Men		
	b	exp b	Sig.	b	exp b	Sig.
Constant	0.107	1.113	0.734	0.279	1.321	0.427
One or more vehicles per adult in household	**–0.314**	**0.731**	**0.008**	**–0.651**	**0.522**	**0.000**
Household income (natural log, $1000)	**–0.152**	**0.859**	**0.035**	**–0.163**	**0.849**	**0.045**
Age (years)	**–0.007**	**0.993**	**0.015**	**–0.011**	**0.989**	**0.001**
Child under 16 in household (1 = yes)	–0.174	0.840	0.129	**–0.281**	**0.755**	**0.027**
Licensed driver (1 = yes)	**–0.579**	**0.560**	**0.001**	–0.338	0.713	0.117
Resides in Land Use Stratum 1: urban with transit, good pedestrian environment factor (PEF) and land use mix (LUM)	**1.341**	**3.823**	**0.000**	**1.589**	**4.898**	**0.000**
Resides in Land Use Stratum 2: urban with transit, bad PEF	0.284	1.329	0.115	0.223	1.250	0.244
Resides in Land Use Stratum 3: urban with transit, good PEF	**0.770**	**2.160**	**0.000**	**0.656**	**1.927**	**0.000**
Resides in Land Use Stratum 4: light rail corridor (not in LU 1, 2, 3)	0.164	1.179	0.295	0.183	1.201	0.259
Nagelkerke R^2	0.089			0.132		
N	2901			2745		

Note: Bold type indicates results significant at the 0.05 level.

that travel patterns for women with children are too complicated and time-sensitive to allow for walking even if the destinations were convenient, such as those in a new urbanist neighborhood. In fact, for households with children and at least one vehicle in LU 3, women made an average of 1.09 walking trips compared with 0.62 for men, a significant difference.[3] These women also made a higher share of their total trips on foot (11.4% versus 6.7% for men). This finding may indicate that having children in a walkable environment is conducive to more walking. About half of the walking trips made by women with children living in LU 3 included at least one other person compared with 37% of the women without children in LU 3.

For the Baltimore data, Poisson models (segmented for men and women) were estimated for the total number of walking trips made during the travel day. The results are shown in Table 5. Of the policy variables of interest, street connectivity, defined here as the street network density in a ¼-mi buffer around the residential area, was significantly associated with lower numbers of walking trips for both men and women, which is a somewhat surprising result. However, land use mix had a positive and significant affect on walking rates for both men and women. Greater housing unit density and percentage of vacant housing negatively affected walking rates, but these variables were only significant for the model for men.

The results also show some interesting differences for other factors. For example, age was associated with lower rates of walking in women, which may be a result of increased household responsibilities and obligations. Women who were temporarily absent from work had higher rates of walking, perhaps because of more leisure time associated with a vacation or utilitarian walking due to a disabled vehicle. The ability to drive and student status were significant and negatively associated with less walking in men but not women in the sample. Longer commute distance is associated with less walking for both sexes; possessing a graduate degree increased women's walking significantly but not that of men.

Finally, differences in attitudes may be different for the sexes. Women who are more concerned about congestion, drunk driving, and gasoline prices appear to have higher rates of walking activity. However, the direction of this relationship may be confounded by the endogenous nature of these variables. Higher rates of walking may accentuate these issues for women or their concerns may change their behaviors and lead to more walking.

Conclusions and Future Research

The support for smart growth, new urbanism, and similar concepts is growing, with more and more local governments adopting regulations and programs to implement the concepts and more developers building in these new styles. These efforts are motivated in part by claims that these types of communities can reduce reliance on automobiles and promote physical activity and therefore improve people's health. It is unlikely that these claims are equally true for everyone. Understanding whether men and women are influenced differently by new urbanist land use features can help explain

[3] There were not enough households with children in LU 1 to examine the difference.

TABLE 5 Poisson Model of Number of Walking Trips per Day: 2001 NHTS, Baltimore Add-on

	Model 1: All Records		Model 2: Men		Model 3: Women	
Variable Name	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value
Household Characteristics						
Vehicles per person	–0.31***	–4.46	–0.33***	–3.28	–0.24***	–2.36
Bikes per person	0.28***	5.90	0.33***	5.04	0.21***	2.79
Housing type						
Detached SF house	–2.19***	–3.52	–1.74**	–2.61	–1.55***	–3.57
Duplex/triplex	–2.36***	–3.69	–2.25***	–3.17	–1.36***	–2.87
Row house	–2.22***	–3.58	–2.04***	–3.06	–1.33***	–3.12
Apartment	–2.09***	–3.38	–1.79***	–2.71	–1.21***	–2.89
Dorm	–0.82	–1.15				
Semi-attached	–16.83	–0.01	–15.93	–0.01	–21.33	0.00
Boat	–17.68	–0.01	–16.91	–0.01		
Home ownership	0.10	1.57	0.12	1.20	0.07	0.86
Income (> $30K)	0.16***	2.96	0.13*	1.65	0.15**	2.11
Individual Characteristics						
Age	–0.01***	–3.10	0.00	–1.17	–0.01***	–3.48
Driver status	–0.31***	–4.40	–0.24**	–2.13	–0.41	–4.30
Primary activity						
Working	–0.06	–0.32	–0.40	–1.39	0.24	0.97
Temp. absent from work	0.26	1.17	–0.23	–0.65	0.64**	2.16
Looking for work	0.19	1.23	0.05	0.23	0.37	1.42
Homemaker	–0.10	–0.67	0.33	0.71	0.04	0.22
Going to school	–0.43***	–3.44	–0.89***	–3.80	–0.19	–1.17
Retired	–0.02	–0.15	–0.16	–0.68	0.17	0.78
Something else	–0.14	–1.04	–0.28	–1.50	0.00	0.00
Full-time employee	–0.37***	–4.22	–0.34**	–2.32	–0.38***	–3.26
Occupation						
Sales/service	–0.10	–0.66	0.08	0.30	–0.34*	–1.81
Clerical/admin	0.16	0.98	0.38	1.22	0.01	0.06
Manufact/construct	–0.18	–1.01	–0.11	–0.41	–0.28	–0.91
Professional	0.34**	2.36	0.43*	1.76	0.18	0.96
Transportation	–14.33	–0.02	–13.66	–0.02		
Military	1.07*	1.75	0.85	1.23	–19.23	0.00
Police/fire	–15.13	–0.01	–14.48	–0.01	–21.34	0.00
Commercial driver	–0.44***	–3.57	–0.40**	–2.49	–0.50**	–2.40
Distance to work	–0.02***	–5.27	–0.01***	–2.56	–0.02***	–4.24
No. of walk trips last week	0.37***	16.68	0.40***	10.85	0.37***	11.75
No. of bike trips last week	–0.04	–0.23	0.04	0.18	–20.99	0.00
Medical condition	–0.65***	–6.40	–0.39***	–2.68	–0.90***	–6.13
Education (> grad)	0.20***	3.01	0.08	0.78	0.32***	3.40
Attitudes & Perceptions						
Worry about traffic accidents						
Not a problem	–0.47**	–2.22	–0.30	–0.70	–0.23	–0.57
A little problem	–0.06	–0.29	0.30	0.68	0.19	0.51
Somewhat a problem	–0.02	–0.09	0.20	0.46	0.36	0.95
Very much	–0.04	–0.14	0.32	0.62		
Severe					0.54	1.39
Worry about congestion						
Not a problem	0.11	1.08	–0.06	–0.38	0.36***	2.76
A little problem	–0.22**	–2.03	–0.38**	–2.21		
Somewhat a problem	–0.17*	–1.67	–0.05	–0.35	–0.09	–0.66
Very much					0.14	0.93
Severe	0.23**	2.22	0.17	1.04	0.41***	2.87
Worry about drunk driving						
Not a problem	0.06	0.30	0.07	0.24	0.40	1.25
A little problem	–0.02	–0.08			0.19	0.52
Somewhat a problem	0.13	0.49	0.70*	1.98		
Very much			–0.09	–0.24	0.43	1.01
Severe	0.36*	1.72	0.33	1.06	0.78**	2.50
Worry about price of gas						
Not a problem	0.21**	1.99	0.41**	2.35	0.38***	2.96
A little problem	0.01	0.12	0.41**	2.33		
Somewhat a problem	0.11	1.03	0.36	2.10	0.26*	1.87
Very much					0.35**	2.19
Severe	–0.26**	–2.15	–0.09	–0.45	–0.07	–0.50
Worry about poor sidewalks						
Not a problem	–0.43*	–1.92	–0.28	–0.63	–0.42	–1.60
A little problem	–0.20	–0.80	0.04	0.08	–0.10	–0.35
Somewhat a problem	0.07	0.27	0.32	0.64	0.03	0.08
Very much	–0.85**	–2.34	–0.16	–0.26	–1.21**	–2.47

(*continued on next page*)

TABLE 5 (*continued*) **Poisson Model of Number of Walking Trips per Day: 2001 NHTS, Baltimore Add-on**

	Model 1: All Records		Model 2: Men		Model 3: Women	
Variable Name	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value
Urban Form & Land Use						
Housing unity density	–0.29***	–2.80	–0.54***	–3.43	–0.03	–0.18
Street connectivity	–0.98***	–5.71	–1.22***	–4.23	–0.81***	–3.77
Land use mix	0.45***	3.98	0.52***	3.12	0.47***	2.99
Percent vacant	–0.46*	–1.89	–0.60*	–1.63	–0.17	–0.50
Transit access	–0.96**	–2.37	–1.03	–1.58	–0.68	–1.28
Percent parkland	0.19	0.96	0.40	1.55	–0.18	–0.58
Percent commercial	0.18	0.79	0.44	1.25	–0.03	–0.11
Neighborhood Socio-demographics						
Median age	–0.01***	–2.88	–0.01*	–1.76	–0.01**	–2.05
Proportion white	0.63***	8.33	0.72***	6.07	0.61***	5.97
Constant	3.15***	3.78	1.74	1.49	1.59*	1.86
Valid *N*	2624.00		1174.00		1450.00	
Log-likelihood	–3335.67		–1499.99		–1780.78	
Pseudo R^2	0.16		0.18		0.17	

***Significant at the 99% level.
**Significant at the 95% level.
*Significant at the 90% level.

whether and how these policies might (or might not) achieve their goals. Moreover, it may help identify which features (e.g., parks, sidewalks, schools) are most important in increasing walking rates for women. Understanding the differences in walking behavior between men and women, if they exist, may help explain how land use is affecting travel. Alternatively, it may help demonstrate that women who need or want to reduce travel are more likely to choose more accessible neighborhoods in which to live.

As with much of the research in land use and travel behavior, the findings of this study are mixed, though many do support the notion that women may walk more in neighborhoods with a mix of uses and a good pedestrian environment compared with women in neighborhoods without those features. However, the evidence presented here points to distinct differences between the sexes in their walking behavior and the influence of land use on that behavior. Explanations for these differences cannot be offered from the empirical evidence. Traditionally, these differences have been explained by the uneven distribution in the amount of household and caregiver responsibilities that women shoulder. Additional influences may relate to safety and security concerns. Taking this further, men and women may respond to these environments differently because of differences in perceptions and attitudes originating from a variety of possible influences including societal roles, learned behavior, and perhaps biology. The application of social learning theories to land use and travel behavior research may provide fruitful explanations. If the question is whether women will take advantage of these new styles of neighborhoods and walk more than they do in typical post–World War II neighborhoods, these findings are encouraging.

Much of the data revealed either directly or indirectly that safety, either because of a lack of sidewalks or fear of traffic or crime, can suppress women's walking behavior. New urbanist developments are very likely to overcome this barrier. The Portland data indicate that women living in areas with a better mix of land uses, particularly with a good pedestrian environment, were more likely to walk than women in less walkable neighborhoods. Moreover, the difference between men's and women's walking rates disappeared in the walkable neighborhoods outside the urban core, again emphasizing the safety issue. The Baltimore data also indicate that a mix of land uses increases walking for both men and women by similar amounts. Finally, the Portland data indicate that the concern that women with children may not be able to take advantage of the walkable features of new urbanism may be unfounded. In some walkable neighborhoods, women with children walked more than men.

However, the effects of land use on women's travel are not straightforward and are confounded by household responsibilities and resources, perceptions and concerns, trip purposes, and comprehensive travel needs. The evidence presented here initiates an examination of these issues that is likely to prove more fruitful over time. It is likely that the simple analysis of men and women masks important differences that arise between groups of women. Recognition that women are a heterogeneous group with different needs and travel patterns would be the next logical step in the examination of the effects of land use on them.

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Gender Differences in Experience with and Fear of Crime in Relation to Public Transport

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Crime and fear of crime stop people from using public transport, particularly at night. To increase the use of public transport, operators must tailor crime reduction programs and policies to the needs and experiences of different demographic groups with respect to both actual crime and fear of crime. Toward that end, the U.K. Department for Transport undertakes regular surveys on fear of crime on public transport and analyzes these data by gender, age, ethnic background, and disability. The results from the 2002 survey are summarized and show differences between men and women in transit use, experience with crime, fear of crime, and preference for strategies to address security. These results point to the need for specific strategies to address the concerns of women. Data from the 2002 survey show that men and women have different patterns of transport use: women are more likely than men to travel by bus, whereas men are more likely than women to travel by train or drive. In addition, men and women experience different types of crimes at different rates: men and women are equally likely to be the victim of theft or pickpocketing; men are more likely to experience a threat of violence, be the victim of robbery or mugging, and be the victim of a physical assault than women; women are more likely than men to be the victim of sexual assault, harassment, or indecent exposure. Men and women also have different levels of fear of crime: women express more fear of crime than men, although the gap declined between 1996 and 2002. In 2002, 43% of women described themselves as public transport users with no fears for their personal security as opposed to 47% of men. Men and women agree on many different forms of crime reduction, but women generally prefer staffing to technological solutions. While waiting for a bus, both women and men favor closed-circuit television (CCTV) at shelters. When traveling by bus, women prefer an additional staff member and the refusal by the driver to board those influenced by alcohol or drugs, whereas men prefer CCTV and in-vehicle radio contact for the driver. On trains, women and men both prefer to have a staff member walking through a train, although for women the preference is more marked. In contrast to whites, Asian, black, and minority ethnic respondents favor CCTV surveillance for personal security on trains. In response to these data, the Department for Transport has worked with the police and transport police, local authorities, transport operators, and local Crime and Disorder Partnerships to develop a package of policies and programs to address these different concerns. Examples include facilitating the Secure Stations Scheme, developing bus driver training programs, establishing Safer Travel on Buses, and issuing advice on ways of reducing graffiti. The department's analysis shows that an extra 10.5% of journeys would be generated if the public felt more secure when traveling, particularly when waiting at rail stations. Gender- (and race- or ethnicity-) sensitive analysis is critical in developing effective and targeted responses to crime that address people's vulnerabilities and fear of crime.

Abstract prepared by Susan L. Handy, University of California, Davis.

Technology as a Strategy for Addressing Personal Security Concerns of Women on Public Transit

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Long concerned with reducing crime and improving personal security on their systems, transit agencies now must also address system security and the threat of terrorist acts. As a way of increasing security, many agencies are increasing their use of technology, including the replacement or enhancement of security guards and police with cameras and other technical devices. The increased use of technology raises important questions. Do efforts to increase system security also increase personal security? Are the different concerns over personal security for different demographic groups equally well served by the increased use of technology? In particular, do security efforts help to address the personal security concerns of women when getting to, waiting for, and riding the bus or train? These issues are discussed and recommendations for future research are presented. According to a recent Transit Cooperative Research Program Synthesis of Transit Practice, effective strategies for improving transit security fall into seven classes: uniformed officer, nonuniformed officer, employee involvement, education and information, community outreach, technology, and architecture and design. Technologies have included video, telephone communications, automated ticketing and access systems, and security lighting. Some agencies are procuring portable X-ray kits in order to check unattended bags. Security technologies currently being proposed for transit include fencing, barriers, lighting, video, access control, sensors, identification, and data fusion, display, and control systems and crisis management software. Personal security strategies need to address both the reality and the perception of security, since feelings of insecurity can deter women from using transit and create stress and discomfort for those who must use transit. A study from the United Kingdom shows that women feel more insecure at night, in parking decks, at stops and stations, while walking to and from transit, and while waiting for transit vehicles than their male counterparts do. A fully automated or technology-based approach to system security might help to increase feelings of personal security to some degree, but it is unlikely to eliminate the disparities in perceived security between men and women. Instead, transit agencies should consider simple technological solutions such as adequate and well-placed lighting to create an environment that discourages crime. In addition, combining technology with staffing is important for balancing the financial demands of providing a safe environment with the psychological needs of current and potential transit users. Further research is needed to better understand the effectiveness of these different strategies in improving personal security overall and for particular demographic groups. Research should also address the role of perceived security in the marketing of transit services. The more that transit agencies understand about the particular security concerns of different groups of potential riders, the better they can do in alleviating these concerns and attracting new riders to their systems. The successful effort of the U.K. Department for Transport in research-based niche marketing provides an important model for others.

Abstract prepared by Susan L. Handy, University of California, Davis.

Is It Safe to Walk Here?

Design and Policy Responses to Women's Fear of Victimization in Public Places

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Fear of victimization and crime are important concerns for women in cities. Although differences among women exist because of age, race, class, cultural and educational background, sexual orientation, and disability status, as well as personal characteristics such as personality traits and sense of physical competence, women typically report higher levels of fear than men. Women's fear is particularly associated with specific environmental conditions and settings. An overview is given of women's fear of crime in public spaces. After a discussion of a series of facts and fallacies about women's fear, the outcomes of fear as reflected in women's behavior and travel patterns are reviewed. Empirical findings are reported from two surveys of women in neighborhood parks and waiting at bus stops in Los Angeles, California. Design and policy responses to women's fear of victimization are then focused on and the interrelationship between environment and crime is analyzed, with suggestions for design and planning strategies for safer public spaces.

It is early morning at the bus stop on Central and 7th in downtown Los Angeles. A middle-aged Latino woman is waiting for the bus, nervously clutching a big plastic bag close to her body. There are no pedestrians on the street, just a few parked cars behind a barbed-wire fence. The nearby corner is occupied by a cheap, rundown motel called the Square Deal with a liquor store on the ground floor. A man in ragged clothes curled up on the sidewalk outside the store not far from the woman appears to be sleeping (or is he dead?). Broken glass, empty beer cans, and other trash litter the bus stop where the woman is standing. She nervously surveys the street for the bus. From time to time she throws a fleeting look at the sleeping man. At last the bus arrives, and the woman disappears behind its protective doors (*1*).

The woman observed at the downtown bus stop was clearly scared. She was aware of a potential source of danger, which was personified in the face and body of a sleeping man. The fear of "stranger danger" was accentuated by the fact that this man was homeless, unpredictable, and according to newspaper stories about the homeless, possibly mentally ill. The woman's fear of plausible victimization—imagined or real—although socially produced was also enhanced by the desolate built environment that surrounded her.

Criminologists explain that feelings of fear of crime do not represent "mathematical functions of actual risk but are rather highly complex products of each individual's experiences, memories, and relations to space" (*2,* p. 304). Women's perception of risk in public space is influenced by both the social and the physical setting. As Valentine explains,

> A woman's perception of safety in her local environment is strongly related to how well she knows and feels at ease with both her social and physical surroundings. When she is beyond her local environment she makes judgments about her safety on the basis of preconceived images she holds about a place and its occupants, as well as from cues she receives from

social behavior from the actual physical surroundings. (*3*, p. 298)

Fear of victimization and crime is widespread among women. Almost every survey on fear of crime reports that women are much more fearful than men (*4*, *5*). A 2000 survey by the U.S. Bureau of Justice Statistics showed that more than half (52%) of the female respondents were feeling afraid walking around their neighborhood at night, whereas only 23% of the male respondents were afraid to do so (*6*). In direct contrast to women, men report low rates of fear of crime. Some criminologists argue, however, that there is a methodological fallacy in crime surveys, which cannot dig below the surface of reported male invulnerability (*7*). Many male respondents are reluctant to give answers to surveys that may present them as weak. In studies in which men have been the subject of qualitative research, it was found that some had equally high levels of fear as did women (*8–10*).

Although the fear of rape and serious violence from men may lie at the back of many women's minds, feminists also argue about an existing "continuity" of violence against women, which includes intimidation, groping, sexual comments and harassment, threats, and other public nuisance crimes with sexual undertones (*11*, *12*). In explaining the gendered nature of the fear of crime, feminists highlight these often invisible and underreported crimes against women.

The discussion that follows focuses on women's fear of crime in public spaces. After a brief overview of the literature to highlight the facts and fallacies about women's fear and to discuss empirical findings that identify the effects of such fear on women's use of public space and their involvement in physical activity, the focus is on design and policy responses to women's fear of victimization, analyzing the interrelationship between environment and crime and suggesting design and planning strategies for safer public spaces.

Fallacies and Paradoxes

Women's high level of fear of victimization and crime does not seem to be justified by statistics, which consistently show low rates of reported crime against women in public spaces. This paradox has led to the conclusion that women's fear of crime is irrational and more of a problem than crime itself (*10*). What the official statistics do not show is that significant numbers of intimidating and even violent acts against women go unnoticed and are underreported. Women are often embarrassed and reluctant to report sexual offenses against them in a public culture that often blames the victim, as some highly publicized recent cases have poignantly shown. Therefore, rape remains consistently the most underreported of the serious crimes (which include criminal homicide, robbery, aggravated assault, larceny theft, burglary, grand auto theft, and arson). The *National Crime Victimization Survey* of 2000 found that rape and sexual assault was the violent crime the least often reported to law enforcement. Only 28% of such incidents reported by the survey respondents were reported to the police (*13*). More empirical and qualitative research justifies women's concerns by contradicting the official statistical numbers and showing that levels of violence against women are significantly higher than those reported by the police (*14*, *15*).

A second fallacy is identified by criminologists as a "spatial mismatch" between the locations in which most violent acts against women usually occur (private spaces) and the locations that are mostly feared by women (public spaces). The majority of violent crimes against women are caused by familiar and familial persons at home or in other private settings, not by strangers in public spaces. Yet the social production of fear, which includes parental admonitions, highly publicized media stories, crime prevention classes at schools, and advice and warnings by the police, tends to emphasize the threat that women are facing in the public realm. Feminists argue that this fallacy, which underestimates domestic violence, leads also to women's being misinformed about the main location of danger and the avoidance of public settings (*10*).

A third fallacy equalizes all women and their perceived agoraphobia under a broad and uniform category. It ignores important differentiations that exist among them because of age, race, class, cultural and educational background, sexual orientation, and disability status, as well as more personal characteristics such as personality traits and sense of physical competence. This generalized, one-size-fits-all approach has been criticized by postmodernist feminists, who rightly argue that the fear of crime can be profoundly affected by all the aforementioned factors (*7*).

Empirical studies typically find that older women generally feel less safe than younger women do (*16*). Lower socioeconomic status is often shown to be associated with unsafe neighborhoods and transient domiciles (*17*). Therefore, women in poor neighborhoods are typically afraid of being assaulted on the street (*18*). Some researchers have investigated fear of race harassment and race violence, which stem in part from "race privilege" or "race prejudice" (*5*). White women are often fearful of nonwhite men. According to Day, many nonwhite women's fear of white men may be a reflection of their historical subordination (*5*, p. 114). Women from nonwhite ethnic backgrounds often experience higher levels of fear in their neighborhoods than white women do (*18–20*). Similarly, women with physical or mental disabilities and lesbians are more fearful of assault in public spaces (*12*, *21*). As Day concludes,

> Fear in public space is shaped by one's identity—including race, class, and gender. It is misleading to speak of women's fear as if it were uniform, though race, class, and gender are not always equally salient in the experience. (*22*, p. 325)

Finally, as Pain argues, "Fear and boldness, although they may be gendered, are not essentially female and male qualities" (*10*, p. *905*). Although many women tend to feel unsafe in certain environmental settings, fear is not inherent in women but rather is socially constructed. The conceptualization of women as victims entails a certain danger of increasing women's fears or of perpetuating the notion that they must operate under some kind of curfew (*23*, p. 283).

Outcomes of Women's Fear

Regardless of being real or only perceived, fear has some significant consequences for women and leads them to utilize precautionary measures and strategies. These range from the adoption of certain behavioral mechanisms when in public to choosing specific routes, travel patterns, and public places over others to completely avoiding places and activities deemed as unsafe for women and, in some instances, staying behind locked doors, barred windows, or even gated communities.

Since the formative years of their childhood, women are inundated by parental and societal warnings regarding their behavior and appearance in public. How and where they walk, to whom they talk, and what they wear in public are determined by well-learned rules for keeping safe. Women will often adopt a defensive strategy when in public spaces, and "rationally and automatically [will] take account of the situation and do a mental calculation of the dangers present before deciding how to behave. . . . [T]hey restrict their behavior, even isolate themselves—in order to avoid being harmed" (*4*, p. *19*). Women's presence in public spaces often involves an element of vigilance, always being aware of others (usually of the other sex or other races) who are using the same space (*2*).

Fear affects women's travel patterns and use of certain public spaces. Empirical studies have shown that women often drive or take a taxi rather than walk or use public transit because of fear for their safety (*11, 24, 25*). In some instances, women may completely avoid the use of certain public spaces, confine their use to certain hours of the day, or visit public spaces if only accompanied by boyfriends, spouses, or friends. As a result, research has revealed an underrepresentation of women in parks and green open spaces (*26–28*).

An emerging literature on women's health finds that safety concerns keep many women from walking for exercise or recreation and from becoming physically active (*29*, *30*). Data collected from five U.S. states (Maryland, Montana, Ohio, Pennsylvania, and Virginia) revealed that higher levels of perceived neighborhood safety were associated with more walking and physical activity. This finding was particularly true for those over 65, women, and minorities (*31*). When income, vehicle ownership, and time constraints are controlled, women are expected to walk less than men because of fear for their safety. Women are also more likely than men to avoid walking after dark for reasons of personal safety (*18*, *32*). For minority women in particular, fear of crime is an important barrier to walking and exercising. Studies have found more barriers to walking in some neighborhoods, including those with high crime rates, and fear for personal safety among ethnic populations (*17*). African American and Latino women typically demonstrate lower rates of physical activity than white women do. A 1994 national survey found that African American women had the highest rates of physical inactivity (46%), followed closely by Latino women (44%) (*33*).

Safety issues, limited finances, and lack of social support are identified as major barriers to minority women's becoming more physically active (*34*). Indeed, in 10 focus groups of minority women in California and Missouri, fear of the surroundings was mentioned by all groups in all settings (urban, suburban, and rural) as a detriment to exercising or being physically active outdoors. Nevertheless, many of the women indicated that they got adequate physical activity from care giving, household chores, and workday activities (*33*). A focus group study of urban African American women aged 20 to 50 years found that many were reluctant to venture from their own porches because they feared for their safety. They expressed the opinion that African American women were not provided the same protection to exercise freely in their communities as women of the dominant culture were. For these women, the homeless and mentally ill presented a potential for verbal threats on the sidewalks and in parks (*34*). Another focus group study of well-educated urban African American women found that although most of them lived in safe neighborhoods, traffic and personal safety were major concerns. Most, however, could readily identify safe places to be physically active or articulate a strategy to make the environment safer (walk with others or with a dog) (*35*). Perceived lack of safety also emerged as an important barrier to physical activity in focus group discussions with American Indian women (*36*) and Latino immigrant women (*37*).

Although some studies did not find a strong link between perceived safety and physical inactivity (*29*, *38*, *39*), studies that focused on women, children, and the elderly have been able to identify a strong relationship between feelings of risk and fear at the neighborhood level and high levels of inactivity (*40*).

Women's Unsafe Places

Women's fear of public spaces often appears to be firmly situated in particular built environments. Men and women produce mental maps of feared environments and dangerous places based on their prior experiences as well as on the reputation that the urban fabric acquires from media stories and accounts by others (*7*). Valentine emphasizes two general categories of spaces as particularly frightening to women: (*a*) enclosed spaces with limited exit opportunities such as multistory parking structures, underground passages, and subway stations and (*b*) unknown and deserted open spaces such as empty public parks, forests, recreational areas, and desolate transit stops (*3*). The first provide opportunities for criminals to trap and attack women, and the second may allow potential offenders to conceal themselves and act outside the visual range of others. Factors that induce fear in public environments include darkness, desolation, lack of opportunities for surveillance by the general public or the residents of surrounding establishments, lack of maintenance, and poor environmental quality (*3*, *32*). In addition, empirical studies such as the analysis of crime data from Chicago showed that women are very sensitive to signs of danger and social disorder, graffiti, and unkempt and abandoned buildings (*24*).

The few studies that focused on women's perceptions of safety in public transportation settings found that such settings represent places of risk for many women, who report being fearful of waiting at empty bus stops and railway stations or sitting alone in empty buses and train cars (*15, 22*). Although private automobiles are perceived as the safest means of transportation by women, having to park them in desolate parking structures causes them considerable stress and fear. In a national survey of 12,300 women in Canada, most respondents reported being fearful of walking alone to their car in a parking garage and of using public transportation after dark (*24*). Indeed, nighttime entails special fears for women in the United States, who also report not feeling safe alone in their neighborhoods at night. Interestingly, the same women are not as fearful of being home alone after dark—an irony given the fact that more rapes take place in or near the home than in any other single place—but worry and avoid visiting laundromats or getting on the bus at night and walking by bars, parks, and empty lots (*4*). In the following section more detail about women's fears is given based on surveys with women encountered in neighborhood parks and at bus stops in Los Angeles, California.

Surveys from Los Angeles

Women in Four Los Angeles Parks

Research has shown than women use parks and open spaces in significantly smaller numbers than men do (*26*, *27*). Fear of victimization and feelings of vulnerability from being alone in public spaces have been considered as partly responsible for the relatively lower numbers of women in parks (*41*, *42*). Additional constraints that hinder women's equal representation in urban parks include less discretionary time (particularly for working mothers) and restrictions on the types of activities likely to be pursued in public spaces by women. Often accompanied by young children, women are more likely to engage in activities related to their domestic role than in discretionary activities (*43*). The above-described patterns emerged clearly in one of the author's studies that examined the uses and users of parks in four socially and ethnically diverse neighborhoods of Los Angeles: (*a*) Beverly Hills, one of the most affluent and exclusive communities in the Los Angeles area with a large majority white population; (*b*) Monterey Park, a suburban community with a majority Asian and minority white and Latino population; (*c*) South Gate, a low-income, working-class, immigrant Latino community; and (*d*) Watts, an inner-city neighborhood in south central Los Angeles with a long-standing African American community and a recent influx of Latino newcomers (*28*).

The study used observation and survey research to identify the patterns of use, the likes and dislikes, and the level of perceived security of users in the four parks. A systematic random sample of 80 park users (40 on a weekday and 40 on a weekend) was surveyed in the largest park in each neighborhood during peak use time. As Table 1 shows, women were a minority in all four parks, with the exception of the park in South Gate, which enjoyed slightly higher levels of utilization by women on weekdays; all other parks had more male users. This finding is important if one takes into consideration that more women than men (in a ratio of 2:1) accompanied young children to the playground.

Although in general both men and women felt safer in the parks than on their neighborhood streets, there was a significant difference between men and women regarding the levels of perceived safety. Ninety-three percent of men felt safe in the park during the daytime, whereas only 75% of women claimed to feel the same. More than three-fourths of the women surveyed stated that they would never visit the park after dark unless their visit

TABLE 1 Peak Use of Four Los Angeles Parks by Women and Men

	Beverly Hills		Monterey Park		Watts		South Gate	
Peak Use	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday
Users	Saturday 1:30 p.m. 386	Tuesday 12:30 p.m. 302	Sunday 2:30 p.m. 133	Tuesday 5:00 p.m. 99	Sunday 12:00 p.m. 700	Monday 6:15 p.m. 363	Sunday 2:00 p.m. 3,085	Tuesday 3:00 p.m. 703
Male	53.4%	53.5%	53.6%	52.0%	55.2%	58.3%	53.6%	48.3%
Female	46.6%	46.5%	46.4%	48.0%	44.8%	41.7%	46.4%	51.7%

was for an organized nighttime event, such as a concert, attended by many people. Feelings of safety on the streets surrounding the parks varied widely by neighborhood, with Beverly Hills residents feeling the safest and Watts residents feeling the least safe of all. Consistent with findings of other empirical studies, women's fears of being exposed in the public environment of the street topped those of men by significant margins. In the sample, African American and Latino women, mostly present in the low-income neighborhoods of Watts and South Gate, were more fearful than other women. Research has shown that the structure of a disadvantaged neighborhood may affect behavior because people who are fearful of street crime are also likely to constrain their outdoor activities (*44–46*). Since these women came from households with low levels of automobile ownership, they were quite likely to walk or use public transit to reach the park, thus having to expose themselves to the "mean streets" of their neighborhood.

An additional indication of women's level of discomfort in parks was reflected by the fact that they would rarely come to the park by themselves. Although one-fourth of the male respondents indicated that they came to the park alone, a very small percentage of women (6.8%) did so. The small numbers of solitary women were mostly found in the parks of Beverly Hills and Monterey Park (the two higher-income neighborhoods) and were primarily involved in jogging or walking their dogs. Indeed, the majority of women visited the park accompanied by one or more family members. It was a rarity to see a solitary woman simply "hanging out," relaxing, and enjoying the environment of the park. As one woman explained, "If you come to the park alone you may be perceived as asking for trouble." Thus, most of the women surveyed felt that they needed a clear reason to be in the park.

Women at Los Angeles Bus Stops

Women waiting at Los Angeles bus stops have certainly a clear reason for doing so. Most of them are captive bus riders who depend on public transit to go to work and school and to complete various errands and chores. The author's survey of transit riders waiting at the 10 most high-crime bus stops in Los Angeles revealed that half of them were members of carless households, whereas almost a third (30.9%) reported living in households with only one vehicle (*15*). The problem of crime on buses and at bus stops is particularly important for inner-city residents. To better understand their needs and fears a random sample of 95 female and 107 male bus riders found waiting at these high-crime bus stops was surveyed. The majority of respondents were Latinos (77.3%) and African Americans (13%); very few were Asians (4.8%) and whites (3.9%). More than one-third of the sample reported a household income of less than $10,000, and about one-half stated that their household income did not exceed $20,000. Almost three-fourths of the respondents relied heavily on the bus system, using it every day to reach a number of activity destinations, mainly work (86.9%), shopping (54.6%), meeting with friends and relatives (44.1%), and school (34.9%).

Safety concerns were prominent among these bus riders. Bus stops represented scary settings for them. Exactly half of the respondents reported feeling unsafe at bus stops, whereas only one-fourth reported feeling unsafe on buses. Feelings of vulnerability and lack of safety were more prevalent among women, of whom 59% surveyed felt unsafe waiting for their bus compared with 41% of men. Almost a third of the respondents (36% of women and 29% of men) claimed to have been victims of some crime during the last 5 years when on the bus or at a bus stop. Forty-five percent of these incidents were at bus stops, 18% inside buses, and the remaining 37% at unspecified locations (it was not clear from the response if the incident had happened on the bus or at the bus stop). Over half of the crimes involved robbery. In addition, almost one-third of the respondents stated that a friend or a relative had been a victim of bus or bus stop crime within the last 5 years. Individuals already victimized were more fearful than those who had not been exposed to bus or bus stop crime. Table 2 shows the types of crimes and problems these respondents believe occur (and which in many cases they have witnessed) at the bus stops and on buses.

It is clear from Table 2 that different types of crime are more visible to women than to men. Drunkenness, obscene language, verbal threats, and groping were of particular concern for women riders. Some women in the sample complained that they were particularly leery

TABLE 2 Problems Perceived by Bus Riders at High-Crime Bus Stops and on Buses

	Bus Stop			Bus		
Perceived Problem	Men	Women	Total	Men	Women	Total
Panhandling	87 (48.1%)	94 (51.9%)	181	52 (52%)	48 (48%)	100
Drunkenness	76 (42.5%)	103 (57.5%)	179	55 (38.2%)	89 (61.8%)	144
Vandalism	78 (55.3%)	63 (44.7%)	141	78 (52.7%)	70 (47.3%)	148
Obscene language	55 (42.3%)	75 (57.7%)	130	50 (40.0%)	75 (60%)	125
Drug use/sales	54 (56.8%)	41 (43.2%)	95	17 (58.6%)	12 (41.4%)	29
Verbal/physical threats	42 (44.2%)	53 (55.8%)	95	35 (39.8%)	53 (60.2%)	88
Pickpocketing	45 (48.4%)	48 (51.6%)	93	34 (45.9%)	40 (54.1%)	74
Jewelry snatching	40 (47.6%)	44 (52.4%)	84	20 (42.6%)	27 (57.4%)	47
Robbery	38 (52.1%)	35 (47.9%)	73	23 (48.9%)	24 (51.1%)	47
Violent crime (murder, aggravated assault)	9 (40.9%)	13 (59.1%)	22	2 (33.3%)	4 (66.6%)	6

Note: $N = 212$.

of individuals standing behind them at the bus stop. They were afraid of strangers gulping from bottles hidden in shabby brown bags. They were intimidated by homeless people who hang out at bus stops mumbling obscenities. Many women claimed that they are often overcome by eerie feelings while waiting alone for the bus, surrounded by vacant buildings or fenced lots, with no human beings inside. Interestingly, many of the problems that women at bus stops and on buses are concerned with represent public offense crimes, which are largely underreported. Most women stated that they do not tend to report such offenses because they do not believe that the police will do anything about them. This underreporting of certain types of transit crime may be aggravated by the fact that some of the transit riders in the Los Angeles bus system are recent immigrants, who may be fearful of the police because of illegal residency status. Is there anything that can be done to help women feel safer in public settings?

Responding to Women's Fear of Crime

Some feminists argue that little real gain can be made in women's safety unless men's behavior is challenged (*12*). Although this argument contains a high degree of truth, it also requires a systematic, continuous, and long-term commitment on the part of the government, involving a series of social and educational programs targeting both men and women and starting from the early and formative years of childhood. It may also necessitate a restructuring of the legal system so that female victims can report without fear of stigmatization. These measures, although definitely worth pursuing and advocating for, are nevertheless time consuming and frustratingly slow to implement since they require structural changes of the educational, legal, and penal systems and even changes in social attitudes. Complementary measures of lesser scope but easier to implement and enforce include a series of design and planning strategies that seek to design out crime and lessen women's fear. Admittedly, such strategies are limited in the types of crime they can address. Their emphasis is on opportunistic crime in public settings rather than premeditated crime or crime occurring in private and domestic environments. Nevertheless, planning and design can play a significant role in reducing women's fear and promoting safety. As the review in the next section indicates, the relationship between crime and the built environment has long been established by scholars.

Crime and the Built Environment

Since the 1960s there has been growing interest in the link between the physical environment and crime. The idea of crime prevention through environmental design attracted particular attention when Jacobs argued that modern city design typically undermines people's ability to observe public streets, thus breaking down informal social control of criminal activity (*47*). She asserted that crime and the physical environment are related in a systematic, observable, and controllable manner. Jacobs viewed natural surveillance ("eyes on the street") as a good deterrent of criminal activity. In a similar manner, Jeffrey argued that the crime prevention strategy with the greatest potential involved heavy reliance on design and physical changes that could help reduce criminal opportunities in the environment (*48*). The theoretical discussions of Jacobs and Jeffrey drew attention to the importance of investigating the link between the built environment and public safety. Studying street crime in Oakland, California, Angel discovered that "the physical environment can exert a direct influence on crime settings by delineating territories, reducing or increasing accessibility by the creation or elimination of boundaries and circulation networks, and by facilitating surveillance by the citizenry and the police" (*49*, p. 15).

The most influential empirical study and one of the earliest to examine the crime–environment connection was conducted in the early 1970s by Newman (*50*). Focusing on public housing developments, Newman elaborated the idea of "defensible space"—an environmental layout whose physical characteristics can deter criminal activities. He argued that such environments are characterized by location within safe zones, surveillance opportunities by neighbors, and a sense of ownership on the part of neighbors who are likely to protect their space against criminals (*50*).

The ideas of Jacobs and Newman prompted a series of public programs on crime prevention through environmental design in the 1970s. But interest in environmental crime prevention languished in the 1980s, when critics condemned such efforts as pure environmental determinism. In recent years, however, new criminology theories have once again emphasized the importance of place in affecting the likelihood of crime and have examined the relationship between features of the built environment and crime (*51–55*). Researchers have observed that a limited number of sites, which often are included in women's mental maps as unsafe, constitute the loci for the majority of offenses. Criminologists call these high-crime spots "crime generators" or "hot spots" (*56–58*). This new generation of studies is concerned with microlevel situational correlates of crime and seeks to understand the environmental factors that may create opportunities for crime. It is informed by new criminology theories such as the routine activity theory (*59*, *60*) and rational choice theory (*61*), which argue that as opportunities for crime increase, more crimes will be committed, and conversely that crime declines as opportunities are reduced.

Research on the microenvironment of crime settings has shown that both the possibility of surveillance of a site by bystanders and signs of care that give the appearance that there are natural guardians who may intervene can strongly discourage potential criminals. In their study of crime in Chicago's rapid transit stations, Block and Davis observed that high levels of guardianship in some high-traffic stations had a positive effect on reducing the incidence of crime (*62*). Criminologists have also spoken persuasively about the "broken window effect"—signs of disrepair, dereliction, and dilapidation as catalysts for crime. Unrepaired broken windows, uncollected trash, and unkempt streets and public spaces send messages to potential criminals that no one is in control and that their actions will go unnoticed (*63–66*).

Studies have shown that certain inherent features of the microenvironment affect the likelihood of crime. For example, it is easier for criminals to commit crimes near major streets (*67*). The greater the number of escape routes (streets and alleys) in the vicinity of a site, the easier it is for a criminal to escape (*68*). The surrounding land uses can also affect crime, with certain land uses (e.g., liquor stores, taverns, pawnshops, pool halls, vacant lots, and abandoned buildings) considered to be crime generators (*53*; *69*, *70*). Similarly, it has been shown that certain urban form and bus stop characteristics influence transit crime. For example, crime rates at Los Angeles bus stops were higher at bus stops in areas with alleys and midblock passages (corroborating the idea that crime is high where there are avenues for escape) and near multifamily housing, liquor stores, check-cashing establishments, vacant buildings, and buildings marked by graffiti and litter. For violent crimes in particular, the location of check-cashing establishments near bus stops and the presence of alleys had the strongest positive correlation with crime rates (*71*). In contrast, some features of the built environment are viewed as having the potential to deter crime.

Although the previous findings are indicative of a strong relationship between certain urban form features (e.g. alleys, multifamily buildings, major streets) and opportunities for crime, it needs to be emphasized that these features are not inherently unsafe. It is rather that certain environmental and design qualities often present in certain environments (e.g., narrowness, darkness, lack of ground floor activities, lack of windows opening up onto a street or public area) make them susceptible to crime. For this reason, good design can make a big difference for real and perceived safety.

Protecting Public Spaces from Crime Through Planning and Design

In the previous section it is suggested that the design of urban form and the layout and appearance of public spaces influence perceived and actual safety and can provide environmental cues as to whether to participate in public settings. As a consequence, certain planning and design interventions can help block opportunities for crime, instill feelings of safety, and thus facilitate physical activity. It is important to understand that design and policy strategies need to respond to real and perceived safety issues, since both have the ability to constrain women's activities and movement.

Many dimensions of the physical environment should be considered in developing appropriate planning and design interventions, such as the characteristics of the population and its relevant needs as well as fears, the characteristics of the setting (residential neighborhood, city center, school, workplace, etc.), and the desired types of activity in public spaces (*72*). Although crime prevention is situational and should be tailored to the social and spatial specificities of each neighborhood or setting, certain planning and design strategies seem to hold particular promise for blocking crime and reducing fear of crime in public spaces for both women and men.

Fixing Broken Windows

General neglect of the building stock and public environment, graffiti and litter, empty buildings, and broken windows are signs that no one really cares about or regulates a street, neighborhood, or public space, that both the physical and social context suffer from disorder. Empirical research has shown that general upkeep and maintenance of the physical environment can have positive impacts on crime reduction. In their book *Fixing Broken Windows,* Kelling and Coles (*73*) give a number of examples to demonstrate the relationship between fixing broken windows and crime reduction. They detail the experiences of Baltimore's Boyd Booth inner-city neighborhood, where crime dropped by 56% from 1993 to 1995 after neighborhood groups with support from the Mayor's office addressed issues of community decay by boarding up vacant houses, erecting fences, installing lighting, and cleaning up the neighborhood's public spaces. They also detail the positive effects on crime of New York City's efforts in the mid-1990s to clean up graffiti and litter from the subway stations and trains (*73*). Physical interventions that counteract the broken window effect and may reduce fear include facade improvements, fixing derelict areas, and ensuring good maintenance and cleanliness of the streetscape.

Facilitating Eyes on the Street

Empty streets and desolate public spaces generate fear and also provide opportunities for criminal acts to go unnoticed. The segregation of the American city into single-use cells through zoning has often denied neighborhoods the opportunity to host an overlay of activities that produces a critical mass of people in public spaces. Nevertheless, the design orientation of buildings with windows facing the street can increase natural surveillance by neighbors. In mixed-use and commercial areas, design can improve opportunities for surveillance by introducing storefronts facing the sidewalk. The placement of transit facilities away from desolate areas and near places where they can be overseen by shop owners or neighbors, the replacement of pedestrian tunnels with safe, ground-level crossings, and the elimination of empty alleys as well as fences and heavy landscaping blocking sight lines can reduce fear and feelings of anxiety. Design can create preconditions for informal but effective control of the public environment.

Lighting the Way

Dark public places often generate feelings of fear. Research has shown that good lighting of streets, parks, bus shelters, and stations can reduce assaults and perceptions of fear (*3*, *74*). A research project in the London borough of Hammersmith showed a clear reduction in women's perception of danger after lighting was enhanced in public spaces (*23*).

Eliminating Bad Neighbors

The land uses that line streets or surround public spaces are crucial for their safety. Negative land uses (such as liquor stores, seedy motels, bars, check-cashing establishments, pawnshops, and adult bookstores and movie theaters) can generate crime because they can encourage antisocial behavior, concentrate unsuspected targets, and attract potential criminals. Such uses often give a neighborhood a bad reputation and increase the fear of crime. These bad neighbors should be eliminated from the vicinity of parks, bus stops, and public spaces.

Creating Safe Territories

Parks and public spaces tend to concentrate people of different ages and walks of life. Some groups, such as elderly women, may feel threatened by other groups (e.g., teenagers) coexisting in the same limited territory. The creation of safe "hang-out" places, such as a senior citizen's center or a group of tables and benches, within a larger public setting can help a user group feel safe by experiencing a sense of territoriality and group ownership. Design of public spaces should help ease tension and fear between different groups by promoting their peaceful coexistence (*28*). Cooper Marcus and Francis talk about "layering and separation," the formation of time and activity zones through design and planning in parks and public spaces that allow different groups to use the same space (*27*).

Protecting Access Routes and Destinations

Although some public spaces and facilities such as station platforms or parks may be sufficiently policed and protected, the route to these facilities may not always be perceived as safe. The planning and design of a recreational or transit facility should extend beyond the facility itself to incorporate the public environments that lead to or are closely associated with the facility (pathways, sidewalks leading to the destination, parking lots, park-and-ride lots, overheads, and underpasses).

Complementarity of Strategies

Crime prevention through environmental design should be complemented by a variety of strategies, which may include

- Policing and surveillance by public or private security officers, neighborhood watch groups, or both;
- Educational programs and information and media campaigns (such as antidrug messages);
- Use of technologies such as closed-circuit television on station platforms, emergency phones at bus stops, and emergency buttons on buses and trains; and
- Employment of social capital and social networks (where available) to oversee the security of the neighborhood through informal social control.

Strategies and interventions that focus on enhancing safety in public spaces should be composite and synergistic. For example, environmental modifications may be complemented by educational campaigns and courses at schools. In addition, the balance and mix of these strategies should be based on the particularity of each setting, the wishes of the community, and the resources available. At the same time, the needs, views, and concerns of women should be incorporated in the planning and design of public settings and services. This type of planning and design can only occur if cities and public agencies include women's groups in their strategic planning processes, as has happened at times in the design of transit services in Toronto and Vancouver, in Canada.

Conclusion

Fear, whether perceived or real, affects women's propensity to engage in activities that take place in public environments. At an extreme, angst over personal vulnerability may result in agoraphobia, a fortress ideology, the suppression of social engagement, and the complete avoidance of activities in public spaces. At a minimum, fear can produce stress, intimidation, and a general reluctance to patronize public spaces.

The link between the built environment and safety from crime is quite well established. Therefore, design and policy interventions that aim to enhance the safety of streets, parks, bus stops, and other public spaces are the necessary first steps for the reduction of women's fears. At the same time, complementary strategies involving intrapersonal, interpersonal, institutional, community, and public policy approaches are required that tackle individual, environmental, and social factors that may provide barriers to women's use of public settings.

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Part-Time Employment and Travel Patterns of Women in the Netherlands

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This study evaluated trends in part-time employment among Dutch women in order to evaluate the impacts of these employment characteristics on travel patterns. The Netherlands has the highest rate of part-time employment in Europe. Part-time workers were characterized by the reason they were in part-time employment, age, and workforce experience (i.e., returning to the labor force, just starting a working career, etc.). The study found that part-time workers made more daily trips than their full-time equivalents (i.e., those working 35 or more hours per week), although they traveled fewer kilometers per trip, regardless of trip purpose. Part-time workers made 4.2 trips per day compared with 3.7 trips for full-time workers. The average part-time worker traveled 17.5 min and 8.7 km to work compared with 32.3 min and 14.0 km for the average full-time worker. Moreover, travel time declined 3% for the part-time worker from 1994 to 1998 but increased almost 9% for the full-time worker, whereas the distance increased 3.6% for the part-time and 7.7% for the full-time worker in the same period. Because part-time workers tend to live closer to their jobs, they more often traveled by bicycle and less often by car than full-time workers; 60% of those working more than 35 h per week used the car for their commute compared with 50% of those working 20 to 35 h per week and 42% of those working less than 20 h. Conversely, 40% of those working less than 20 h per week cycled to work compared with 32% of those working 20 to 35 h and 25% of those working more than 35 h per week. Transit use and walking were low among all part-time workers (4% and 7%, respectively) but lower among those working full time, reflecting their longer commutes. Part-time workers tended to travel to work in the morning during the peak period just as full-time workers did. However, part-time workers came home earlier, although the exact time varied by their age, lifestyle, and household patterns. The researchers questioned why part-time workers chose to work closer to home and incur lower commute times. On the basis of economic analyses of the elasticity of the demand for time, the study found that part-time workers were more sensitive to changes in travel time than were full-time workers. However, there were important differences among groups of part-time workers characterized by the reason they chose less than full-time work. Those who were balancing caretaking (for children or older relatives) were more willing to spend time commuting than were those simply seeking a life balance. But part-time and full-time workers were similar in that the higher their income the more willing they were to travel farther and longer to work. The study authors conclude that more research must be done at the household level to understand how, when, and why different adults make the lifestyle, and ultimately travel, decisions that they do. Is it likely that there will be a return to more traditional models in which one partner works and the other does not, or will more household care responsibilities be outsourced and both adults turn to full-time employment? The authors conclude that understanding these important social trends, combined with the aging of society, is key to understanding people's travel needs and the appropriate response of the government of the Netherlands.

Abstract prepared by Sandra Rosenbloom, University of Arizona.

Gender Differences in Travel Patterns
Role of Employment Status and Household Structure

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Many signs indicate that the mobility of women has changed significantly in the past several decades: young women possess a driver's license almost as often as young men do, and women's car availability and their average mileage per year have increased. At the same time, more and more women combine job and family. The effects that these changes have on women's mobility in Germany are explored. The central questions are whether women adapt their mobility behavior to that of men or develop a woman-specific behavior, particularly for the use of the car, and whether household structure and employment status have the same effect on travel patterns for men and women. With data from a national travel survey in Germany, a group classification is carried out in order to compare those with similar basic conditions. The grouping variables are sex, employment status, and household structure. The analysis is restricted to individuals between 30 and 49 years of age in order to minimize variation in the life cycle to the extent possible. The results show that single men and women share many similarities. Gender differences reach the highest level for multiperson households. As long as only sex and household type are taken into account, the gender differences found are consistent with the literature. However, the additional distinction of employment status reveals a more differentiated view of gender differences in travel patterns. Men are rarely part-time employees or homemakers, but once they have this role, they often have even more strongly pronounced travel characteristics that normally are ascribed to women. In contrast, the travel patterns of full-time employed women are still different from those of their male counterparts. In addition, when working full time, women are to a higher degree than men responsible for household duties and child care. In this context, the car seems to have the ambivalent role of affording more flexibility while at the same time solidifying the traditional role of women in household duties and child care.

The mobility of women has progressively changed during the past several decades. Nowadays, young women in Europe and the United States possess a driver's license almost as often as young men do. At the same time, women's passenger car availability and kilometers traveled per year by car have increased, particularly among those in younger age brackets. Although women still use public transport more often than men, the mobility of women seems to adapt gradually to the strongly car-orientated mobility of men. Simultaneously, a change of basic conditions that influence people's travel patterns can be noted. In Germany, the share of women working has increased in the past several decades. On the level of household structure, it can be seen that the number of single households is increasing, whereas the number of multiperson households with children is decreasing. Even though most western European countries have witnessed declines in fertility, more and more women try to combine job and family. In Germany, it is no longer customary for women to give up their jobs and stay at home for many years with the children as was the custom—at least for West Germany—for a long time.

By using data from a national travel survey in Germany, the linkages between gender and mobility are explored against the backdrop of the following questions: Are the gender differences in travel patterns decreasing because of the continuous growth of women's car use? If so, does this decrease apply to women in general or only to certain subgroups of women? Do women adapt their travel patterns to those of men or do they develop—especially concerning the use of a car—their own woman-specific travel patterns? What is the role of household structure and employment status in this context? Do these factors affect men and women in the same way or are there differences depending on sex?

RESEARCH BACKGROUND

Before presentation of the data, methodology, and the results of the analysis, an overview of gender differences reported in the literature and of changes in employment status and household structure that took place in Germany within the last several decades is given.

What do we know about gender differences in travel patterns and especially about car use of women? Especially within the last three decades, a large number of gender studies have emerged. Whereas the early studies mainly focused on commuting (R. J. Hjorthol, unpublished data, 2004), the range of issues analyzed widened with time. Despite the large number of gender studies, the literature on gender differences in travel patterns is still characterized by mixed evidence on the nature and sources of disparities. Nevertheless, there is a consensus regarding the following aspects, even though there are studies that come to opposite conclusions.

In Western countries, the basic differences in travel patterns are that women make more trips but ones of shorter average distance and have less access to cars (Hanson and Johnston 1985; Rosenbloom 1998, Heine et al. 2001). Although young women are catching up with men in terms of car access and car use, car access of elderly women is still very low [Organisation for Economic Co-operation and Development (OECD) and European Conference of Ministers of Transport 2000; OECD 2001; Rosenbloom and Winsten-Bartlett 2002; R. J. Hjorthol, unpublished data, 2004]. Even though women have more complicated travel patterns and make more household and family support trips, they use the less flexible public transport to a higher degree and are more often captive riders than men (Hanson and Johnston 1985; Rosenbloom 1987; Buhr 1998; Preissner and Hunecke 2002; Hunecke 2000; Heine et al. 2001). The causal factor usually mentioned is the greater responsibility of women for household and child care (Hanson and Johnston 1985; R. J. Hjorthol, unpublished data, 2004). Although the everyday life of men is largely characterized by one main activity, which is usually their professional occupation, the everyday life of women often covers several areas. Women tend to make more family and household support trips (Rosenbloom 1987; Niemeier 1998) and to coordinate several diverse activities in terms of space and time—shopping, running errands, accompanying children, and working (Hunecke 2000). Because of this complexity, trip chaining is a substantially woman-specific characteristic of everyday mobility (McGuckin and Murakami 1998). Another woman-specific characteristic is serve-passenger trips (Hunecke 2000; Heine and Mautz 1999; Buhr 1998). Women often have the function of a chauffeur for their children or other persons in the family (e.g., their parents) to out-of-home activities. Furthermore, it must be noted that women often do not have the possibility to leave their young children at home, which changes the requirements for transport noticeably. Generally, the presence of children increases women's car use (Buhr 1998; Heine and Rosenbaum 2001; Vance et al. 2005).

The increasing availability of passenger cars to women is often referred to as "catching-up motorization" (Buhr 1998; Heine and Mautz 1999). However, the increase in car use seems to have less to do with catching up and adapting to male mobility behavior but rather with the utilization of passenger cars for woman-specific daily routines characterized by high space-time rigidity (Kwan 2000, Blumen 1994). Buhr (1998) and Heine and Mautz (1999) prove on the basis of qualitative studies that the car allows women to achieve more autonomy, which is often a precondition for women to do any work besides their family work. Using the car allows women to fulfill their family obligations on a higher level, since the car is more suitable than any other means of transport to perform complex spatial-temporal activity patterns. In this way, the use of a car has a stabilizing effect on the existing role behavior rather than contributing to its dissolution.

In addition, safety reasons play an important role for women's increasing car use. The car, which then gets the function of a shelter, is particularly important in the case of transporting children (Heine and Mautz 1999; Hunecke 2000; Preissner and Hunecke 2002).

Which important societal trends with a great influence on travel patterns took place during the last several decades? Since the mobility of individuals is closely connected to their activities, occupation and household type have a strong influence on the emerging mobility patterns. Both factors have changed greatly within the last several decades, during which the proportion of employed women has visibly increased. In 1970 30% of women were gainfully employed in the former Federal

Republic of Germany. Since then this rate has increased continuously and has now reached 41% (BBE Cologne 2004). From 1996 to 2003, the share of employed mothers rose by 6%. In Germany today, about 60% of the women with children are employed (Federal Statistical Office 2004a).

Despite the increase in employment of women, it is almost exclusively women who limit their professional activity in the stage of setting up a family. The activity of men, 56% of whom are gainfully employed (BBE Cologne 2004), is not much affected by the birth of a child. In all age groups, men are slightly more likely to work when living in a household with children. The opposite is true for women, who are much more likely to work when living in a household without children (Federal Statistical Office 2004a).

Moreover, the large share of part-time employed women is remarkable. Although 40% of mothers work part time and only 20% work full time, the share of part-time employed fathers only reaches 3%. Instead, 83% of fathers pursue a full-time occupation [values refer to the former Federal Republic of German (Federal Statistical Office 2004a)]. It is often concluded from these figures that women in Germany have good job opportunities in terms of getting a leading position only if they remain single and do not have children (Federal Statistical Office 2005).

Regarding the lower employment rate and higher rate of part-time employees among women, it is not surprising that a comparison of the two time use studies carried out in Germany in 1991–1992 and 2001–2002 reveals that the traditional division of labor between sexes still exists. There is only a slight tendency toward modification in the share of tasks. In the former Federal Republic of Germany in 1991–1992, women performed 1.8 times more maintenance activities than men. Today, the proportion is 1.6 (Federal Statistical Office 2003).

Parallel to this development, the household structure in Germany has changed. The share of multiperson households with children, once the most common household type, has decreased to about 31% (Grabka and Kirner 2002). At the same time, the percentage of single-person households increased from 30% in 1979 to 37% in 2001 (Schneider et al. 2000; Federal Statistical Office 2004b). These changes have a significant influence on travel patterns. Whereas in multiperson households there is at least the possibility of sharing work between household members, singles have to do most of the maintenance work themselves.

To summarize, it can be said that women in Germany are employed to a larger extent than they were in the last several decades. But at the same time they have not been relieved of their family duties. Even though the share of women's car use is increasing, woman-specific travel patterns still exist. In this context, qualitative studies emphasize the important role of cars to enable women to fulfill work and family obligations at the same time.

Data Description and Methodology

The results presented in this section are based on the survey "Mobility in Germany," which was carried out by the Institute for Applied Social Science GmbH (Infas) and the German Institute for Economic Research (DIW) in 2002 on behalf of the Federal Ministry of Transport, Building and Housing (Infas and DIW Berlin 2003). Randomly chosen households reported their travel activity over the course of a single day. Furthermore, general information concerning the household and the household members was elicited (e.g., ownership of cars and public transit tickets). The survey included all persons of the household, which means that the trips of children were also registered. The sample covers 25,848 households and 61,729 persons, who reported more than 190,000 trips (Infas and DIW Berlin 2003).

To get a valid comparison in the sense of comparing individuals with similar basic conditions, the data evaluation is restricted to comparable groups classified by the following variables: age, employment status, sex, and household structure (see Figure 1). In order to keep age-conditioned distortions of the results as small as possible, only persons between 30 and 49 years of age were considered. This restriction reduced the analyzed sample to 17,792 persons. The classification of three attributes for detailed study—employment status, sex, and household type—resulted in a total of 18 subgroups. The examination of these groups is carried out by a descriptive comparative analysis.

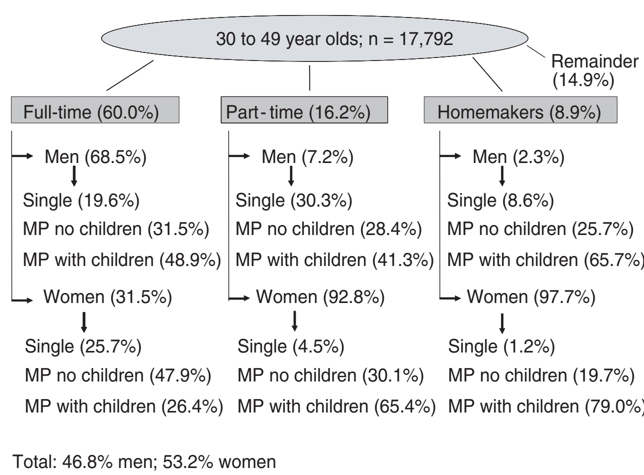

FIGURE 1 Classification and size of analyzed groups (MP = multiperson).

Empirical Results: Activity and Mobility Patterns

The results are presented as follows. First, differences in travel patterns due to household structure are explored. A distinction is made according to whether the household structure affects men and women in the same or in a different way. Then analysis of the relationship between behavioral patterns and employment is added. The central issue of the comparative analysis is to explore whether the differences described earlier are modified if occupation is taken into account. Since the differences between fully employed men and women are especially high, the third section will analyze the differences and the possible reasons in more depth for this particular group.

Different Travel Patterns Depending on Sex and Type of Household

Household structure in terms of the number of persons living in the household and presence of children brings about similar and dissimilar effects concerning the travel patterns of men and women (see Table 1).[1] Particularly noteworthy are the following similarities:

- Individuals living in multiperson households have a higher average number of trips per day than those living in single-person households. However, there is a significant difference between multiperson households with and without children. Whereas those in multiperson households without children have the lowest number of trips per day of all household types, those in households with children have the highest number. Children obviously augment the number of trips by adult household members.
- The presence of children significantly augments the number of serve-passenger trips and reduces leisure trips. Those who have the highest share of leisure trips and the lowest share of serve-passenger trips live in single-person households.
- Above-average car use is typical for individuals living in multiperson households. The presence of children augments the number of car trips and decreases the number of trips with public transport.

The dissimilarities that can be found are consistent with the results reported in the literature:

- Women make more but shorter trips than men.
- Family life increases the average trip length of men, especially of men living in households with children. In contrast, women have the shortest average trip length when living in a household with children.
- Women who live in multiperson households perform an above-average number of shopping trips. It seems that men, once in a multiperson household, leave this duty to other household members.
- The share of serve-passenger trips is higher for all female groups compared with any male group. The gap is particularly broad for men and women living in multiperson households with children. For this household type, the share of serve-passenger trips for women is 22.8% and 9.3% for men.
- Women are more often passengers and less often drivers of a car than men. Car use in total is higher for men than for women, but the differences between sexes are less pronounced.
- Women use public transport more often than men except if they live in a multiperson household with children. For this group, men reach a slightly higher amount of public transport than women.

Influence of Employment Status on Travel Patterns

The distinction of employment status is added to increase the resemblance of the basic conditions of the groups compared. From the percentages shown in Table 2, it can be seen that for all household types a high percentage of men are fully employed (more than 80%). For women, a comparatively high percentage of fully employed persons is only found in single-person households. If a woman has a full-time job, it is very likely that she is single or lives in a multiperson household without children. In all, the range of different lifestyle models is greater for women than for men. Whereas women aged 30 to 49 can be full-time workers, part-time workers, or housewives, there is only one lifestyle model for men of the same age group, which is having a full-time job.

Hence, consistent with the general statistics (see section on research background) there is no male counterpart for some of the subdivisions found for women, a fact that is quite noteworthy in itself. In 92.8% of the cases, those with part-time jobs are women. Likewise 97.7% of homemakers are women (see Figure 1). Even with the very large sample from the study on mobility in Germany, the size of particular male groups drops to small numbers (sometimes $n < 10$), which makes it difficult to get statistically valid results by means of comparative analyses.

The results of comparing the part-time employed and homemakers with the full-time employed show that

[1] Most of the differences are significant at the 0.1% level. The smallest differences exist between single men and women. Accordingly, the magnitudes of the chi-square and *F*-values are the smallest for differences between single women and men, whereas the differences between men and women of multiperson households with children are the highest.

TABLE 1 Differences in Travel Patterns Depending on Sex and Household Type (Persons Aged 30 to 49)

	Single-Person Household		Multiperson, No Children		Multiperson with Children		Total	
	Men	Women	Men	Women	Men	Women	Men	Women
Average trip number per day	3.16	3.50	3.11	3.17	3.28	3.96	3.20	3.65
	F = 14.3; df = 1; ***		F = 1.0; df = 1; ns		F = 169.0; df = 1; ***		F = 151.3; df = 1; ***	
Average trip length (kilometers)	13.5	12.8	15.8	11.3	15.4	8.3	15.2	9.7
	F = 0.8; df = 1; ns		F = 55.8; df = 1; ***		F = 334.2; df = 1; ***		F = 330.8; df = 1; ***	
Trip purpose (%)								
Occupation	32.1	33.0	35.5	31.2	35.4	17.1	34.8	23.0
Shopping	21.6	20.6	18.6	24.4	16.5	23.7	18.0	23.6
Private business	9.9	12.3	11.5	12.1	10.0	11.2	10.4	11.6
Leisure	34.6	31.3	30.9	28.2	28.8	25.2	30.5	26.8
Serve passenger	1.9	2.7	3.6	4.0	9.3	22.8	6.2	15.1
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	χ^2 = 25.1; df = 4; ***		χ^2 = 106.5; df = 4; ***		χ^2 = 2,135.6; df = 4; ***		χ^2 = 2,026.5; df = 1; ***	
Use of means of transport (%)								
Walking	21.8	20.5	16.1	20.2	14.8	20.6	16.5	20.5
Bicycle	9.5	9.8	7.4	7.7	7.0	7.1	7.6	7.6
Car as passenger	4.4	5.1	8.6	16.1	11.3	14.1	9.2	13.6
Car as driver	52.9	51.6	59.7	48.5	59.5	54.2	58.3	52.3
Car total	*57.3*	*56.7*	*68.2*	*64.6*	*70.8*	*68.3*	*67.5*	*65.9*
Public transport	8.3	11.5	4.4	6.2	3.3	3.1	4.5	5.0
Other	3.0	1.6	3.8	1.3	4.1	0.8	3.8	1.1
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	χ^2 = 43.7; df = 5; ***		χ^2 = 466.9; df = 5; ***		χ^2 = 614.2; df = 5; ***		χ^2 = 942.6; df = 5; ***	

***$p \leq 0.001$; ns = not significant.

TABLE 2 Size of Analyzed Groups

		Type of Household							
		Single		Multiperson, No Children		Multiperson with Children		Total	
		N	%	*N*	%	*N*	%	*N*	%
Men (n = 8,304)	Full-time	1,434	*81.2*	2,303	*87.2*	3,573	*91.5*	7,310	*87.9*
	Part-time	63	*3.6*	59	*2.2*	86	*2.2*	208	*2.5*
	Househusband	3	*0.2*	9	*0.3*	23	*0.6*	36	*0.4*
	Rest	265	*15.0*	269	*10.2*	224	*5.7*	758	*9.1*
	Total	*1,765*	*100*	*2,640*	*100*	*3,905*	*100*	*8,312*	*100*
Women (n = 9,452)	Full-time	865	*74.1*	1,612	*52.1*	888	*17.0*	3,366	*35.5*
	Part-time	120	*10.3*	805	*26.0*	1,746	*33.5*	2,671	*28.2*
	Housewife	19	*1.6*	305	*9.9*	1,222	*23.4*	1,546	*16.3*
	Rest	164	*14.0*	372	*12.0*	1,360	*26.1*	1,897	*20.0*
	Total	*1,168*	*100*	*3,094*	*100*	*5,216*	*100*	*9,480*	*100*

employment status has for most of the variables examined the same effect for both sexes independent of the household type (Tables 3–5):

- Part-time employed persons as well as homemakers have a higher trip number per day than do fully employed persons.
- The average trip length of part-time employed and especially of homemakers is lower that that of the full-time employed. Likewise, the total distance traveled per day is lower. There is only one group for which the specified differences do not apply: part-time working single women have fewer but longer trips than their male counterparts and also higher total trip distances per day.
- Part-time employed persons as well as homemakers reach a higher share of shopping trips and a lower share of occupational trips. Regarding the other trip purposes there is no clear pattern.
- The modal split of part-time employees but especially of homemakers is characterized by a lower share of car use than that of full-time employed persons. The extent to which the share of passenger cars is smaller depends greatly on sex and household type. The differences between the subdivisions of women are much smaller than they are for men. Housewives have by far the lowest values concerning car availability at any time.

Three aspects are remarkable:

1. Concerning variations between full-time employees and part-time employees or homemakers (respectively the sum of the square root of the difference if the

TABLE 3 Gender Differences Depending on Employment Status: Multiperson Households with Children

		Full-Time		Part-Time		Not Employed	
		Men ($n \leq 3{,}573$)	Women ($n \leq 888$)	Men ($n \leq 86$)	Women ($n \leq 1{,}746$)	Men ($n \leq 23$)	Women ($n \leq 1{,}222$)
Trips per day	M	3.31	3.37	4.38	4.29	(5.00)	4.03
	S	*2.07*	*2.20*	*2.59*	*2.69*	*(3.01)*	*2.99*
		$F = 0.6$; df = 1; ns		$F = 0.1$; df = 1; ns		$F = 2.3$; df = 1; ns	
Average trip length (kilometers)	M	15.8	12.1	8.0	8.3	(6.5)	6.4
	S	*43.1*	*35.6*	*25.6*	*21.7*	*(7.9)*	*21.9*
		$F = 16.1$; df = 1; ***		$F = 0.1$; df = 1; ns		$F = 0.0$; df = 1; ns	
Travel distance per day (kilometers)	M	56.2	47.1	36.8	38.3	(32.8)	28.8
	S	*93.3*	*80.9*	*66.8*	*58.0*	*(27.5)*	*55.1*
		$F = 5.4$; df = 1; *		$F = 0.0$; df = 1; ns		$F = 0.1$; df = 1; ns	
Trip purpose							
Occupation	%	36.2	32.2	19.9	24.9	(1.0)	2.7
Shopping	%	16.0	19.2	22.4	22.9	(22.9)	25.8
Private business	%	10.0	10.3	13.2	10.1	(12.4)	12.9
Leisure	%	29.4	24.8	26.5	22.5	(23.8)	25.8
Serve passenger	%	8.5	13.5	18.0	19.6	(40.0)	32.9
Total	%	*100*	*100*	*100*	*100*	*(100)*	*100*
		$\chi^2 = 91.9$; df = 4; ***		$\chi^2 = 8.5$; df = 4; ns		$\chi^2 = 3.2$; df = 4; ns	
Use of means of transport							
Walking	%	14.6	15.3	25.0	17.9	(10.5)	22.3
Bicycle	%	7.0	7.3	20.9	7.3	(1.9)	7.0
Car as passenger	%	10.3	13.0	6.6	12.7	(5.7)	12.9
Car as driver	%	60.7	58.7	39.2	57.4	(81.9)	55.3
Car total	%	71.1	71.7	45.9	70.1	87.6	68.3
Public transport	%	3.1	4.8	6.3	3.9	(0.0)	1.8
Other	%	4.2	0.9	1.9	0.8	(0.0)	0.6
Total	%	*100*	*100*	*100*	*100*	*(100)*	*100*
		$\chi^2 = 100.2$; df = 5; ***		$\chi^2 = 114.1$; df = 5; ***		$\chi^2 = 30.0$; df = 5; ***	
Car availability							
At any time	%	88.0	79.4	76.5	81.7	(87.0)	68.2
Occasionally	%	9.3	12.4	17.6	11.7	(8.7)	18.6
Exceptionally	%	1.2	1.2	0.0	1.6	(0)	2.5
Not at all	%	0.9	3.9	4.7	2.3	(4.3)	5.5
No driver's license	%	0.6	3.0	1.2	2.7	(0)	5.3
Total	%	*100*	*100*	*100*	*100*	*(100)*	*100*
		$\chi^2 = 98.2$; df = 4; ***		$\chi^2 = 6.7$; df = 4; ns		$\chi^2 = 4.2$; df = 4; ns	

M = mean, *S* = standard deviation; ***$p \leq 0.001$; **$p \leq 0.01$; *$p \leq 0.05$; ns = not significant. Mean values and percentages are in parentheses if $n < 80$; χ^2 is in parentheses if too many cells are below $n = 5$.

variables have several categories), the differences between the groups are higher for male than for female subgroups.

2. The differences between part-time employees and homemakers on the one hand and full-time employees on the other correspond to a great extent to the differences that can be found between the sexes. Thus, for example, women make more trips than men. The same applies to part-time employees and homemakers in comparison with full-time employees.

3. With the additional distinction of employment status, the gender differences described in the previous section can be upheld only for parts of the groups. They still apply when fully employed men and women are compared but often have to be reversed if part-time employees and homemakers are compared. For the part-time employed as well as for homemakers, men reach higher average trip numbers per day, have a lower average trip length, and their share as car driver as well as share of car use in total are lower than those of their female counterparts. Moreover, regarding the magnitude of the chi-square and *F*-values, the differences between fully employed men and women are higher than those between the other groups since those values are higher and the differences are less often not significant. The smallest differences exist between homemakers.

What is the meaning of these differences? In principle, it can be said that men rarely take over the rather woman-specific role of a part-time employee or a homemaker. However, once they have this role, they adopt the behavior of their female counterparts, in some cases even exhibiting more strongly pronounced characteristics than those seen among women. How-

TABLE 4 Gender Differences Depending on Employment Status: Multiperson Households Without Children

		Full-Time		Part-Time		Not Employed	
		Men ($n \le 2{,}303$)	Women ($n \le 1{,}612$)	Men ($n \le 59$)	Women ($n \le 805$)	Men ($n \le 9$)	Women ($n \le 305$)
Trips per day	M	3.17	3.16	(3.39)	3.47	(2.96)	2.92
	S	*2.03*	*2.04*	*(2.01)*	*2.34*	*(1.04)*	*2.44*
		F = 0.0; df = 3; ns		F = 0.1; df = 1; ns		F = 0.0; df = 0; ns	
Average trip distance per day (kilometers)	M	16.2	12.7	(8.0)	9.8	(7.1)	8.8
	S	*37.4*	*38.1*	*(17.6)*	*38.9*	(7.3)	23.7
		F = 21.6; df = 1; ***		F = 0.4; df = 1; ns		F = 0.1; df = 1; ns	
Travel distance per day (kilometers)	M	55.7	46.4	(30.0)	37.6	(21.1)	32.7
	S	*80.3*	*83.9*	*(45.2)*	*83.2*	*(18.1)*	*55.2*
		F = 9.4; df = 1; **		F = 0.4; df = 1; ns		F = 0.4; df = 1; ns	
Trip purpose							
Occupation	%	37.5	38.2	(25.9)	32.9	(0.0)	2.8
Shopping	%	17.7	21.0	(29.9)	23.4	(50.0)	38.5
Private business	%	10.4	10.7	(9.2)	11.0	(3.8)	21.5
Leisure	%	30.9	27.2	(34.5)	26.7	(46.2)	31.7
Serve passenger	%	3.5	2.9	(0.6)	6.0	(0.0)	5.5
Total	%	*100*	*100*	*(100)*	*100*	*(100)*	*100*
		χ^2 = 30.3; df = 4; ***		χ^2 = 18.0; df = 4; ***		χ^2 = 8.4; df = 4; ns	
Use of means of transport							
Walking	%	15.3	18.0	(25.7)	17.7	(23.1)	29.7
Bicycle	%	7.3	6.3	(12.6)	9.2	(11.5)	10.2
Car as passenger	%	7.8	15.7	(10.3)	14.8	(11.5)	13.9
Car as driver	%	61.6	51.9	(41.7)	52.8	(30.8)	40.1
Car total	%	*69.4*	*67.6*	*(52.0)*	*67.6*	*(42.3)*	*54.0*
Public transport	%	4.0	6.8	(7.4)	4.7	(15.4)	4.7
Other	%	4.0	1.3	(2.3)	0.8	(7.7)	1.5
Total	%	*100*	*100*	*(100)*	*100*	*(100)*	*100*
		χ^2 = 301.1; df = 5; ***		χ^2 = 20.2; df = 5; ***		χ^2 = 12.6; df = 5; *	
Car availability							
At any time	%	88.8	79.2	(74.6)	76.2	77.8	54.9
Occasionally	%	6.7	10.0	(16.9)	12.2	11.1	17.1
Exceptionally	%	0.7	1.4	(3.4)	1.7	0	3.9
Not at all	%	2.5	6.0	(1.7)	4.8	11.1	11.5
No driver's license	%	1.3	3.4	(3.4)	5.1	0	12.5
Total	%	*100*	*100*	*(100)*	*100*	*100*	*100*
		χ^2 = 74.9; df = 4; ***		χ^2 = 3.3; df = 4; ns		χ^2 = 2.5; df = 4; ns	

M = mean, *S* = standard deviation; ***$p \le 0.001$; **$p \le 0.01$; *$p \le 0.05$; ns = not significant. Mean values and percentages are in parentheses if $n < 80$; χ^2 is in parentheses if too many cells are below $n = 5$.

ever, women who are increasingly working full time like men only partly adopt man-specific behavior. The behavior of full-time working women is clearly different from that of part-time employed women and housewives. Nevertheless, the differences between the female groups are clearly smaller than they are between male groups.

It is concluded that the general differences between men and women described in the previous section cannot be attributed exclusively to the fact that the share of part-time employees and housewives among women is higher than that for men. If only full-time employees are considered, gender differences are smaller than if the total sample is taken into account. However, full-time employees are the only group in which the differences described before arise at all. In other words, the group that was expected to have strongly adapted to male behavior turns out to be the group with the greatest differences in comparison with its male counterpart.

Travel Patterns of Fully Employed Men and Women in Multiperson Households

Since the differences between fully employed men and women are especially great, a closer look at this group is in order. Because the travel patterns of single men and women prove to have the greatest similarity, only those in multiperson households with and without children are taken into account. In the following, the focus is on the means of transport depending on the trip purpose (Figure 2). When the means of transport by trip purpose is distinguished, the results on travel patterns depending on sex and type of household do not change. For all trip purposes the travel patterns of both fully employed men and women are highly focused on the use of a private car. The share of public transport is generally low. The only trip purpose in which public transport plays at least a moderate role is occupation.

Women are more often a passenger and less often the driver of a car compared with men. Moreover, their

TABLE 5 Gender Differences Depending on Employment Status: Single-Person Households

		Full-Time		Part-Time	
		Men	Women	Men	Women
Trips per day	M	3.26	3.52	3.61	3.47
		F = 6.9; df = 1; **		F = 0.1; df = 1; ns	
Travel distance per day (kilometers)	M	53.9	52.2	45.2	57.8
		F = 0.2; df = 1; ns		F = 1.3; df = 1; ns	
Average trip length (kilometers)	M	14.5	13.8	9.1	13.9
		F = 0.5; df = 1; ns		F = 5.3; df = 1; ns	
Trip purpose					
Occupation	%	35.7	37.4	35.5	27.2
Shopping	%	20.3	19.4	26.2	28.0
Private business	%	9.1	10.1	7.1	18.8
Leisure	%	32.9	30.5	27.3	23.1
Serve passenger	%	2.1	2.5	3.8	3.0
Total	%	*100*	*100*	*100*	*100*
		χ^2 = 8.0; df = 4; ns		χ^2 = 15.3; df = 4; **	
Use of means of transport					
Walking	%	19.6	18.6	21.9	13.0
Bicycle	%	8.6	7.7	13.7	13.3
Car as passenger	%	4.1	4.6	0.0	4.6
Car as driver	%	57.8	57.4	43.2	56.9
Car total	%	*62.0*	*62.0*	*43.2*	*61.5*
Public transport	%	7.1	10.2	21.3	10.8
Other	%	2.7	1.5	0.0	1.4
Total	%	*100*	*100*	*100*	*100*
		χ^2 = 32.8 ; df = 5; ***		χ^2 = 30.7; df = 5; ***	
Car availability					
At any time	%	83.8	77.9	64.5	73.3
Occasionally	%	5.6	4.4	6.5	11.7
Exceptionally	%	1.0	3.0	8.1	5.8
Not at all	%	7.5	11.4	21.0	5.0
Have no driver´s license	%	2.0	3.2	0.0	4.2
Total	%	*100*	*100*	*100*	*100*
		χ^2 = 27.9; df = 4; ***		χ^2 = 14.5; df = 4; **	

M = mean; ***$p \leq 0.001$; **$p \leq 0.01$; ns = not significant.

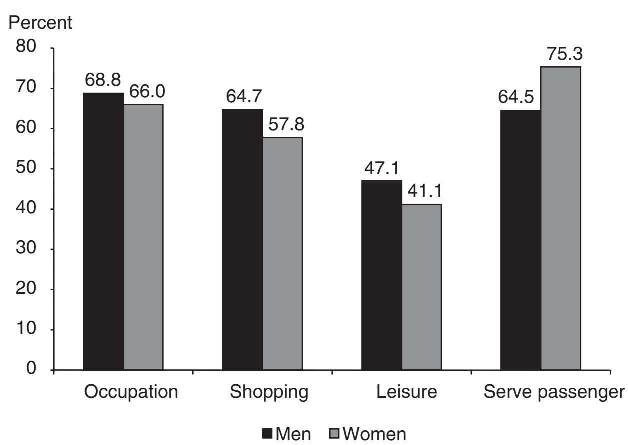

FIGURE 2 Multiperson households with children: use of car as driver for different trip purposes.

total car use (as passenger and as driver) is—apart from leisure trips—lower than that of men. However, there is one exception concerning women living in a multiperson household with children: serve-passenger trips are the only trip purpose for which they have a lower percentage of car use as a passenger and a higher percentage of car use as a driver. Also, in absolute figures, they use the car more often than men. Obviously, household duties, especially when there are children in the household, are still to a much higher extent carried out by women than by men even when they both have the same basic condition of a full-time job. In this situation, the car seems to be rather a precondition for women to work and at the same time fulfill family duties. So it is doubtful that the car has an equalizing effect concerning gender roles.

Conclusions: Same Conditions, Different Effects

Despite the claim that gender roles are equalizing, gender differences are particularly persistent in the (Western) German context. This finding is confirmed by evaluation of the data from the 2002 survey of mobility in Germany. However, the results show that more distinct travel patterns and a more differentiated coherence of sex and travel patterns can be revealed if the additional distinction of employment status is considered.

Comparing full-time employees depending on household type, the results demonstrate that travel patterns of men are more or less stable for all household types. In contrast, the travel patterns of women differ a great deal. In principle, travel patterns of men and women are much alike when the sexes are single. The differences are greater when men and women in multiperson households without children are compared and reach the highest level with regard to those in households with children. Even when only the fully employed are compared, family life affects the travel patterns of women much more than those of men. This finding makes it evident that neither on the individual nor on the societal level has any major progress been made to enable both women and men to combine traditional family life with modern lifestyles, particularly with a job.

Consistent with the statistics of the German Federal Statistical Office, only a few men in the sample of those aged 30 to 49 are part-time workers or homemakers. But once they have taken on this role, they show the same travel patterns as those of women in the same situation. In many cases they have even more strongly pronounced travel characteristics, which are normally ascribed to women. With reference to employment status, it can be seen that the gender differences found in the literature only exist for full-time employees. If instead men and women working part time and homemakers are considered, the gender differences are reversed. The fact that the gender differences exist between fully employed men and women demonstrates that women in Germany who are increasingly employed full time adopt the behavior of their male counterparts only in part. Women are still—even when employed full time—to a greater extent responsible for household duties and child care. The large share of car use for serve-passenger trips seems to support the results of qualitative studies that the car is often a precondition for women to fulfill work and family duties at the same time. The car therefore has an ambivalent role since it affords more flexibility but at the same time is solidifying the traditional role of women.

Because travel patterns are highly linked with employment status and family obligations, it is important to understand the extent to which societal changes with respect to equalizing gender roles will occur. As long as the activities of men and women vary, travel patterns will also be different. The question is thus whether the share of men working part time and being homemakers might increase in the future and whether these men will adopt woman-specific behavior and vice versa. In the authors' opinion, these questions are interesting not only from an analytical point of view but also from a planner's perspective. For transport enterprises it is of particular importance to know whether they will lose an important customer group in the long run because of the increase in car use by women or whether they also might win new customer groups of men working part time or being homemakers who adopt woman-specific behavior.

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Injury Prevention and Ergonomics

Safety of Pregnant Drivers in the United Kingdom

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It is widely accepted that women have a different driving style and travel patterns from those of men, whereas pregnant women have yet again a different set of travel patterns and preferences. Pregnancy can cause a wide range of symptoms and physical changes that are not limited to the abdominal region. Research to date has not considered the real-life experiences and problems of car travel during pregnancy. The project Automotive Design: Incorporating the Needs of Pregnant Women at Loughborough University addresses issues such as seat belt safety, behaviors, and needs in a holistic manner for the first time and provides explicit information about pregnant women. A pregnancy and driving questionnaire is used to investigate how U.K. women's experiences of driving and using passive safety systems (seat belts, airbags, and head restraints) are affected during car travel. The main safety concerns found in 450 completed questionnaires were low levels of correct seat belt and head restraint positioning and proximity to the steering wheel and airbags. The correct position for the shoulder section of the seat belt is between the breasts and for the lap section around the abdomen and across the hips underneath the abdomen. Some U.K. pregnant women used the correct position for the shoulder belt, and others positioned the lap belt correctly across the hips. However, the seat belts are designed to protect the car occupant when used correctly, not correctly in part. Therefore this study is focused on correct usage of the entire seat belt. Certain factors seem to influence correct seat belt positioning positively, and this information could be used to target schemes to provide seat belt information. Targeting information to women in their first pregnancy will improve seat belt positioning for that first pregnancy and will help in subsequent pregnancies. Pregnant women commonly reported concern that the seat belt was incorrectly positioned, and they felt unsafe while using the seat belt. In some cases women took action to alleviate this fear, for example, by ceasing to use the seat belt or by holding it. This is evidence that women modify their seat belt behavior for protection during pregnancy but may actually put themselves at greater risk of injury. The majority of women in their third trimester of pregnancy were seated with their abdomen less than 25 cm from the steering wheel because of abdominal protrusion. This problem is counteracted by moving the seat rearward, but that results in difficulty reaching the pedals. More suitable designs would help women to increase their steering wheel clearance while maintaining their ability to reach the pedals. All the information about pregnant women's experiences of using passive safety systems is presented as an information catalog for automotive designers as part of this project. This catalog includes guidelines to aid future vehicle design concepts with the aim of improving car travel for pregnant women. Detailed findings of this project have been submitted for publication or can be obtained from the authors.

Pregnant Women and Safety Belts
What Do We Know?

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Injuries are a leading cause of death among pregnant women, and motor vehicle crashes are a leading cause of hospitalized injuries during pregnancy. The protective effect of safety belts for pregnant women and fetuses has been well documented. Self-reported data from two population-based surveys were used to examine safety belt use among reproductive-aged women and prenatal counseling about safety belts during pregnancy. The prevalence of safety belt use among reproductive-aged women ranged from 70% to 91% across 19 states. The prevalence of counseling about safety belts during pregnancy ranged from 37% to 57%. Younger, non-Hispanic black, and less educated reproductive-aged women were less likely to use seat belts. Pregnant women with these characteristics were more likely than older, non-Hispanic white, and more educated women to receive counseling about safety belt use. Population-based data on safety belt use among pregnant women are needed. Because belt use may change as the pregnancy advances, it should be measured during various stages of pregnancy. Adherence to counseling guidelines is low and should be increased. Provider counseling should be used in combination with effective tools such as legislation and high-visibility law enforcement, and the impact of counseling should be rigorously evaluated.

There are more than 4 million live births in the United States each year (Ventura et al. 2004). Every year, more than 1 million women of reproductive age (15 to 44 years) are treated in emergency departments for motor vehicle crash injuries, and more than 6,000 women are killed [Centers for Disease Control and Prevention (CDC) 2002]. A woman's greatest risk for motor vehicle injury occurs during this life stage (CDC 2002). Eighty-five percent of pregnancies occur during the ages 15 to 34, and motor vehicle crashes are the leading cause of death for women in this age group (CDC 2002; Ventura et al. 2004).

Historically, it has been difficult to quantify the burden of motor vehicle crash injuries involving pregnant women. Maternal deaths by definition include only those that are "related to or aggravated by pregnancy or its management" and exclude deaths from accidental causes such as motor vehicle crashes [Committee on Fetus and Newborn, American Academy of Pediatrics (AAP), and Committee on Obstetric Practice, American College of Obstetricians and Gynecologists (ACOG) 2002]. As a result, crash-related deaths do not appear in maternal mortality statistics. However, some reports suggest that injuries are a leading cause of death for pregnant and postpartum women in the United States (Dannenberg et al. 1995; Fildes et al. 1992), and motor vehicle crashes have emerged as a leading cause of injury-related hospitalizations during pregnancy (Weiss et al. 2002).

There are also risks for the fetus involved in a motor vehicle crash. In recent years, the burden of crash-related fetal loss has been described at a population level. Weiss et al. (2001) reviewed fetal death certificates in 16 states and found that motor vehicle crashes caused more than 80% of the injury-related fetal deaths. They also found that the crash-related fetal death rate (2.3 per 100,000 live births) was approximately one-half that of the crash-related infant death rate (4.9 per 100,000 live births).

Safety belts were introduced for occupant protection in the United States in the 1960s (Graham 1989). Although evidence of the protective effect of safety belt use during pregnancy began to appear during the early 1970s, case reports were also appearing in the literature that described instances of injury to or even death of the fetus as a result of the safety belt, the lap belt in particular (Handel 1978; Matthews 1975; McCormick 1968; Pepperell et al. 1977; Raney 1970; Rubovits 1964; Whitehouse 1972). These case reports may have fueled early concerns about wearing safety belts during pregnancy. In issuing guidelines regarding safety belts and pregnancy with AAP in 1992, ACOG reported data suggesting that belt use among pregnant women in the early 1970s was approximately half that of all women (ACOG 1992). Reasons given for not wearing a safety belt during pregnancy included concerns about harming the infant as well as discomfort or not being in the habit of wearing one (Johnson and Pring 2000; McGwin et al. 2004; Pearlman and Phillips 1996).

Evidence has continued to accumulate over the years supporting the use of a properly positioned safety belt during pregnancy (Crosby and Costiloe 1971; Hyde et al. 2003; Wolf et al. 1993). At the same time, safety belt use in the United States has increased dramatically from less than 20% in the early 1980s to 81% in 2002 (Beck et al. 2004; Williams and Lund 1986). However, few data exist about safety belt use during pregnancy. Clinic-based surveys conducted in 1993, 1997, and 2001 reported that 45% to 86% of pregnant women in the United States always wear safety belts (McGwin et al. 2004; Pearlman and Phillips 1996; Tyroch et al. 1999). In addition, approximately 25% to 50% of pregnant women are not aware of the proper positioning of safety belts during pregnancy (Johnson and Pring 2000; McGwin et al. 2004; Tyroch et al. 1999).

AAP and ACOG have recognized the importance of occupant safety during pregnancy by issuing guidelines for health care providers to counsel all pregnant women on the proper use of safety belts during pregnancy (Committee on Fetus and Newborn, AAP, and Committee on Obstetric Practice, ACOG 2002; ACOG 1992). These guidelines are consistent with general occupant safety recommendations from the U.S. Preventive Services Task Force, which call for providers to counsel all patients to use occupant restraints (DiGuiseppi et al. 1996). Although approximately 25% of pregnant women receive less-than-adequate prenatal care (calculated as a function of month of initiation and number of visits, adjusted for gestational age at delivery), 99% of pregnant women in the United States receive at least some prenatal care (Martin et al. 2003). Prenatal care visits are thus an ideal mechanism for educating women about safety belt use.

Given the impact of motor vehicle crashes on pregnant women and fetuses, it is important to monitor health-promoting behaviors that can improve crash outcomes. Although limitations existed in the available data sets, it was possible to examine population-based data on safety belt use among women of reproductive age and prenatal counseling about wearing safety belts during pregnancy. A previous paper (Beck et al. 2005) uses these data to evaluate physician adherence to AAP-ACOG counseling guidelines, the results of which are summarized briefly here.

Data Sources and Analytic Methods

Data were from two ongoing, population-based surveillance systems administered by the CDC. The Behavioral Risk Factor Surveillance System (BRFSS) collects self-reported data on a variety of health-related topics. All 50 states, the District of Columbia (DC), and three territories participate. A disproportionate stratified sample of adults (aged at least 18 years) was selected for the 50 states and DC. Data were collected with telephone interviews. Details of the BRFSS methodology are described elsewhere (Mokdad et al. 2003). In 2002 the median response rate, as defined by the Council of American Survey Research Organizations (White 1984), was 58% (range across states: 42% to 83%).

In 2002 BRFSS respondents were asked how often they used safety belts when they drove or rode in a car. For this analysis, safety belt use was dichotomized as "always wears" versus "does not always wear" (i.e., nearly always, sometimes, rarely, or never) because a person may be involved in a crash during any given vehicle trip and must therefore wear a safety belt on each and every trip. Respondents who reported that they never rode in cars were excluded from the analysis (0.2%).

The analysis was limited to women of reproductive age (18 to 44 years) in the 50 states and DC. The exclusion of women less than 18 years old was dictated by the BRFSS sampling design. In 2002, fewer than 1% of girls aged 10 to 17 years gave birth and 0.03% of women aged 45 to 54 years gave birth in the United States (Martin et al. 2003; Census Bureau 2002). Pregnancy status was assessed at the time of the interview (currently pregnant or not). Safety belt use among women of reproductive age was examined by sociodemographic variables (age, race or ethnicity, education) and by type of safety belt legislation (primary versus secondary enforcement) in the state in 2002. Washington upgraded from secondary to primary enforcement during the study period and was excluded from this portion of the analysis (Insurance

Institute for Highway Safety n.d.). All missing observations were excluded from the analysis (missing data for the variables examined ranged from 0.0% to 1.3%).

The Pregnancy Risk Assessment Monitoring System (PRAMS) collects self-reported data on maternal behaviors and experiences that occur before, during, and after pregnancy. Women who deliver live-born infants are sampled from birth certificates at 2 to 6 months postpartum. Data are collected with mailed, self-administered surveys or with telephone interviews. Details of the PRAMS methodology are described elsewhere (Colley Gilbert et al. 1999).

In 2000, 19 states (Alabama, Alaska, Arkansas, Colorado, Florida, Hawaii, Illinois, Louisiana, Maine, Nebraska, New Mexico, New York, North Carolina, Ohio, Oklahoma, South Carolina, Utah, Washington, West Virginia) participated in PRAMS. New York data did not include New York City. The median response rate, weighted to reflect the sampling design, was 78% (range across states: 72% to 86%).

In 2000 survey respondents were asked whether, during any prenatal care visit, a doctor, nurse, or other health care worker talked with them about using a safety belt during pregnancy. Safety belt counseling was examined by selected indicators. Maternal age, race or ethnicity, education, and parity were obtained from birth certificates. All other variables were self-reported on the PRAMS questionnaire: payment source for prenatal care, type of prenatal care provider, and timing of entry into prenatal care. Women who did not receive any prenatal care were excluded from all analyses; the prevalence of not receiving any prenatal care ranged from 0.3% to 1.5% across states. All missing observations were also excluded (missing data for the variables examined ranged from 0.02% to 6.8%).

To accommodate the complex survey designs, SUDAAN software was used for analysis. For the BRFSS data, prevalence estimates and 95% confidence intervals (CIs) were calculated to provide national estimates of safety belt use among all reproductive-aged women and for the subset of pregnant women. State-based estimates of safety belt use were calculated only for women of reproductive age. Numbers were not sufficient to report state-based estimates of safety belt use among pregnant women. For the PRAMS data, prevalence estimates and 95% CIs for being counseled to use a safety belt during pregnancy were calculated by state. With aggregated data for 19 states, risk ratios (and 95% CIs) were calculated to examine the association between sociodemographic characteristics and the outcome variables (counseling and safety belt use).

FINDINGS

The BRFSS analysis was restricted to women of reproductive age (18 to 44 years), and the mean age of this group was 31.5 years. The majority (61%) of respondents had more than a high school education. Two-thirds of the respondents were non-Hispanic white, 16% were Hispanic, 13% were non-Hispanic black, and 6% were other race. Five percent of the respondents were pregnant at the time of the interview.

In 2002 self-reported safety belt use in the United States (50 states and DC) was 83.8% (95% CI: 83.2, 84.4) for reproductive-aged women and 84.1% (95% CI: 81.9, 86.3) for pregnant women. Safety belt use among reproductive-aged women ranged from 59.8% to 94.1% across all states.

Among the 19 states that also participated in PRAMS, safety belt use among reproductive-aged women ranged from 70% to 91% (Table 1). Subsequent analyses were restricted to women in these 19 states. The prevalence of always wearing safety belts was higher in states with primary enforcement laws than in states with secondary enforcement laws (85.2% versus 79.3%, respectively). Non-Hispanic black women were slightly less likely to wear safety belts than were non-Hispanic white women, women aged 29 years or younger were slightly less likely to wear safety belts than older women, and women with a high school or less than a high school education were slightly less likely to wear safety belts than women with more than a high school education (Table 2).

PRAMS respondents were younger (mean age: 27 years) and less educated (48% with more than high school education) than the BRFSS respondents. Sixty-four percent of the PRAMS respondents were non-Hispanic white, 14% were Hispanic, 17% were non-Hispanic black, and 5% were other race.

TABLE 1 Prevalence of Safety Belt Use Among Women of Reproductive Age: 19 States (BRFSS, 2002)

State	Sample *N*	Prevalence % (95% CI)
Alabama[a]	848	85.6 (82.7–88.5)
Alaska	800	73.9 (69.6–78.2)
Arkansas	916	69.5 (66.0–73.0)
Colorado	1085	81.1 (78.2–84.0)
Florida	1463	84.6 (82.4–86.8)
Hawaii[a]	1398	91.4 (89.2–93.6)
Illinois	692	75.0 (69.5–80.5)
Louisiana[a]	1427	80.9 (78.5–83.3)
Maine	614	76.6 (72.7–80.5)
Nebraska	1136	76.3 (73.4–79.2)
New Mexico[a]	1086	89.7 (87.5–91.9)
New York[a]	1217	83.1 (80.6–85.6)
North Carolina[a]	1738	91.3 (89.3–93.3)
Ohio	1070	78.8 (75.9–81.7)
Oklahoma[a]	1601	82.1 (79.7–84.5)
South Carolina	1160	76.8 (73.5–80.1)
Utah	1122	78.7 (75.4–82.0)
Washington	1294	89.9 (87.9–91.9)
West Virginia	800	76.1 (72.6–79.6)

[a] State had primary enforcement belt law in effect January 1, 2002.

TABLE 2 Associations Between Safety Belt Use Among Women of Reproductive Age and Sociodemographic Characteristics: 19 States (BRFSS, 2002)

Characteristic	Risk Ratio (Unadjusted)	95% CI
Maternal race/ethnicity		
Hispanic	0.99	0.95–1.04
Non-Hispanic black	0.95	0.92–0.99
Non-Hispanic other	1.00	0.96–1.05
Non-Hispanic white	referent	
Maternal age (years)		
18–24	0.90	0.88–0.93
25–29	0.95	0.93–0.98
30–44	referent	
Maternal education		
<HS	0.92	0.87–0.97
HS	0.95	0.92–0.97
>HS	referent	
Type of safety belt law		
Primary	1.07	1.05–1.10
Secondary	referent	

Note: HS = high school.

The prevalence of pregnant women who reported prenatal counseling to use a safety belt was 48.2% overall; the prevalence ranged from 36.7% to 56.5% across the 19 states (Table 3). Women who were least likely to report having been counseled to wear safety belts were at least 30 years of age, were non-Hispanic white, had more than a high school education, were not receiving Medicaid, or were receiving prenatal care from a private provider (Table 4). The prevalence of being counseled decreased as level of education increased (<high school, 56.6%; high school, 50.5%; and >high school, 43.4%).

TABLE 3 Prevalence of Prenatal Counseling to Use Safety Belts During Pregnancy: 19 States (PRAMS, 2000)

State	Sample *N*	Prevalence % (95% CI)
Alabama	1536	49.9 (46.8–53.0)
Alaska	1430	49.9 (47.0–52.8)
Arkansas	1604	36.7 (33.2–40.2)
Colorado	2118	48.3 (45.6–51.0)
Florida	1957	45.9 (42.6–49.2)
Hawaii	2443	48.8 (46.6–51.0)
Illinois	1936	50.3 (47.9–52.7)
Louisiana	2220	52.2 (49.7–54.7)
Maine	1123	55.4 (52.1–58.7)
Nebraska	2066	50.8 (48.1–53.5)
New Mexico	1571	55.7 (53.2–58.2)
New York[a]	1220	39.0 (35.5–42.5)
North Carolina	1764	55.9 (52.8–59.0)
Ohio	1611	46.7 (43.4–50.0)
Oklahoma	1932	42.9 (39.4–46.4)
South Carolina	1563	51.9 (48.0–55.8)
Utah	1610	42.8 (39.7–45.9)
Washington	1540	56.5 (53.0–60.0)
West Virginia	1273	46.9 (43.6–50.2)

[a] Data do not include New York City.

TABLE 4 Associations Between Prenatal Counseling to Use Safety Belts During Pregnancy and Sociodemographic Characteristics : 19 States (PRAMS, 2000)

Characteristic	Risk Ratio (Unadjusted)	95% CI
Maternal race/ethnicity		
Hispanic	1.25	1.18–1.32
Non-Hispanic black	1.37	1.32–1.43
Non-Hispanic other	1.23	1.15–1.32
Non-Hispanic white	referent	
Maternal age (years)		
<17	1.19	1.09–1.29
18–24	1.17	1.12–1.23
25–29	1.10	1.04–1.16
≥30	referent	
Maternal education		
<HS	1.31	1.24–1.37
HS	1.16	1.11–1.22
>HS	referent	
Parity		
1st birth	1.02	0.98–1.06
2nd or higher birth	referent	
PNC payer		
Medicaid	1.21	1.16–1.25
Non-Medicaid	referent	
PNC provider		
Public	1.25	1.20–1.30
Private	referent	
Entry into PNC		
2nd/3rd trimester	1.01	0.96–1.06
1st trimester	referent	

Note: HS = high school; PNC = prenatal care.

Discussion of Results

It was found that 84% of women of reproductive age always wore safety belts in 2002. These findings are consistent with recent reports of belt use among women. The National Highway Traffic Safety Administration (NHTSA) found 79% belt use in a 2002 observational survey (Glassbrenner 2003), and the 2000 Motor Vehicle Occupant Safety Survey found a self-reported prevalence of 88% (Block 2001). The patterns of safety belt use observed by age, race or ethnicity, and education were similar to those reported in other studies (Block 2001; Glassbrenner 2003; Lerner et al. 2001; Nelson et al. 1998). Of interest is the fact that the type of enforcement law in the state had an impact on safety belt use among reproductive-aged women. Numerous evaluations comparing primary and secondary enforcement laws have shown that adult use of safety belts is higher in states with primary laws. On average, belt use tends to be about 8% to 14% higher in states with primary laws than in those with secondary laws (Beck et al. 2004; Dinh-Zarr et al. 2001; NHTSA 2003). The analysis in this study, although limited to women of reproductive age, still showed a difference of six percentage points.

Given the evidence about the benefits of safety belts during pregnancy, it is important to monitor the prevalence of safety belt use among pregnant women. Knowledge of who is not wearing safety belts can help direct resources to promote belt use during pregnancy. Existing data regarding safety belt use during pregnancy are limited for several reasons. Several published studies that have examined pregnancy-related behavior are clinic-based and may not be generalizable to the broader population of pregnant women (McGwin et al. 2004; Pearlman and Phillips 1996; Tyroch et al. 1999). Although the BRFSS data are population-based, the major limitation of using these data to measure behaviors of pregnant women is that the surveillance system targets the general population of U.S. adults and not pregnant women. Pregnancy status is assessed at the time of the interview, but the survey is not designed to measure safety belt practices during pregnancy specifically. The survey question ("How often do you use seat belts when you drive or ride in a car?") measures behavior over a general time frame. The wording of the question assumes a constant pattern of behavior over time, which may not be valid when women become pregnant. Thus, it is difficult to interpret the meaning of the prevalence of safety belt use among currently pregnant women. In addition to this measurement issue, the number of pregnant women in the sample is not sufficient to conduct an in-depth analysis or to examine belt use among pregnant women at the state level.

Although PRAMS does not provide national estimates, it is a potential source of population- and state-based data on safety belt use during pregnancy. Questions on occupant safety for women and infants are available for participating states to add to their surveys; one of these questions measures safety belt use during the last 3 months of pregnancy. Measuring behavior during the latter stages of pregnancy is important because this is a time when previously reported concerns about belt use (i.e., discomfort, fear of harming the infant) may become more pronounced (because of the woman's growing abdomen). Thirty-one states currently participate in PRAMS; however, only one state (Utah) currently uses this question. Two states (Maryland and Vermont) used this question for 2001 to 2003. Available 2001 data from Maryland indicate that 85% of women always wore safety belts during the last 3 months of pregnancy (Maryland Department of Health and Mental Hygiene 2004).

Some limitations of self-reported surveys should be discussed. One issue is the inability to assess whether the belt is properly positioned. The lap belt should be placed under the abdomen and across the upper thighs. The shoulder belt should be positioned between the breasts, which may require adjusting the seat position. However, direct observation of belt use by pregnant women may not be feasible. In lieu of direct observation, women could be surveyed about their knowledge of proper belt placement as well as their frequency of belt use, similar to the methods used by McGwin et al. (2004). Respondents are asked to identify the proper belt position from text descriptions and photographs of various belt positions. Social desirability is another concern with self-reported surveys, that is, whether respondents will answer survey questions according to what they believe to be the socially acceptable response. However, there is evidence that social desirability has a minimal impact on measures of safety belt use in the United States (Nelson 1996). Recall bias may also be a concern, particularly for the PRAMS survey, which women complete several months after delivery.

Since 1992 ACOG has recommended that prenatal care providers counsel all patients about safety belt use during pregnancy. Verbal discussion of this issue is specifically recommended, as opposed to the distribution of written materials such as brochures. Therefore, the survey question asked women to report only discussions with their providers. Although certain groups of women were more likely to receive counseling than others, the overall prevalence of counseling was low (less than 50%). The significance of these findings is discussed in more detail elsewhere (Beck et al. 2005). The reasons for the low levels of provider counseling on this topic are not clear. The prevalence of counseling for many other health-related behaviors (e.g., smoking, drinking, breastfeeding, nutrition) is much higher (≥80%) (Petersen et al. 2001). Because of the data issues for reporting of maternal mortality statistics, prenatal providers may be less aware of the potential risks for their patients. However, pregnant women may have as many as 12 to 14 prenatal visits during a routine pregnancy, and virtually all (99%) receive at least one prenatal visit (CDC 2000). Therefore, prenatal providers have a unique opportunity to educate women about occupant safety. Providers can correct misconceptions about the protective effects for the woman and fetus and instruct women about the proper position of the safety belt.

It may be advisable to devote resources toward educating prenatal providers about the risks faced by their clients. Increased awareness of the issue may lead to increased prevalence of prenatal counseling about belt use during pregnancy. In addition, obstetricians and gynecologists as well as pediatricians could become advocates for strengthening laws in those states with secondary enforcement safety belt laws. Precedent exists for the role of physicians in advocating for the safety of their patients. For example, pediatricians were an important force in the passage of child restraint laws in the 1980s (Graham 1989).

To fully inform the discussion about occupant safety for pregnant women, population-based data on proper safety belt use among pregnant women are needed.

Because belt use may change as the pregnancy advances, particularly during the last trimester, belt use should be measured during various stages of pregnancy. Provider counseling should be used as a means to educate women about the proper positioning of the safety belt to protect the woman and fetus in the event of a crash. In addition, the impact of counseling on safety belt use and knowledge of proper belt positioning should be rigorously evaluated. Finally, findings here about the impact of primary enforcement laws suggest that effective strategies to increase safety belt use among the general population can be effective for reproductive-aged women as well. To promote the safety of pregnant motor vehicle occupants, prenatal counseling should be used in combination with strategies such as legislation and high-visibility law enforcement.

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Protecting the Pregnant Occupant and Fetus in Motor Vehicle Crashes
Biomechanical Perspective

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Providing effective protection for fetuses of pregnant occupants in motor vehicle crashes (MVCs) poses a challenge to automotive safety engineers because of limited data on the causes of fetal loss and injury. Recent studies have improved the understanding of biomechanical factors leading to adverse fetal outcomes in MVCs and have resulted in tools to evaluate restraint system performance for pregnant occupants. An anthropometry study of seated pregnant occupants throughout gestation has provided data on the size and shape of the pregnant abdomen relative to steering wheels and belt restraints. In-depth investigations of 42 crashes involving pregnant occupants resulted in logistic regression models that estimate the risk of adverse fetal outcome on the basis of crash severity and maternal restraint use. Data from these studies were used to develop a pregnant abdomen and injury reference values for the small female Hybrid III crash dummy. Highest-priority areas for future research are to monitor fetal outcomes after MVCs systematically, improve instrumentation for the pregnant crash dummy, expand the database of MVCs involving pregnant women, and measure material property characteristics of uterine and placental tissue.

Each year in the United States, approximately 128,000 of the 4 million pregnant women (10% of women aged 15 to 45) are involved in tow-away crashes (*1*). The actual number of fetal losses from motor vehicle crashes (MVCs) each year in the United States is unknown because mortality databases do not explicitly include maternal involvement in MVCs as a cause of fetal death. However, analysis of information available on fetal death certificates leads to a conservative estimate that 370 fetal deaths occur each year because of maternal involvement in an MVC (*2*), which is twice the number of infants under age 1 killed each year in MVCs. Moreover, although the number of children with physical and mental disabilities resulting from trauma sustained in utero during MVCs is also unknown, it is expected to be substantially higher than the estimated number of fetal losses. Despite these statistics, few studies have addressed the unique transportation safety needs of pregnant occupants and their fetuses.

Early Biomechanics Research

Early biomechanics research on fetal loss resulting from MVCs involved sled tests performed on pregnant baboons in the 1960s (*3–5*). Results were limited but suggested that use of a three-point belt was better than a lap belt alone. Culver and Viano (*6*) attempted to estimate the anthropometry of a pregnant occupant for use in motor vehicle design by using scaling techniques to generate small, average, and large pregnant occupants and assuming that abdomen size varied with maternal stature. In the early 1990s, Pearlman and Viano (*7*) developed the first pregnant crash test dummy by modifying a standard Hybrid III small female dummy to accommodate fetal and uterine components that were instrumented to measure fetal acceleration and load transmitted through the abdomen. However, the utility of this dummy is limited by an unrealistic abdominal shape, a stiff force-deflection response, and a lack of correlation between measurements and the risk of adverse fetal outcome.

Recent Biomechanics Research

Research at University of Michigan Transportation Research Institute

In the late 1990s, General Motors funded several projects to improve automotive safety for pregnant occupants (*8*). The objectives of these studies were to obtain a better understanding of the anthropometry of the pregnant motor vehicle occupant, to determine biomechanical factors surrounding fetal trauma to pregnant occupants involved in real-world crashes, and to develop an improved pregnant crash test dummy for evaluating the effectiveness of vehicle restraint and crashworthiness technologies in reducing fetal loss and disabling trauma in MVCs.

Anthropometry of Pregnant Occupants

In this study, the automotive-seated anthropometry and vehicle seat positioning of 22 women was investigated four times during their pregnancies (*9*). Subjects in five different stature groups were tested in the adjustable seating buck shown in Figure 1, which was configured to different vehicle interior package geometries with varying belt anchorage locations. Data collected included preferred seating positions of pregnant drivers, proximity of the pregnant occupant to the steering wheel and airbag module, contours of the subjects' torsos and abdomens relative to the seat-belt centerline, and subject perceptions of their seated posture and proximity to vehicle components. The anthropometry data showed that abdominal size does not vary significantly with stature. This finding revealed a problem with the abdominal size of the original pregnant dummy, which was developed with the assumption that abdominal size does vary with stature. Figure 2 compares the mean midline abdominal contour of all subjects at 7 months' gestation with the abdominal contour of the original pregnant dummy. Figure 3 shows the position of a lap belt relative to the midline abdominal contour and the anterior-superior iliac spines (ASIS), which suggests that even with the lap belt positioned as is recommended (as low as possible over the pelvis), there is potential for lap-belt loading of the uterus. Figure 4 shows a postural representation of a subject and illustrates how the clearance between the abdomen and steering wheel rim decreases as gestation progresses because pregnant occupants do not adjust their seat position rearward during pregnancy.

Investigations of Crashes Involving Pregnant Occupants

In-depth investigations of 42 real-world crashes involving pregnant occupants were performed over a 2-year period (*10*). Investigators collected information about the crash circumstances and conditions, measured and

FIGURE 1 Adjustable laboratory seating buck used in study of pregnant anthropometry.

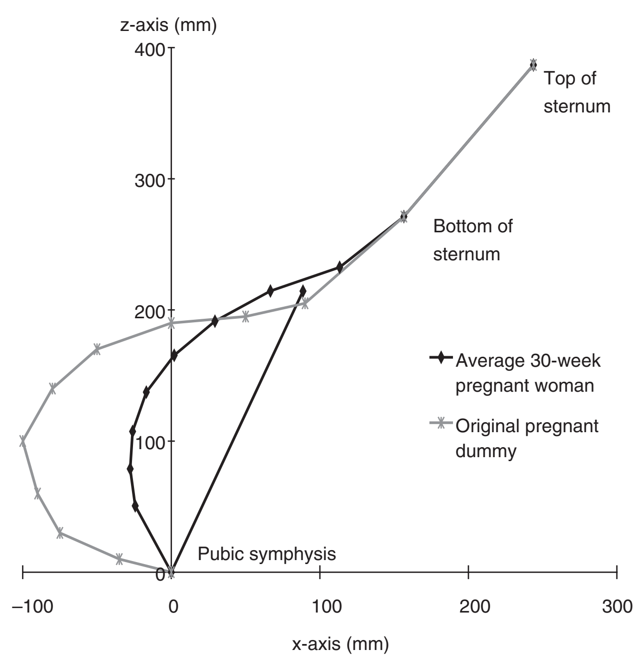

FIGURE 2 Mean midline abdominal contour of pregnant subjects at 30 weeks' gestation compared with contour of original pregnant crash test dummy.

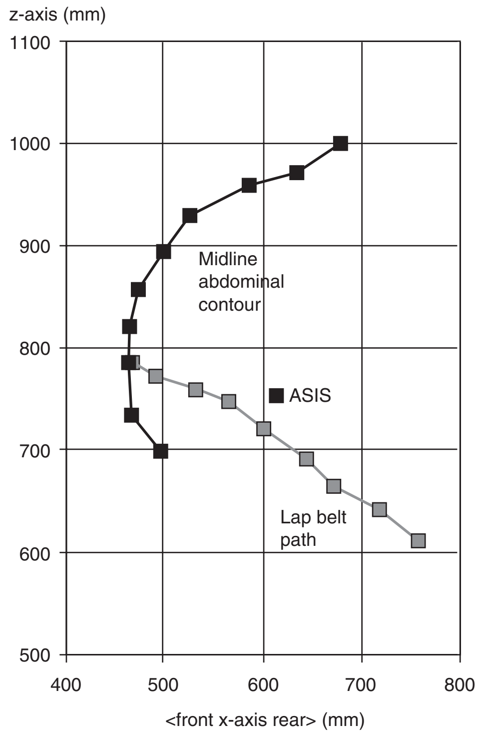

FIGURE 3 Midline contour of pregnant abdomen compared with path of lap belt and ASIS.

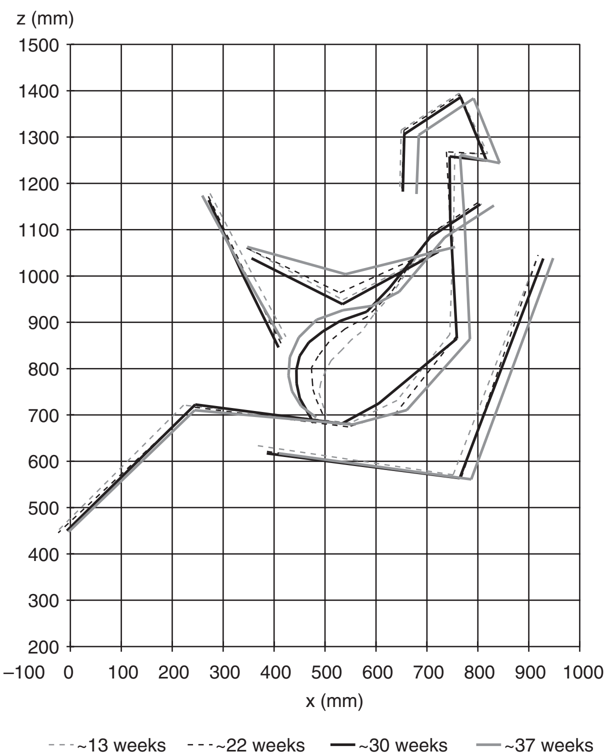

FIGURE 4 Postural representation of 162-cm woman throughout gestation.

photographed the crash scene and vehicle damage, and obtained detailed information regarding the occupant and fetal injuries from medical records and subject interviews. Results of the study are consistent with the previously reported observation that the leading cause of fetal death from MVCs is placental abruption, the premature separation of the placenta from the uterus, which prevents transfer of oxygen and nutrients to the fetus (*11*, *12*). Data in the literature and in the current study also indicate that placental abruption occurs more frequently than other common adverse fetal outcomes such as uterine rupture and direct fetal injury.

Analysis of these crash-injury data demonstrated clear associations between adverse fetal outcome (fetal loss, placental abruption, uterine laceration, delivery at less than 32 weeks, or direct fetal injury) and higher crash severities and the lack of maternal belt restraint use. Figure 5 shows the estimated risk of adverse fetal outcome by crash severity and restraint condition, with points used to develop the curves by means of logistic regression analysis included. Overall, improperly restrained occupants (no restraint, improper belt use, airbag only) were 5.7 times more likely to have adverse fetal outcomes than properly restrained occupants (properly positioned three-point belts, with or without airbags). However, belt use does not affect the likelihood of adverse fetal outcome in high-severity crashes.

Development of Pregnant Crash Test Dummy

The results of the anthropometric and crash investigation studies were implemented in the design, development, and validation of the new pregnant crash dummy shown in Figure 6, the Maternal Anthropomorphic

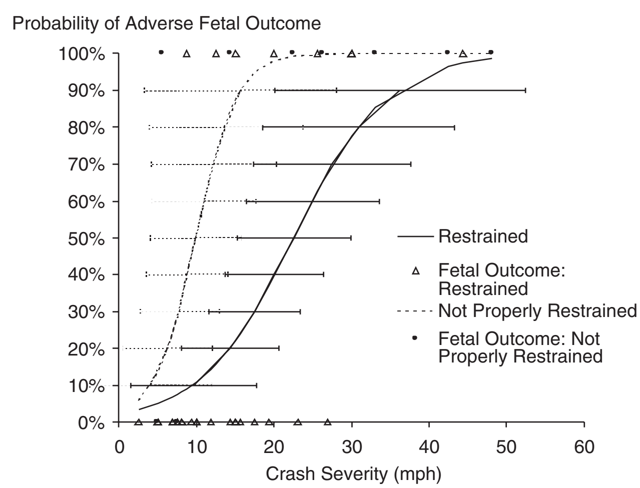

FIGURE 5 Estimated risk of adverse fetal outcome as a function of crash severity and maternal restraint.

FIGURE 6 MAMA-2B set up for sled test impact simulation of frontal crash.

TABLE 1 Test Matrix for Developing MAMA-2B Criteria

Test No.	ΔV (km/h)	Position	Restraint	Risk of Adverse Fetal Outcome (%)
1	13	Driver	None	36
2	13	Driver	Three-point belt	9
3	25	Driver	Three-point belt	26
4	25	Driver	Three-point belt + airbag	26
5	25	Driver	Three-point belt + airbag	26
6	20	Driver	None	54
7	13	Passenger	Three-point belt	9
8	35	Passenger	Three-point belt	51
9	35	Driver	Three-point belt	51
10	35	Driver	Three-point belt	51
11	35	Driver	None	86
12	45	Driver	Three-point belt	76
13	45	Driver	Three-point belt + airbag	76
14	55	Driver	Three-point belt	90
15	55	Passenger	Three-point belt	90

Measurement Apparatus, Version 2B (MAMA-2B). The MAMA-2B can be used to assess restraint system performance for pregnant occupants and their fetuses (*13*). As part of the pregnant dummy development program, two primary mechanisms of placental abruption in MVCs were hypothesized based on modeling and limited biomechanical testing of uterine and placental tissues. The first is that the uterine-placental interface (UPI) fails in shear because of local deformation of the uterus in an area where the placenta is attached. The second is that the UPI fails in tension because of the inertia of the amniotic fluid and the dynamic viscous coupling of the uterus to the lumbar spine.

The MAMA-2B is implemented in the Hybrid III small female crash test dummy and uses a fluid-filled silicone-rubber bladder to represent the uterus at 30 weeks' gestation. The MAMA-2B incorporates improved anthropometry with a midline contour that is based on the results of the study of automotive-seated pregnant anthropometry. The MAMA-2B abdomen was designed with a humanlike mechanical response to dynamic rigid-bar, belt, and close-proximity airbag loading and was instrumented with intrauterine pressure transducers located at the anterior and posterior surfaces of the bladder. To develop injury criteria for the MAMA-2B, peak uterine pressure was measured in a series of sled test simulations of frontal crashes. The crash severity and restraint conditions for the sled tests are shown in Table 1 and were based on the injury risk curves developed from the crash investigation study (shown in Figure 5). As shown in Figure 7, peak anterior uterine pressure measured in the tests is correlated with the likelihood of adverse fetal outcome and can differentiate between loading conditions as shown in Figure 8. With proper belt restraint of a pregnant occupant, lower peak pressures at a given crash severity result than with improper restraint, and tests in the passenger mode (i.e., without the steering wheel) have lower peak pressures than tests run in the driver position. The intrauterine pressure data from the sled tests also suggest that airbags are beneficial to pregnant occupants.

Other Recent Research

A limited number of tests have been performed to characterize the mechanical properties of placental

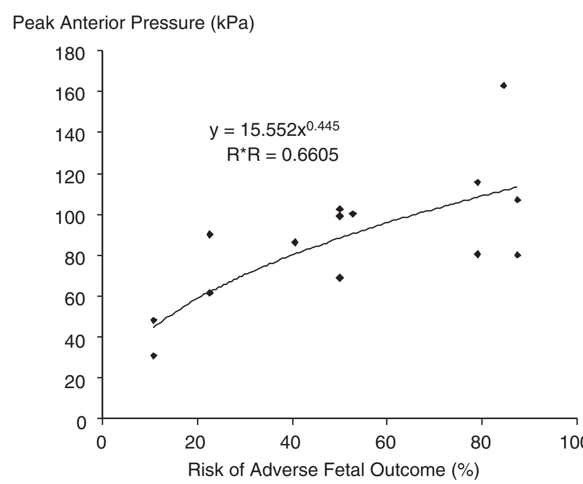

FIGURE 7 Correlation between anterior pressure and risk of adverse fetal outcome.

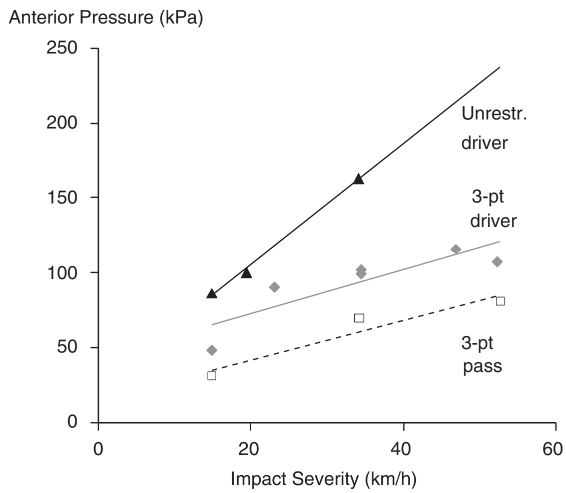

FIGURE 8 Variation in anterior pressure with restraint and impact severity.

and uterine tissue for use in computer modeling studies of injury mechanisms (*8*). Preliminary results indicate that the two tissues have similar characteristics, but failure data were not measured. Acar and Weekes (*14*) performed a study of the anthropometry of pregnant occupants to identify issues in vehicle design relevant to pregnant occupants. Their results are being used to generate guidelines for accommodating the needs of pregnant occupants in vehicles. However, their data are limited because they do not track changes throughout gestation on individual subjects.

Researchers at Virginia Polytechnic Institute and State University (*15*) developed a finite-element model of a 7-month pregnant uterus and incorporated it into a MADYMO model of a small female driver. Simulations of unrestrained, three-point-belt, and three-point-belt-plus-airbag conditions were performed at crash severities between 13 and 55 km/h. Peak uterine strain was correlated with the likelihood of adverse fetal outcome predicted by the University of Michigan Transportation Research Institute crash investigation data ($R^2 = 0.846$). The simulations also indicate that the lowest levels of uterine strain at a given crash severity occur for the three-point-belt-plus-airbag condition, suggesting that this is the safest restraint for the 7-month pregnant occupant involved in a frontal crash. Additional research (*16*) using this model suggests that uterine compression at the site of placental attachment is strongly correlated with peak strain at the UPI. Other researchers have developed models of pregnant occupants (*17*), but little is known about the details of their work since results have not been published in a technical journal.

Future Research Needs

Although these recent studies have made substantial contributions to improving automotive safety for pregnant occupants, further research and development efforts are needed to address the problem of fetal trauma from MVCs. In particular, research is needed to

- Implement requirements for hospital trauma records and fetal death certificates to include maternal motor vehicle trauma as the cause for fetal injury or death so that more precise estimates of the magnitude of adverse fetal outcomes from MVCs can be made;
- Perform additional in-depth investigations of MVCs involving pregnant occupants to establish an enhanced crash-injury database that can be used to develop better models for predicting the risk of adverse fetal outcomes under different conditions, for example, drivers versus passengers and front versus side impacts;
- Perform biomechanical testing on uterine and placental tissues to more accurately define the dynamic response and failure tolerances of these materials, which would help to develop more realistic physical and computer models that could be used to improve automotive safety for pregnant occupants and their fetuses; and
- Implement additional design and instrumentation enhancements to the MAMA-2B so it can become a more reliable tool to assess the effects of changes in occupant restraint systems relative to improving protection for the fetus.

Acknowledgments

Some of the research discussed in this paper was funded by General Motors (GM) pursuant to an agreement between GM and the U.S. Department of Transportation. The authors acknowledge Bethany Eby and Jamie Moore of the University of Michigan Transportation Research Institute and Steve Moss of First Technology Safety Systems for their contributions to this work.

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Computational Model of Pregnant Motor Vehicle Occupant

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A validated model of a 30-week-pregnant motor vehicle occupant is presented and the risk of fetal injury in frontal crashes is examined. A model of the pregnant uterus was imported into MADYMO 6.0 and included in the fifth-percentile female human body model by using membrane elements to serve as ligaments and facet surfaces for the overlying skin. A simulation matrix of 15 tests was developed to predict fetal outcome and included frontal crash impulses from minor (<24 km/h) to moderate (24 to 48 km/h) and severe (>48 km/h) crashes for the driver and passenger occupant positions. The test matrix included various restraint combinations: no restraint, lap belt, three-point belt, three-point with airbag, and airbag only. Overall, the risk of adverse fetal outcome was found to increase with increasing crash severity and to be higher for properly restrained drivers than for passengers. The peak uterine strain was reduced by 26% to 54% for the passenger position versus the driver position. This difference was due primarily to driver interaction with the steering wheel. For both occupant positions, the maternal injury indices were greatest for the unrestrained occupant. The current modeling effort has verified previous experimental findings regarding the importance of proper restraint use for the pregnant occupant.

Automobile crashes are the largest single cause of death for pregnant women (Attico et al. 1986) and the leading cause of traumatic fetal injury mortality in the United States (Weiss and Strotmeyer 2002). Each year in the United States 160 pregnant women are killed in motor vehicle crashes and an additional 800 to 3,200 fetuses are killed although the mother survives (Klinich et al. 1999a, 1999b). Unfortunately, fetal injury in motor vehicle crashes is difficult to predict because real-world crash data are limited and cadaver studies are not feasible.

In an effort to reduce the risk of injury to pregnant occupants in car crashes, a pregnant anthropometric test dummy (ATD) was developed at the University of Michigan Transportation Research Institute (Rupp et al. 2001a). The Maternal Anthropomorphic Measurement Apparatus Version 2B (MAMA-2B) is a second-generation prototype ATD that is a retrofitted Hybrid III small female dummy. One of the primary limitations of the pregnant dummy is the lack of injury criteria for the fetus. The MAMA-2B was designed to measure anterior and posterior pressure in the fluid-filled abdomen insert as well as the strain on the perimeter of the insert. However, only the anterior pressure measurements were repeatable (Rupp et al. 2001a). Therefore, it would be beneficial to have an injury criterion for the pregnant dummy that utilizes currently established ATD measurement methods. One leading example would be to measure overall abdominal compression in a manner similar to that used to measure chest compression. For example, this measurement could be done by using a string potentiometer as is done in the chest.

The most common cause of fetal death from motor vehicle accidents is placental abruption, which is the premature separation of the placenta from the uterus (Klinich et al. 1999b). Both the pregnant dummy and the pregnant model presented in this study utilize this injury mechanism to predict fetal outcome (Moorcroft et al. 2003a). However, because of the difficulties in measuring this mechanism in the pregnant dummy, such as tissue strain and pressure, a computational model is desired that can accurately predict fetal injury risk. Therefore, a validated model of the pregnant occupant is presented here to examine the risk of fetal injury in frontal crashes for a range of restraint configurations in both driver and passenger occupant positions.

Methodology

Motor vehicle crashes were simulated with the MADYMO software package developed by the Netherlands Institute of Applied Geoscience (TNO). In order to create the pregnant occupant, a finite element model of a pregnant uterus was inserted into the abdomen of a multibody human model (Figure 1) (Moorcroft et al. 2003a, 2003b, 2003c). The finite element uterine model is designed to represent an occupant in her 30th week of gestation. The abdomen consists of the uterus, placenta, and amniotic fluid. A fetus was not included because the injury mechanisms that predominantly contribute to fetal loss, as described by Rupp et al. (2001a), are independent of the fetus. In other words, placental abruption is not effected by direct fetal loading of the placenta. The uterus is approximately ellipsoidal with a major axis of 27 cm and 18 cm, and it is 1 cm thick. The placenta is located at the fundus of the uterus and is 2 cm thick. The remainder of the interior of the uterus is filled with the amniotic fluid. The human model is a fifth-percentile female (5 ft tall, 110 lb) and the weight of the pregnant occupant model is 135 lb. The multibody human model provides biofidelic response of an occupant in a motor vehicle crash while reducing the computational time compared with a full finite element human model. The anthropometry of a pregnant woman was quantified by Klinich et al. (1999a); the

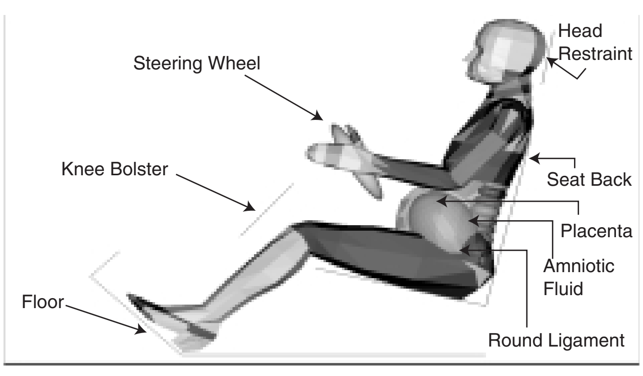

FIGURE 1 Pregnant occupant in driver-side interior.

abdominal contour of the pregnant model matches their data.

The uterine model is supported to the human model by the uterosacral and round ligaments, as well as the cervix. The bottom four nodes of each ligament are constrained to move with the pelvis for both translation and rotation. The uterine model is also surrounded by fat to represent the boundary conditions involving the spine, abdominal organs, and the pelvis. All uterine bodies were modeled as linear elastic solids. Although the uterus and placenta are considered viscoelastic and anisotropic (Conrad et al. 1966; Pearsall and Roberts 1978; Mizrahi and Karni 1975), sufficient data were not available to accurately apply these material types. The amniotic fluid was modeled as a solid because MADYMO did not utilize fluid elements at the time of model development.

Tension tests on human uterus tissue have been reported byRupp et al. (2001b), Pearsall and Roberts (1978), and Wood (1964). The Young's modulus ranged from 20.3 kPa to 1,379 kPa, with an average of 566 kPa. The Poisson's ratio is set to 0.40 since the uterus is a muscular organ, and the density is 1,052 kg/m^3 (Moorcroft et al. 2003a). Rupp et al. (2001b) reported the results of five tension tests on placental specimens. The average modulus was 33 kPa, with a high of 63 kPa. Testing was not taken to failure. The highest modulus is used in the pregnant model because it is expected that the placenta is stiffer than the fat. The Poisson's ratio is assumed to be 0.45 because the tissue is muscular ($\nu = 0.40$) engorged with blood ($\nu = 0.50$). The density of the placenta is 995 kg/m^3 (Moorcroft et al. 2003a). The amniotic fluid, which is 99% water and therefore incompressible, was assumed to have a negligible Young's modulus and a Poisson's ratio of 0.49. The Young's modulus of 20 kPa is used for the fluid because moduli of lower values produced unstable results. The computational model uses peak von Mises strain in the uterus near the placenta as the measure for predicting risk of injury. High risk is associated with the presumed 60% strain tissue limit, allowing the prediction of fetal injury based on the strain. This strain limit is based on tissue tests of the uterine-placental interface (UPI) (Rupp et al. 2001b).

Material properties of the ligaments connecting the uterus to the pelvis were not available in the literature. A brief search of general ligament properties showed that the elastic modulus of ligaments is typically two orders of magnitude greater than that of the uterus (Iwamoto et al. 1999; Zhang et al. 2001; Yamada 1970). Therefore, the elastic modulus of the uterosacral and round ligaments is set to 100 times the modulus of the uterus. The density and Poisson's ratio were also taken from general ligament data (Iwamoto et al. 1999; Zhang et al. 2001). An isotropic representation of fatty tissue was used by Todd and Thacker (1994) in modeling the human buttocks. The Young's modulus for a seated female is 47 kPa with a Poisson's ratio of 0.49. This Poisson's ratio represents a nearly incompressible material. Contacts were created such that the fluid interior of the uterus was free to move within the uterus, with contact friction. However, the fluid could not penetrate the uterus or placenta. Default master-slave contact treatments within MADYMO were used for all contacts.

Four techniques were used to validate the pregnant model. First, a global biofidelity response was evaluated by using a seat belt to compress the pregnant abdomen dynamically (Moorcroft et al. 2003b). The results for force versus compression were within the published corridors from scaled cadaver tests (Hardy et al. 2001). Second, a similar validation procedure was performed with a rigid bar (Moorcroft et al. 2003b) and these results were also consistent with previous data (Hardy et al. 2001). The third technique involved validating the model against real-world crashes in order to investigate the model's ability to predict injury. When fatal crashes from pregnant occupants were used (Klinich et al. 1999b), the model showed strong correlation (R^2 = 0.85) between peak strain at the UPI as measured in the model compared with risk of fetal demise as reported in the real-world crashes over a range of impact velocities and restraint conditions (Moorcroft et al. 2003a). The fourth method compared the physiological failure strain from placental tissue tests with the failure strain measured in the model. Tissue tests by Rupp et al. (2001b) suggested approximately a 60% failure strain for UPI tissues, which is in agreement with the model's prediction of 75% risk of fetal loss at a 60% strain in the UPI. In summary, the global-, injury-, and tissue-level validation techniques all indicate that the model is good at predicting injurious events for the pregnant occupant.

The simulations presented here were chosen to determine the effect of restraint use and occupant position on the response of the pregnant occupant. The test matrix consisted of 15 simulations with occupant position and occupant restraint variations (Table 1). The applied sled pulse is a half-sine wave imposed for a duration of 100 ms. Acceleration is defined with respect to time; therefore the area under the curve corresponds to the change of velocity of the crash. Two interiors were used in the simulations, a standard driver-side interior and a passenger-side interior. The driver and passenger interiors are typical MADYMO interiors made up of rigid planes to represent the seat, vehicle floor, and knee bolster.

Positioning of the pregnant occupant was based on the seated anthropometry of a pregnant woman in her 30th week of pregnancy as defined by Klinich et al. (1999a). Four parameters were chosen to define the position of the occupant on the driver side by using the parameter values that correspond to the small female group in the study by Klinich et al. (average height, 5 ft; average weight, 134 lb). The abdominal clearance, defined as the distance between the abdomen and the bottom of the steering wheel, is 38 mm. The mean overlap of the uterus to the steering wheel is 12%, where the overlap is defined as the ratio of the vertical height of the uterus above the bottom of the steering wheel to the total vertical height of the uterus. The seatback angle, relative to vertical, is 13 degrees, and the steering wheel tilt is 29 degrees from vertical. Standard MADYMO finite element belts were used for the three-point restraint condition, with no force-limiting properties and no pretensioner. For the driver airbag tests, a MADYMO 600-mm driver airbag (volume, 35 L) is used, with inflation triggered 15 ms into the

TABLE 1 Pregnant Model Test Parameters and Results

Occupant	Restraint	Crash Speed (km/h)	Risk of Fetal Injury[a] (%)	Maximum Strain in the Uterine Wall (%)	HIC[b]	V*C[b] (m/s)	Chest Deflection (mm)
Driver	None	13	44	23.3	1	0.12	38.6
Driver	None	20	65	36.6	13	0.31	39.1
Driver	None	25	77	44.6	41	0.47	39.4
Driver	None	35	100	60.8	156	0.72	39.7
Driver	3-pt belt	13	32	15.5	4	0.03	43.4
Driver	3-pt belt	25	51	27.9	62	0.09	47.1
Driver	3-pt belt	35	89	52.6	185	0.12	52.4
Driver	3-pt belt	45	99	58.7	211	0.13	54.3
Driver	3-pt belt	55	100	61.2	310	0.17	58.2
Driver	3-pt belt + airbag	25	52	28.1	49	0.22	45.1
Driver	3-pt belt + airbag	35	59	33.0	114	0.24	48.2
Driver	3-pt belt + airbag	45	80	46.6	173	0.20	49.0
Passenger	None	35	52	28.2	2820	0.33	32.7
Passenger	3-pt belt	35	60	33.7	181	0.30	51.5
Passenger	3-pt belt + airbag	35	46	24.4	140	0.27	47.8

[a] Based on the peak strain at the uterine placental interface as measured in the model.
[b] HIC represents the head injury criterion and V*C represents the viscous criterion.

simulation. The knees are approximately 11 cm from the knee bolster. For the passenger position, the seat was moved backward to match the distance seen in the typical passenger compartment and representing a fully aft seat position (abdominal clearance to dashboard, 40 cm). The same finite element belts were used for the passenger tests as for the driver tests, with the shoulder belt repositioned to extend from the right shoulder to the left hip. A standard MADYMO passenger airbag (volume, 135 L) was used and triggered at 15 ms. There is no knee bolster interaction on the passenger side given the large distance between the knees and bolster (28 cm).

Results

For the pregnant driver occupant, the unrestrained occupant resulted in substantially higher risk of abdominal and head trauma compared with the fully restrained driver in a similar crash (Figure 2). For all simulations both strain in the uterus and maternal responses were considered with respect to fetal outcome (Table 1). In particular, the risk of fetal injury was determined on the basis of the correlation between peak strain at the UPI and risk of fetal death in real-world crash investigation (Klinich et al. 1999b; Moorcroft et al. 2003c). Simulations in which the occupant was positioned in the passenger-side interior resulted in lower peak uterine strains measured at the UPI compared with those for the driver-side interior for all restraints tested. Substantial reductions were seen for the unrestrained and three-point belt cases for similar crash speeds. For belted simulations, the peak strain is 26% to 36% less in passenger-side simulations compared with driver-side simulations even though the forward motion of the occupant is roughly equal between simulations with the same restraint. The key difference in the tests is the presence or absence of the steering wheel.

In the driver-side configuration, the occupant contacts the steering wheel to some degree in all the configurations tested. A lower peak strain is recorded in the unrestrained cases because the abdomen does not contact the steering wheel because of the seatbelts in the belted cases and there is no contact between the head and the windshield in the unrestrained cases. For the two types of belted cases, the occupant does not approach the dashboard, and therefore strain is primarily due to inertial effects as the belt restrains the lower abdomen and the upper abdomen continues to translate. The main effect of varying the occupant position therefore appears to be to alter the abdominal loading pattern from one of contact in the driver-side cases to one of inertia in the passenger-side cases.

The importance of examining the maternal response is highlighted in the unrestrained passenger-side case. Although this simulation produced a low peak strain, based on the head injury criterion (HIC) value of 2820, it is reasonable to predict maternal death. This elevated value is the result of severe contact between the occupant's head and the windshield. HIC scores for the remaining simulations were generally low and consistent between seating positions. Thorax response for the unrestrained occupant shows the same trend as that for the strain, in which the limited contact between the thorax and any vehicle surface reduces the passenger injury risk as compared with the driver response. For the restrained occupant, a slight increase is seen in thorax injury risk with the removal of the steering wheel. This finding is a result of the contact between the steering wheel and the pregnant abdomen, which reduces the load applied to the shoulder belt in driver-side simulations as compared with that in the passenger-side simulations.

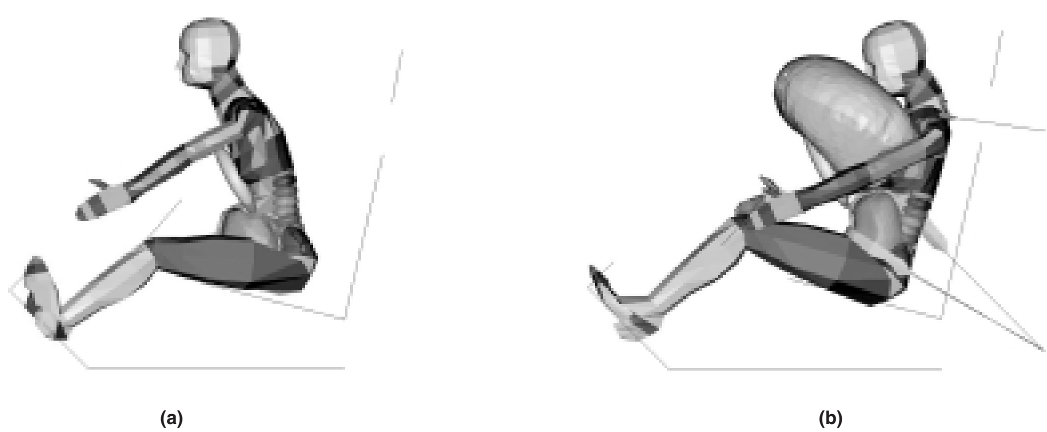

FIGURE 2 (*a*) Unrestrained pregnant driver in simulated 35-km/h crash; (*b*) fully restrained pregnant driver in simulated 35-km/h crash.

Discussion of Results

Overall, there is a high probability that placental abruption would occur in the driver-side, unrestrained, frontal impact simulation. In the passenger-side simulation, there is a near 100% risk of life-threatening maternal brain injury in the similarly unrestrained condition and therefore a high risk for fetal death. The use of a three-point belt as well as an airbag reduces the risk to the pregnant women and the fetus. The difference in abdominal clearance between the driver-side and passenger-side simulations played an important role in peak strain in the uterine wall. The strain was 26% to 54% less in passenger-side simulations, primarily because of the presence or absence of the steering wheel. On the basis of the results of this study, it is recommended that when it is practical, the pregnant woman ride in the passenger seat with a three-point seat belt and airbag and the seat positioned as far rearward as possible.

Placental abruption is believed to occur when the strain in the uterine wall exceeds 60%. The risk for placental abruption is largest for high strains that occur near the placenta, which can be dramatically influenced by the lap belt position. Simulations have demonstrated that the vertical position of the lap belt can increase fetal risk by a factor of 3 (Figure 3) (Moorcroft et al. 2004). As the lap belt approaches the height of the placenta, which is located at the top of the uterus, the observed strain increases for a given crash pulse. Simulations with the lap belt directly loading the uterus at the placental location produced the highest recorded strain. Once the lap belt height is above the placenta, the strain decreases, with the strain for the top belt position matching that seen for the recommended belt location. However, it is important to note that there is increased risk to the mother with incorrect lap belt placement, including elevated head and chest injury response. This fact is important because the best way to protect the fetus is to protect the mother.

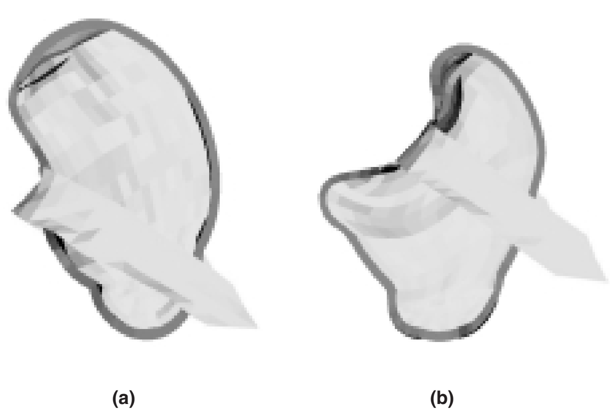

FIGURE 3 Simulations at 35 km/h showing uterine compression for (*a*) correctly positioned belt and (*b*) incorrectly positioned belt.

Predicting fetal injury from abdominal deflection is loosely analogous to using chest deflection to predict thoracic injury. As a simple comparison, chest deflection for the small female is limited to 52 mm by federal safety standards (Eppinger et al. 1999). A chest deflection of 52 mm is approximately 35% compression, which corresponds to approximately 40% risk of an Abbreviated Injury Scale 3 injury or greater (Mertz et al. 1991, 105–119). Given the obvious anatomical differences between the thorax and pregnant uterus, it is interesting that 35% compression of the uterus is also the higher limit of injury (Duma et al. 2004). The abdominal deflection could be measured in the same manner as the chest deflection by using a string potentiometer or chest band or through processing of digital video. It is important to note that the measurements need to be taken from a pregnant dummy with the same anthropometry and abdominal force-deflection response as those of a pregnant woman.

Overall, it is important to note that previous simulations indicate that for all frontal impacts it is safest for the pregnant occupant to ride in the passenger seat while wearing a three-point seat belt and utilizing the frontal airbag when appropriate (Moorcroft et al. 2004). The results of the current study support these earlier findings.

As with all computational models, this model is limited by the accuracy of input and simplifications made. The tissue data, from which the failure strain is derived, are sparse, and simplifications are made to use that data as a material model. In addition, the boundary conditions and geometry can and should be improved in future generations of the model. Furthermore, the model only looks at injury at the UPI. In cases with very large deflections, direct injury to the fetus may occur at injury rates different from those for placental abruption. In order to investigate this injury risk, a fetus would need to be added to the model. It is recommended that the methods in this study be applied to future generations of the pregnant occupant model to provide a continually improved understanding of pregnant occupant injury risk prediction.

Conclusions

A finite element model of the pregnant abdomen was created to predict fetal outcome following a motor vehicle crash. The model was incorporated into a human body model in a dynamic solver and validated with data from previous studies. The model is sensitive to changes in restraint conditions such as inertial, steering wheel, seat belt, airbag, and combined loading. Peak uterine strain was reduced by 30% to 50% in passenger-side simulations versus driver-side simulations, primarily because of increased distance between the abdomen and the nearest vehicle surface, namely, the steering wheel for driver-side tests and the dashboard for passenger-side tests. Overall, the model has verified previous experimental findings regarding the importance of proper restraint use for the pregnant occupant. The model can be used to run numerous tests and design advanced restraint systems specifically for pregnant occupants.

Acknowledgments

The authors thank Altair Engineering, Inc., for the use of HyperWorks as the pre- and postprocessor and TNO for the use of MADYMO. The authors also thank Kathy Klinich, at the University of Michigan Transportation Research Institute, for her assistance in the development of the pregnant model.

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What Are Young Female Drivers Made Of?

Differences in Driving Behavior and Attitudes of Young Women and Men in Finland

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Young female drivers in Finland are described by comparing the driving behavior and attitudes of young women and men. The study also questioned whether the traffic behavior and attitudes of female drivers have changed to resemble those of male drivers more closely during the past 20 years. The study used questionnaires to collect data from about 40,000 drivers on their attitudes and behavior (quantity and quality of driving, number and type of accidents, number of violations). Data on traffic offenses were also gathered by questionnaires from 30,275 drivers on an official register. Accident databases covering three levels of severity were used in the study: self-reported accidents, accidents in which claims were made to insurance companies, and fatal accidents investigated by the Road Accident Investigation Teams in Finland. The results showed that on the whole, female drivers hold more positive attitudes toward traffic regulations and safety. They committed fewer traffic offenses and were involved in accidents less often than men (exposure controlled for). Typical female drivers' accidents were those involving backing up and minor single-vehicle accidents. It is concluded that traffic attitudes and accident patterns of female drivers have not changed to resemble those of men more closely during the past 20 years in Finland.

Compared with men, women have traditionally had a subordinate role in motor vehicle traffic: women drive less, are less likely to own a car, and are not as interested in motor vehicles and occupations connected with traffic and cars. They are also less frequently involved in accidents and commit fewer traffic offenses than men. However, equality of the sexes is emerging in the field of motor vehicle traffic, at least as far as driver licensing and the amount of driving are concerned. In terms of research, the driving behavior of women has not attracted much attention until now, when the number of female drivers' accidents is on the increase.

Hierarchical models of driving behavior try to take into account several focuses of human behavior in explaining driver behavior (Michon 1984; Mikkonen and Keskinen 1980; van der Molen and Bötticher 1988). In Finland, Mikkonen and Keskinen had developed the theory of internal models in the control of traffic behavior by 1980 but unfortunately it was only in Finnish. The model consists of three levels of internal models according to their extent: the largest model is called the route model. It contains knowledge about roads and events between a start and a goal. A route model is divided into several visual scenes, each of which is called a sight model. This level includes information needed in current traffic situations. A sight model is divided into several maneuvering models. Internal models include only the information needed for interplay between the road user and the environment. Although the theory of Mikkonen and Keskinen (1980) is a cognitive theory, the authors suggested a close connection between internal models and the motivational and emotional system. The role of motives and emotions is to control the use of the internal models (Keskinen et al. 2004).

Evidence with regard to young (male) drivers led to calls to attribute a more important role to emotions, motives, and personality factors in explaining driving behavior (Evans 1991; Jessor 1987; Jonah 1986; Näätänen and Summala, 1976). Young men are skillful drivers as far as vehicle maneuvering is concerned: they require less training than any other driver group to pass the driving test. However, young men still have the highest accident and offense rates. Different persons with different motives have different internal models in traffic. A young man who seeks praise and admiration from his friends by showing off his driving skills has a different kind of internal model than a middle-aged man who only uses the car to get from one place to another. The whole driving style differs depending on what the goal of driving is.

A driver's circumstances and overall behavior in life, as well as factors related to his or her personality, are also reflected in traffic behavior (Tillman and Hobbs 1949; Evans 1991; Jessor 1987). Keskinen (1996) and Hatakka et al. (2002) enlarged the theory of internal models in the control of traffic behavior by adding a fourth level (the largest, highest level) to the model. In this model the role of motives and emotions is more heavily emphasized, and driving behavior is seen in a larger context. The highest level is called goals for life and skills for living, which refers to general motives and attitudes in life, the importance of cars and driving for a driver's personal development, and skills for self-control.

Study Goals

This study describes young female drivers by comparing the driving behavior and attitudes of young women and men. The quantity and quality of driving, the number and type of accidents, and the number of violations are studied as driving behavior. The second aim of the study is to find possible changes in the difference between male and female drivers' behavior and attitudes during the past 20 years. The focus of this study is on 18- to 25-year-old drivers. Differences in female and male drivers' behavior in traffic are discussed in the framework of Keskinen's hierarchical model of driving behavior.

Materials, Subjects, and Methods

The materials of this study were gathered in conjunction with several research projects conducted by the Traffic Research Group at the University of Turku, in Finland, during the past 15 years (Table 1). The main focus of many of the research projects was on driver training, and therefore the subjects of the studies were mostly novice drivers. The current study concludes the findings concerning female drivers; a more detailed description may be found elsewhere (Laapotti 2003).

Self-Reported Information

Amount of Driving and Type and Number of Accidents During First 18 Months as Driver

The sample was drawn from the official register of driving licenses. The sampling procedure made it possible to compare drivers of different ages who had received their license at the same time and who had the same amount of driving experience. The sample covered about 25% of

TABLE 1 Summary of Study Materials

Study Year and Original Paper	Sample Description	Response Rate	Source of Information	Main Contents of the Study
1978 and 2001 Elio et al., 1978 Laapotti et al., 2001 Laapotti et al., 2003	Novice drivers aged 18 to 20 years, driving time 6–18 months	80% in 1978 65% in 2001	Questionnaire	Driving behavior and attitudes Comparison between years Change
1989 and 1990 Keskinen et al., 1992; Laapotti et al., 2001	Novice drivers aged 18 to 50 years, driving time 6–18 months n = 30,275	75%	Questionnaire Driver's license register	Self-reported driving kilometrage and accidents Traffic offenses
1978 to 2001 Laapotti and Keskinen, 1998	Drivers aged 18 to 21 years n = 413 fatal accidents	—	Culpable parties in fatal accidents, Road Accident Investigation Teams	Fatal motor car loss-of-control accidents: background factors
1984 to 2000 Laapotti and Keskinen, 2004	18-, 20-, 25-, 35-, 45- and 55-year-old drivers n = 140,800 accidents	—	Culpable parties in accidents Finnish Motor Insurers´ Centre	Type of accidents Change
2002 Hatakka et al., 2003	Novice drivers, aged 18 to 59 years, driving time 1–48 months n = 6,800	48%	Questionnaire	Self-reported quantity and quality of driving and accidents

all novice drivers in Finland during 1989 and 1990. The information on driving experience and accidents was gathered by using a mailed questionnaire and covered the whole independent driving career of the drivers (range 6 to 18 months, mean 12.2 months, and mode 13 months). The drivers were asked to report all the accidents they had been involved in, whether they were at fault or not. They were asked to include all accidents, even minor ones, that had resulted in at least some material damage. The questionnaire allowed respondents to provide details on up to four accidents. The drivers were also asked to report on how many kilometers they had driven with a car (total mileage).

Driving Behavior and Attitudes During First 18 Months as Driver

The study replicated the traffic attitude survey conducted in 1978 in Finland, called Survey78 (Elio et al. 1978) and compared the results of Survey78 with the replicated survey in 2001 (called Survey01). The questionnaire included 83 attitude-related items. Eighteen of these items concerned driver training and education. The remaining 65 items focused on issues such as traffic regulations, personal driving style, occupational driving, road maintenance, and vehicles. In the explorative factor analysis, four factors were found. Four summary variables were named by using the criterion of factor loadings of at least 0.40: obeying traffic rules and driving safely (16 items), pleasure and confidence in one's driving (four items), attitudes toward occupational driving (five items), and attitudes toward road maintenance and other road users (eight items). This study reports the main results of the first summary variable (obeying traffic rules and driving safely). The comparison of all attitude-related items between 1978 and 2001 is reported elsewhere (Laapotti et al. 2003).

Quantity and Quality of Driving and Accidents During First 4 Years as Driver

The subjects were asked how much they had driven (in kilometers) by car during the intermediate phase of driver training. (In Finland the intermediate phase of driver training is a period of independent training between licensing and the second phase of driver training.) The reasons for driving and the driving environment during the intermediate phase were determined by requesting the subjects to evaluate what percentage of their driving was to or from work or school, for errands, for an occupation, at work, on leisure time trips, or just for fun. Further, the subjects were asked to estimate what percentage of their driving time was in the dark, in built-up areas, alone, in the evening, and at night. The number of accidents and violations during the intermediate phase of driver training was also determined.

Traffic Offense Rates from Drivers' License Register

It was possible to calculate offense rates (offenses per kilometers driven) for those novice drivers who returned the questionnaire concerning accidents and kilometers driven (n = 30,275). The register of drivers' licenses is maintained by the Vehicle Administration in Finland and includes all traffic offenses apart from parking tickets for which a penalty has been imposed. The follow-up period for traffic offenses was about 2 years. The current study reports the results concerning minor offenses. Minor offenses are not based on a court decision and do not result in a withdrawal of the license. Most of the minor offenses are speeding.

Number and Type of Accidents from Accident Databases

All Accidents

The Finnish Motor Insurers' Centre maintains accident statistics covering all accidents for which damages have been paid. The data cover drivers found guilty of an accident, including information about when and where the accident happened, the type of accident, and the age and sex of the driver. The drawback with the all accidents data is that claims to insurance companies are usually not made for minor—especially single-vehicle—accidents with low damages because the loss of the no-claims bonus results in a higher insurance premium. Drunk driving accidents are also underrepresented in this data set because insurance companies do not pay damages in such cases.

Fatal Accidents

In Finland, an accident is defined as fatal if someone involved in the accident dies within 30 days as a consequence of the accident. All fatal motor vehicle accidents in Finland are investigated by the Road Accident Investigation Teams. These teams prepare in-depth, on-the-spot crash reports on the basis of their findings. Each investigation team consists of a police officer, a traffic safety engineer, an automobile inspection engineer, a medical expert, and nowadays also an expert from the field of behavioral science [more details may be found elsewhere (Hakamies-Blomqvist 1994)]. The reports produced by the investigation teams include descriptions of the type of the accident and how it took place, the time and location, weather and road conditions, speed used by all parties concerned, and speed limits. These reports also contain testimony by the driver (if he or she survived), the other driver in the case of a collision, passenger or passengers, and eyewitnesses.

The members of the teams work together to produce a final report on the course of the accident and its probable causes and to suggest the means to prevent such accidents in the future. Both coded data material and the original team reports are available for research. Researchers have widely utilized data collected by these teams because they allow the use of disaggregated data covering a large amount of variables; reports in English include those by Hakamies-Blomqvist (1994), Hernetkoski and Keskinen (1998), Laapotti and Keskinen (1998, 2004), and Rajalin (1994).

Statistical Methods

Statistical analysis was conducted using SAS, Version 8.2. Analysis of variance (genmod) was used to find the effects of age, sex, and mileage on the number of accidents and offenses. Chi-square testing was used in group comparisons. Logistic regression analysis (logistic) was used in the modeling of categorical variables: the prevalence of certain accident types was explained by the sex and age of the drivers and by calendar year.

Results

Driving Exposure

Women are less likely to have a driving license than men in Finland. In 2001, 62% of all 18- to 19-year-old women compared with 76% of all 18- to 19-year-old men were licensed. However, the difference between the sexes in driving license ownership has decreased sharply among young people and will decrease among older people as today's middle-aged female drivers continue to age. Not only are women less likely to have a driving license, but they also drive less than men. Women drive about half as much as men. For example, at the beginning of the 1990s, young men drove about 26,000 km annually and women of the same age about 13,000 km annually.

As far as the purpose for driving was concerned, female drivers reported more driving on errands than men. Young men reported the most "just for fun" driving (22% of total driving). Young drivers reported more leisure time driving and driving for fun than middle-aged drivers.

Driving conditions also varied between driver groups. Young female drivers reported less driving on slippery roads than young male drivers. Young drivers, both men and women, reported more driving with passengers, in urban areas, on weekends, and at night than middle-aged drivers.

Attitudes and Confidence in One's Personal Driving Skills

On the basis of the summary variable, it was found that female drivers had more positive attitudes toward traffic rules and safe driving than men did (df = 1, $F = 410.08$, $p < .001$). It was found that young drivers in 2001 claimed to have been less respectful of traffic rules and driving safely than young drivers in 1978 (df = 1, $F = 66.97$, $p < .001$). However, there was an interaction effect between the drivers' sex and the survey year in that the negative change in attitudes toward traffic rules and safe driving between Survey78 and Survey01 was smaller among women than among men (df = 1, $F = 4.49$, $p < .05$).

The comparison between 1978 and 2001 revealed that confidence in one's personal driving skills had increased among both young women ($\chi^2 = 167.14$, $p < .001$) and young men ($\chi^2 = 774.08$, $p < .001$). However, the difference between women and men remained the same: women rated their driving skills lower than those of men (Figure 1).

Traffic Offenses

Women commit fewer traffic offenses than men, middle-aged drivers fewer than young drivers, and those with low driving mileage fewer than those with high driving mileage (Figure 2). However, the age of the driver and the amount of driving had a weaker effect on the number of offenses among women than among men. For example, women with high mileage had even fewer traffic offenses than men with low mileage.

Number of Accidents

Female drivers had fewer traffic accidents than men, and the result held true even when driving mileage was controlled for (Figure 3). The difference in the number of accidents between women and men becomes bigger when the more serious accidents are concerned. For example, women are responsible for about 25% of all accidents for which damages have been paid in 2003 in Finland but only for about 16% of all fatal accidents in 2003 in Finland (Finnish Motor Insurers' Centre 2004).

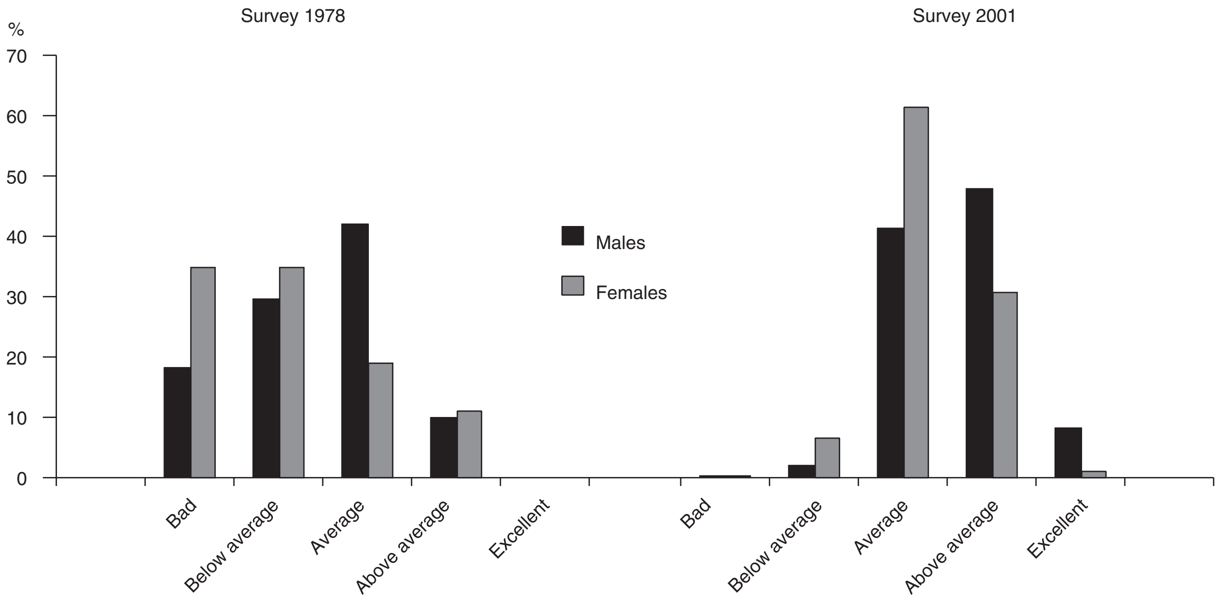

FIGURE 1 Self-evaluation of driving skills in Survey78 and Survey01.

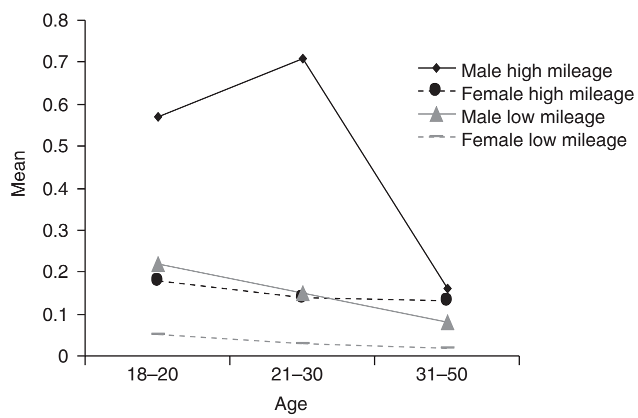

FIGURE 2 Mean number of offenses in different age, sex, and mileage groups (high mileage = 20,000 to 29,999 km/year, low mileage = 100 to 9,999 km/year); analysis of variance: significant main effects on number of offenses: age, sex, and mileage ($p < .001$); coeffect: sex * mileage ($p < .001$).

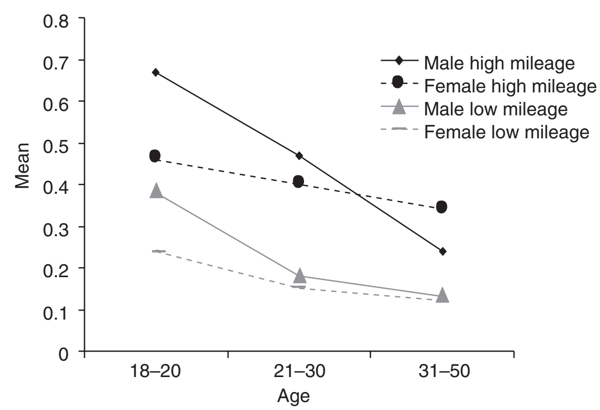

FIGURE 3 Mean number of self-reported accidents in different age, sex, and mileage groups (high mileage = 20,000 to 29,999 km/year, low mileage = 100 to 9,999 km/year); analysis of variance: significant main effects on number of offenses: age, sex, and mileage ($p < .001$); coeffects: age * sex ($p < .001$), sex * mileage ($p < .05$).

Types of Accidents

Accidents while backing up and minor single-vehicle accidents were typical types of crashes for women. Of all young female drivers' crashes, 27% were accidents while backing up, whereas for young men the percentage was 21%. It was more typical for men than women to have rear-end collisions. Of all male drivers' crashes, 33% were rear-end crashes, whereas the corresponding figure for women was 27%.

Of all female drivers' fatal accidents, 57% were head-on collisions (compared with 36% of male drivers' fatal accidents). A typical male drivers' fatal accident was driving off the road. Of all male drivers' fatal accidents, 47% were off-the-road accidents, whereas the proportion for women was 26%. Men lost the control of their vehicle typically at high speeds, in good weather and road conditions, and when drunk (40% of all their loss-of-control accidents). For female drivers those kinds of accidents were rare (7% of all their loss-of-control accidents). Female drivers lost control of their vehicle typically in slippery road conditions while sober and using moderate speed (48% of all their loss-of-control accidents). No change in the difference in accident patterns between men and women was found from 1984 to 2000 (Laapotti and Keskinen 2004).

Discussion of Results

According to the results, female drivers drove less per year than male drivers, which suggests that female drivers are less experienced than men. The amount of driving as such is connected to the skills at the lower levels of driving behavior, that is, vehicle maneuvering and mastering traffic situations (Keskinen 1996; Hatakka et al. 2002). The current study found that the proportion of minor single-vehicle and backing-up accidents was higher for women than for men. Further, female drivers lost control of their vehicle proportionally more often in bad road and weather conditions than men did. These types of accidents may be regarded as signs of problems at the lower levels in the hierarchy of driving behavior. Vehicle handling was found to be more problematic for women than for men in earlier studies as well (Karpf and Williams 1983; Rolls et al. 1991; Storie 1977).

The study found that the goals and context of driving differed between men and women. Driving on errands was typical for female drivers of all ages. Young men were an exceptional group in the sense that nearly one-fourth of their driving was just for fun, whereas for other driver groups the proportion of such driving was 16% or lower. This result supports the finding that young men are more interested in cars and driving than other driver groups are (Rolls et al. 1991).

The study found that young women had more positive attitudes toward traffic rules and safe driving than men did. Women committed fewer traffic violations than men. Further, speeding and drunk driving were seldom the background factors explaining the fatal accidents of women, whereas for young men speeding and drunk driving were typical. Young women have fewer problems at the higher levels of driving behavior than young men. It may be concluded that women manage well in traffic as far as safety is concerned.

Driver licensing most often takes place at the age of 18 to 19 in Finland. At this age, young persons in industrialized countries are still in the process of developing their adult identity. They are questioning the values and interests of adult society and are choosing their own for themselves. The stage of adolescence, both physiological and psychological, tends to start and end a little bit earlier among girls. Young men may still be rebellious at 18 and 19, whereas women already behave in a more adult fashion by then (Roberts et al. 2001). This explanation may be why women and men differ from each other in terms of driving behavior more at a young age than later on in life.

Female drivers rated their own driving skills lower than those of male drivers, both in 1978 and in 2001. This finding may be in connection with the traditional view that a good driver is one who is skillful in vehicle handling and in mastering traffic situations. The current study aims to stress that a good driver is also safety oriented.

Evidence thus far supports the conclusion that young female drivers are more safety oriented than their male counterparts. This study indicates that there are no major changes to this status quo. Although the number of driving licenses and the amount of driving by women have increased rapidly during the last 20 to 30 years, the difference in traffic attitudes and driving behavior between the sexes still remains.

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Women's Involvement in Pedestrian–Vehicle Crashes
Influence of Personal and Environmental Factors

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Pedestrian–vehicle crashes are examined for patterns by gender. The analysis focuses on how the pedestrian crashes of men and women vary by personal characteristics (age, condition, injury) and physical characteristics of the crash area (location type, density, land use, pedestrian activity). The data for this study are pedestrian–vehicle crashes in Baltimore City, Maryland, from the State of Maryland Motor Vehicle Accident Report. The results from the analysis presented here suggest that, in general, there are few significant gender effects in the majority of pedestrian crashes. Women tend to be involved in fewer pedestrian crashes overall, and when they are involved, they appear to exhibit fewer risk-taking behaviors, such as violating traffic laws and consuming alcohol or drugs. Women were slightly less likely to be injured in a crash and less likely to die as a result. The effects of land use on pedestrian crash rates were not significant by gender. However, a higher percentage of women's crashes occur in areas with high pedestrian activity, which may be reflective of the distribution of areas in which women walk.

The National Highway Traffic Safety Administration (NHTSA) (2001) reports that although pedestrians are involved in a small proportion of vehicle crashes (2% to 3%), they represent a much higher proportion of crash fatalities (11% to 13%). In a majority of these deaths (55%), improper pedestrian behavior was a contributing factor. A variety of other studies have shown that male pedestrians are more likely to be involved in a crash and die as a result than their female counterparts [Hayakawa et al. 2000; Hebert Martinez and Porter 2004; Hijar et al. 2003; Khan et al. 1999; World Health Organization (WHO) 2003]. From these results, it would appear that women are less at risk for involvement in a pedestrian–vehicle crash. Contributing factors to the lower crash rates for women may include fewer risk-taking behaviors such as alcohol consumption, illegal midblock crossing or jaywalking, and crossing under unsafe conditions (low visibility or high vehicular volume). However, less research has focused on those factors related to women's involvement in pedestrian crashes and the personal and environmental factors associated with them.

Gender differences in pedestrian–vehicle crashes are examined for the city of Baltimore, Maryland. The objective of the analysis was to determine the relationships, if any, between characteristics of pedestrians and the physical characteristics of crash location with particular emphasis on women's involvement in crashes.

Background Literature

There is a long list of research on the travel and transportation differences between men and women; however, most of this work has focused on motorized travel. Studies focused exclusively on the gender differences in pedestrian trips are sparse and the few that do exist show mixed results. For example, evidence shows that women are more dependent on transit, tend to make more household maintenance trips, and engage in more trip chaining (Rosenbloom 1997). Transit use is linked to pedestrian trips, since walking is frequently an access mode for transit. Because women have a greater reliance on transit, one would expect them to make more pedestrian trips connected with transit use. There is some evidence, however, that household responsibilities and resulting travel patterns may not accommodate much additional pedestrian activity. For example, Handy (1996) found that women walked to the store fewer times per month than men. In contrast, some studies on women's walking patterns show that women walk farther than men do (Carlsson-Kanyama et al. 1999) and make more walking trips (Root et al. 2000).

Another thread of literature important to the topic of pedestrian activity is the interaction between urban form and travel. Like the research on women's travel, the land use and transportation connection has a rich and varied literature, a review of which may be found elsewhere (Crane 2000), but not without some shortcomings, particularly when the relationship among land use, transportation choices, and gender differences is examined. The literature has less to say about how or if these land use variables may affect women's travel differently from that of men; a more in-depth treatment has been made by Clifton and Dill (2005). Likewise, studies examining women's involvement in pedestrian crashes are limited.

In 2002, 4,808 pedestrians were killed in traffic crashes in the United States. However, data from NHTSA (2004) reveal that although traffic fatalities have increased over the past 10 years, pedestrian fatalities have steadily decreased. Female pedestrian fatalities represent a minority of crashes in the United States and account for 32% of all pedestrian fatalities (NHTSA 2004; Demetriades et al. 2004). Regarding fatal pedestrian crash rates, men are involved in greater numbers of fatal crashes per population than women in every age category (NHTSA 2004).

Much research has been dedicated to the differences between men and women in risk-taking behaviors. This research may help explain the differences in crash involvement by gender. Men may be placing themselves at greater risk by crossing an intersection improperly, disobeying a pedestrian signal, or crossing at a nonintersection (midblock) location. In a study of Baltimore and Washington, D.C., pedestrian–vehicle crashes, Preusser et al. (2002) found that pedestrians were judged culpable in 50% of the crashes. Alcohol and substance abuse by the pedestrian are involved in 15% of pedestrian crashes (Stutts et al. 1996) and men are more likely than women to be drinking heavily and using illicit drugs (Thom 2003).

Because 75% of all pedestrian crashes occur in urban areas (Hebert Martinez and Porter 2004), it is important to understand the interaction between pedestrian crashes and the built environment. Intuitively, it appears that the built environment could have significant influence on pedestrian crash rates. Pedestrian generators, such as high-density development and commercial land uses, would expect to experience more crashes because they have more pedestrian demand. Women may be at an increased risk in these areas because they may be more likely to be shopping or running errands. However, as stated before, women are consistently found to have lower crash involvement rates than men.

As shown by previous research, men and women have different travel patterns. These differences in travel behavior, including mode choice, trip purpose, and time of day, may lead to distinct patterns in walking behavior. In turn, these travel patterns, along with other factors, may result in different patterns of crash involvement. The literature documents, although to a lesser extent than the coverage of differences in travel behavior, men's disproportionate involvement in pedestrian collisions. This finding, in turn, raises questions about disparities in pedestrian crashes between the sexes and the relationship to underlying travel behavior and the environment. An examination of pedestrian–vehicle crashes cannot be used to make the link between these differences in the travel behavior of men and women because the data are insufficient. However, study of these negative outcomes for pedestrians can suggest ways in which the sexes are affected differently by their own behavior and their environment.

The purpose of this study was to examine how personal and environmental factors differ between men and women involved in police-reported pedestrian crashes. Specifically, this study aimed to examine gender differences in pedestrian crashes with respect to involvement, severity of injury, personal factors and behaviors, and environmental conditions. To accomplish this aim, pedestrian crash data for the city of Baltimore, Maryland, were examined by using descriptive statistics and multivariate analysis.

Data and Methodology

This study presents a detailed analysis of gender, pedestrian crashes, and land use variables by using a variety of statistical tests. The data for this study are pedestrian–vehicle crashes in Baltimore City, Maryland, from the State of Maryland Motor Vehicle Accident Report. The data on pedestrian–vehicle collisions include more than 3,000 individual crash records over a 3-year period from 2000 to 2002. The data contained information on the pedestrian such as age, gender, clothing, obedience to pedestrian signals, and presence of alcohol. In addition, the data included crash time and location information such as presence of signal, turning movement, road condition, weather, and time of day. The location of the crash was recorded as the nearest intersection. These data were supplemented with characteristics of the crash location, including measures of land use and pedestrian activity. The socioeconomic characteristics of the area surrounding the crash were obtained from the 2000 U.S. census, including information such as median income, total population and population density, number of households, total employment, and percentage of population that walks to work. All measures were aggregated to the block-group level. In addition five measures of the built environment were calculated: single-family residential dwelling unit density, percentage of single-family dwellings within ¼ mi of a bus stop, percentage of single-family dwellings within ¼ mi of commercial locations, percentage of land dedicated to parks, and population density.

The city of Baltimore is the largest city in Maryland and has a population of over 650,000 residents with a population density of over 8,000 persons per square mile. The median household income for Baltimore City, $30,078, is lower than the national median of $41,994 and significantly lower than the Maryland state median of $52, 868. Twenty-three percent of Baltimore City residents are below the poverty level, significantly higher than the national average of 12%. Notably, unlike the national and state averages, Baltimore City has a higher percentage of women than men in the workforce: 52.6% women versus the national average of 46.5% and Maryland state average of 48.8%. More than 6% of Baltimore City's employees walk to work, more than twice the national average. In addition, Baltimore City provides numerous public transit options and facilities: bus routes, light rail, a subway system, and a commuter rail connecting to Washington, D.C.

Baltimore's high number of pedestrians, population with a greater reliance on alternative modes, variation in urban structure across the metropolitan area, and high number of pedestrian–vehicle crashes make it a compelling case for closer investigation. Figure 1 shows the spatial distribution of the pedestrian–vehicle crashes differentiated by gender of the pedestrian involved in the crash. The clustering of crashes around major arterials can be seen on this map. Of the 3,009 crashes, women accounted for 40%.

With the data just described, the research design utilized multivariate statistical analysis to examine the differences in crash rates by gender, including the effect of personal characteristics and environmental conditions. The data were analyzed using descriptive statistics to examine the differences in crash involvement for the sexes based on severity of injury, age of pedestrian, presence of alcohol or other substance, pedestrian obedience to traffic signals, age of pedestrian, time of day, and land use.

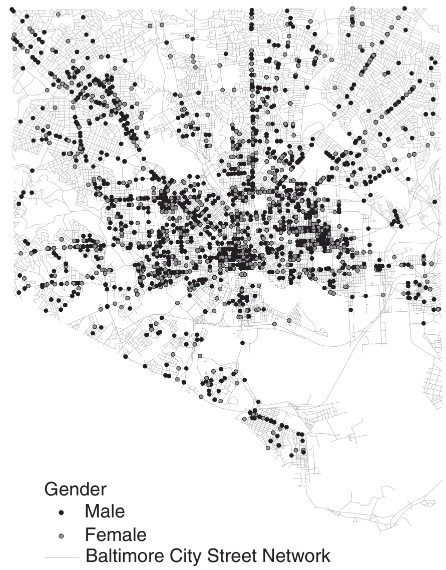

FIGURE 1 Spatial distribution of pedestrian crashes by gender.

A model of crash densities was employed to estimate the effects of personal and environmental factors on the spatial differences in crash involvement of men and women. In order to better understand the effects of the pedestrian, location, and environmental characteristics, multivariate analysis of the crashes was performed. Ordinary least squares linear regression analysis was used to determine the effects of each variable on the number of crashes per square mile per population. The spatial unit of analysis was the block-group level. The model was segmented by gender: one was estimated for the male crash data and one for the female crash data. The dependent variable was the natural log of the number of crashes per square mile per population, and the independent variables were the characteristics of the population and crash and the land use variables. The location characteristics include median income and percentage of nonwhite population, children in the area, and vehicle ownership. The variables of interest that could have an impact on future land use policies are pedestrian activity, commercial accessibility, transit accessibility, and roadway density. Table 1 shows the model specification and estimation for both men and women. There was no significant multicollinearity among the variables in the model. In addition, these models were corrected for heteroscedasticity.

TABLE 1 Model Estimation Results: Natural Logarithm of Crash Density per Population

	Female	Male	Total
Pedestrian activity	0.013 **	0.002	0.008
Income (in $1000)	0.003	–0.005	0.000
% park	–0.015***	–0.011	–0.011**
Commercial accessibility	0.010***	0.006**	0.009***
Transit accessibility	–0.018***	–0.011***	–0.015***
Race	0.702***	0.995***	0.900***
% pop. < 16 years old	0.158	0.215	0.016
Education	–0.930*	–0.040	–0.458
Vehicle ownership	0.171	–0.132	–0.431
Density of roads	0.033***	0.036***	0.037***
N	339	422	473
R^2	0.412	0.431	0.430

Corrected for heteroscedasticity.
*Statistically significant at the 10% level.
**Statistically significant at the 5% level.
***Statistically significant at the 1% level.

RESULTS

Pedestrian and Crash Characteristics

As shown in Table 2, the majority of crashes involved adults aged 16 to 64. A very few (less than 5%) crashes involved the elderly (65+). Thirty-six percent of pedestrian crashes occurred with children (0 to 15 years of age). Men and women involved in a pedestrian–vehicle collision have similar age profiles.

Seventy-eight percent of the pedestrian crashes were reported to have occurred at locations with malfunctioning or no signalization, and almost 80% of the fatal crashes occurred in areas with no traffic signal, either because there was no signal at the intersection or pedestrians were crossing midblock. To explore this issue further, additional statistics were computed for severity of injury by compliance with traffic laws. Results show that pedestrians who did not obey a traffic signal were slightly more likely to sustain injuries than those who crossed with a signal (56% for the former and 51% for the latter). Of those involved in a pedestrian–vehicle collision, women were more likely to have been crossing in accordance with traffic laws (13% for women com-

TABLE 2 Pedestrian Crashes by Pedestrian Characteristics

Characteristics of Crash or Tract Where Crash Is Located	Total *N*	Total %	Male	Female	Statistical Significance
Number of crashes	3009	100.0%	1778	1207	
Age					0.168
Child (0 to 15 years of age)	1001	35.7%	37.1%	33.7%	
Adult (16 to 64 years of age)	1685	60.1%	58.8%	62.0%	
Elderly (over 65 years of age)	118	4.2%	4.1%	4.3%	
Total	2804	100.0%	100.0%	100.0%	
Traffic law obedience					0.000
No or malfunctioning signal	1971	78.1%	79.6%	75.8%	
Obeyed signal	229	9.1%	6.2%	13.3%	
Disobeyed signal	324	12.8%	14.2%	10.9%	
Total	2524	100.0%	100.0%	100.0%	
Severity of injury					0.064
No injury	1463	49.0%	47.3%	51.5%	
Nonfatal injury	1478	49.5%	51.1%	47.2%	
Fatality	44	1.5%	1.6%	1.2%	
Total	2985	100.0%	100.0%	100.0%	
Substance abuse					0.000
None	1200	90.7%	87.4%	95.7%	
Substance present	93	7.0%	9.3%	3.6%	
Substance contributed	30	2.3%	3.3%	0.8%	
Total	1323	100.0%	100.0%	100.0%	
Time of day					0.029
Daylight	2051	69.1%	67.4%	71.6%	
Dawn or dusk	145	4.9%	5.5%	4.0%	
Dark	772	26.0%	27.1%	24.4%	
Total	2968	100.0%	100.0%	100.0%	

pared with 6% for men). These findings are consistent with research on the increased propensity of men to engage in risk-taking behavior.

Regarding severity of injury, over half of the crashes resulted in injuries and 1.5% of reported crashes resulted in pedestrian fatalities. Women were slightly less likely to be injured in a crash with 51% of the crashes involving no injuries. Consistent with previous research, men were more likely to be injured in a crash and slightly more likely to die as a result. However, these gender differences in severity of injury were slight and only significant at the 90% confidence interval.

For the pedestrians involved in the crash, the presence of alcohol, medication, and illegal substances was reported in three categories: no substance detected, substance present, and substance contributed to crash. In over 90% of the crashes involving pedestrians, no illegal substance was detected. Seven percent of pedestrian crashes involved pedestrians who had medication, alcohol, or illegal substances present in their system, and in 2% the pedestrians had substances in their system that contributed to the crash. Of these, men proved more likely to test positive for some substance. In over 3% of all crashes involving men, alcohol, medication, or illegal substances contributed to the crash compared with less than 1% for women. In addition, men were more likely to have alcohol or other drugs or medications present at the scene of the accident and were more likely to have alcohol listed as a contributing factor to the crash.

To explore this issue further, the results indicate that the severity of injury increased with presence of the illegal substance. Table 3 shows pedestrian crashes by severity of injury and traffic obedience and substance abuse for both men and women. Seventy percent of pedestrian crashes in which a substance contributed to the crash resulted in injuries or fatalities. Alcohol was present in 8% of pedestrian crashes but accounted for more than 12% of fatalities. Also, an illegal drug was present in only 0.9% of pedestrian crashes but accounted for 3% of all fatalities. The data show differences in the relationship between severity of injury and presence of substance by gender. Specifically, for pedestrians involved in fatal crashes, 10.5% of men showed that a substance contributed to the crash, whereas no female fatalities were reported with a contributing substance.

Almost 70% of all pedestrian crashes occurred during daylight hours and accounted for about 61% of fatalities. In contrast, more than 30% of pedestrian crashes occurred after dark but accounted for nearly 40% of the fatalities. These results indicate that nighttime pedestrian crashes were more likely to result in more severe injuries. Men and women had similar distributions of crashes by time of day; women (72%) are involved in slightly more crashes during daylight than men (67%). Although these differences were small, the analysis shows that the relationship between time of day and gender of the pedestrian is statistically significant.

Land Use and Crash Characteristics

Further gender analysis of the crashes was performed by using land use characteristics for the location of the pedestrian crash; the results are shown in Table 4. Journey-to-work data at the tract level from the U.S. census were used as one indicator of pedestrian activity. Areas were categorized into low pedestrian activity (less than 10% of workers walk), medium (10% to 27% walk), and high (27%

TABLE 3 Pedestrian Crashes by Severity of Injury and Pedestrian Characteristics

	Total %	Total *N*	Severity of Injury			Statistical
			No Injury	Nonfatal	Fatality	Significance
Traffic law obedience—male						0.393
No or malfunctioning signal	79.6%	1196	80.6%	78.5%	88.6%	
Obeyed signal	6.2%	93	6.6%	6.1%	0.0%	
Disobeyed signal	14.2%	213	12.8%	15.4%	11.5%	
Total	100.0%	1502	100.0%	100.0%	100.0%	
Traffic law obedience—female						0.750
No or malfunctioning signal	75.8%	775	76.8%	75.2%	61.5%	
Obeyed signal	13.3%	136	12.9%	13.5%	23.1%	
Disobeyed signal	10.9%	111	10.3%	11.3%	15.4%	
Total	100.0%	1022	100.0%	100.0%	100.0%	
Substance abuse—male						0.004
None	87.4%	692	91.6%	84.7%	68.4%	
Substance present	9.3%	74	6.2%	11.5%	21.1%	
Substance contributed	3.3%	26	2.2%	3.8%	10.5%	
Total	100.0%	792	100.0%	100.0%	100.0%	
Substance abuse—female						0.095
None	95.7%	508	97.5%	94.7%	84.6%	
Substance present	3.6%	19	2.1%	4.3%	15.4%	
Substance contributed	0.8%	4	0.4%	1.1%	0.0%	
Total	100.0%	531	100.0%	100.0%	100.0%	

TABLE 4 Pedestrian Crashes by Land Use

Characteristics of Crash or Tract Where Crash Is Located	Total *N*	Total %	Male	Female	Statistical Significance
Pedestrian activity					0.081
Low (less than 10%)	2143	71.8%	73.1%	69.8%	
Medium (10% to 27%)	506	17%	16.6%	17.5%	
High (>27%)	336	11.3%	10.3%	12.7%	
Total	2985	100.0%	100.0%	100.0%	
% parkland					0.241
Low (0% to 10%)	2534	84.9%	84.4%	85.7%	
Medium (10% to 40%)	322	10.8%	10.8%	10.8%	
High (>40%)	129	4.3%	4.8%	3.6%	
Total	2985	100.0%	100.0%	100.1%	
Population density					0.413
Low (0 to 10,000 persons/mile^2)	1160	38.9%	39.7%	37.6%	
Medium (10,001 to 20,000 persons/mile^2)	1271	42.6%	42.4%	42.9%	
High (>20,001 persons/mile^2)	554	18.6%	17.9%	19.5%	
Total	2985	100.0%	100.0%	100.0%	
Median household income					0.912
Low (<$25,000)	1201	40.2%	40.6%	39.8%	
Medium ($25,000 to $40,000)	1474	49.4%	49.1%	49.8%	
High (>$40,000)	310	10.4%	10.3%	10.4%	
Total	2985	100.0%	100.0%	100.0%	
% within ¼ mile of commercial parcel					0.714
Low (0% to 55%)	164	5.5%	5.7%	5.1%	
Medium (55% to 85%)	299	10.0%	10.2%	9.8%	
High (>85%)	2522	84.5%	84.1%	85.1%	
Total	2985	100.0%	100.0%	100.0%	
% within ¼ mile of bus stop					0.890
Low (40% to 80%)	93	4.3%	4.4%	4.2%	
Medium (80% to 95%)	374	17.4%	17.7%	17.1%	
High (95% to 100%)	1681	78.3%	77.9%	78.8%	
Total	2148	100.0%	100.0%	100.1%	

and more). Surprisingly, the results show that crashes have a negative correlation with levels of pedestrian activity. Tracts with a low percentage of the people who walk to work had the highest percentage (72%) of pedestrian–vehicle collisions compared with tracts with medium pedestrian activity (17% of crashes) and high activity (11% of crashes). Men were involved in slightly higher percentages of pedestrian crashes than women in tracts with low pedestrian activity; however, women were involved in a higher percentage of crashes in areas with medium and high pedestrian activity than men were. These differences are small and they are only statistically significant at the 90% confidence level. These results may indicate that neighborhoods with lower pedestrian activity are more prone to having pedestrian crashes because motorists are not expecting pedestrians to be present. Walking to work is just one indicator of pedestrian activity, and additional data on pedestrian demand may reveal different patterns. Figure 2 shows the spatial distribution of the pedestrian crashes by percentage of workers who walk to work.

Similarly, tracts were categorized by the amount of parkland as low (less than 10% of tract area), medium (10% to 40% of tract area), and high (greater than 40%). The results were counterintuitive; tracts with the least amount of parkland have the highest number of pedestrian–vehicle crashes. Eighty-five percent of all crashes occurred in tracts with a low percentage of parks, and only 4% of all crashes occurred in tracts with high levels of park area. Again, motorists driving near park areas may be more attentive to pedestrian traffic. Gender of the pedestrian involved in crashes did not appear to have a significant relationship with parkland. The combination of age and presence of parkland had a notable but not significant effect on crashes. A low percentage (3%) of adults and elderly were involved in crashes in areas with a high provision of parks. In contrast, nearly twice as many pedestrian crashes (almost 6%) involving children occurred at locations with a high density of parkland.

Population density and income levels of neighborhoods had an effect on the frequency of pedestrian crashes. Areas with medium levels of population density (10,000 to 20,000 persons per square mile) had the highest percentage (43%) of pedestrian crashes compared with 38% in low-density areas (fewer than 10,000 persons per square mile) and 19% in high-density areas (more than 20,000 persons per square mile).

There were no significant gender effects by the income level of the tract. The lowest percentage of crashes (10%) occurred in high-income areas, pointing to the generally lower levels of walking for transportation purposes in these areas. However, nearly 16% of fatal crashes occur in high-income areas. The reasons

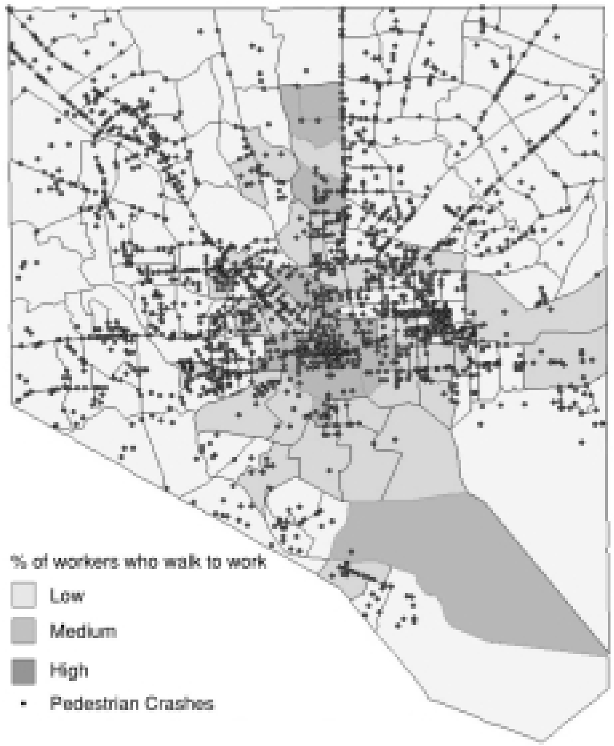

FIGURE 2 Spatial distribution of pedestrian crashes by percentage of workers who walk to work.

for this finding may be related to the more suburban nature of these areas, with wider roads, higher vehicle speeds, and less pedestrian infrastructure.

The relationship between pedestrian–vehicle crashes and pedestrian access to commercial land uses was examined. The percentage of single-family residential units in the tract within ¼ mi of commercial uses was employed as a measure of pedestrian access to retail and services and categorized as high (over 85% of households live within ¼ mi of commercial area), medium (55% to 85%), and low (less than 55%). Eighty-four percent of all pedestrian crashes occurred in areas with high levels of pedestrian access to commercial sites.

The relationship between transit access and pedestrian crashes was another land use variable analyzed in this study. The transit access measure was calculated as the percentage of single-family residential units in a tract that have a transit stop within ¼ mi. As with much of the analysis, gender did not seem to have a significant effect on this relationship. But interestingly, areas with high transit access had the highest percentage of crashes (over 78%) and a higher percentage of crashes involving children occurred in areas of high transit access (81%). These results may indicate that areas with good accessibility to bus stops have more pedestrians and therefore more opportunity for pedestrian crashes.

Regression Analysis

An examination of the pedestrian crash densities for each gender as a function of a variety of personal and environmental factors was made by using multivariate regression models. The models' estimations, shown in Table 1, show a negative relationship between crashes and percentage of parkland available at the block-group level. This relationship was statistically significant for the female crash model but not for the male model. Since parks are an attractor for pedestrian activity, this negative relationship may be indicative that drivers are more careful around areas in which there would be a higher chance of pedestrians, specifically children, crossing the streets.

Although the differences were not statistically significant, the models seem to indicate a gender difference based on income. The female model indicates that more of their crashes were associated with locations with higher income levels. This finding may be explained by the fact that these higher-income areas may have a greater percentage of the population who can afford cars. However, the male model shows a negative relationship between income and pedestrian crashes.

The race variable is defined as the percentage of nonwhite population in the area. This variable is positively associated with male and female crashes. This statistically significant result showed that locations with a greater percentage of minority groups were more likely to have pedestrian crashes for both models.

The interest of this study is the relationship between the land use variables and pedestrian crashes. The land use variables of interest in the model are those that show the different levels of population and infrastructure density. The variables for density of roads and commercial accessibility were statistically significant for both models; however, the pedestrian activity variable is only significant for the female model. These models show that the propensity of crashes increases with the increase in density of roads (over 3%), pedestrian activity (approximately 1% for women and 0.2% for men), and commercial accessibility (approximately 1% for women and 0.6% for men). The reasons for these findings may be related to the greater number of pedestrians in that area and therefore greater opportunity for a pedestrian–vehicle crash. In the more suburban areas, with lower housing densities, there is usually less pedestrian infrastructure, more vehicle ownership, and therefore less pedestrian activity.

It is interesting that transit accessibility has a statistically significant and negative impact on crashes. The log models show that a one-unit increase in transit accessibility results in a decrease of crashes by over 1%. This result may indicate that in areas with high transit accessibility, more people tend to walk and drivers may be more attuned to the pedestrian nature of the area. The downtown area has the greatest transit access and is an area with typically lower travel speeds for vehicles, which may contribute to the lower crash rates.

The variable for education, defined as percentage of the population who attended college, was only statistically significant for the female model. The education variable was negatively related to crash rates, which may indicate that people may depend more on walking as a mode of transportation in locations with a less-educated population. However, this explanation does not address why this variable was significant only for the female model.

Conclusions

The evidence from the analysis presented here suggests that, in general, there are few significant gender effects in the majority of pedestrian crashes. Women tend to be involved in fewer pedestrian crashes overall and, when they are involved, appear to exhibit fewer risk-taking behaviors, such as violating traffic laws and consuming alcohol or drugs. Women were slightly less likely to be injured in a crash and less likely to die as a result. The effects of land use on pedestrian crash rates did not show significant effects by gender. However, a higher percentage of women's crashes occur in areas with high pedestrian activity, which may be reflective of the distribution of areas in which women walk. These findings are not new but do confirm the evidence presented in previous research.

Because there are no corresponding data on pedestrian demand and behaviors, one can only speculate about potential causes for these gender differences in crashes. Fortunately, it does not appear overall that women are at a particular disadvantage in terms of pedestrian safety. Improvements to walking environments are likely to have a similar effect for the safety of men and women. However, policy and treatment interventions in term of risk-taking behavior may prove more effective if men are targeted. Before one dismisses the issue of gender differences in pedestrian–vehicle collisions as insignificant, a comprehensive and complementary analysis of pedestrian demand and behavior would provide a more thorough understanding of women's pedestrian safety issues.

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Nonfatal Transportation-Related Injury Among Women

Differences in Injury Patterns and Severity by Age

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Transportation ranks among the leading causes of death and injury for women in the United States. National estimates of nonfatal injury were based on weighted data from 31,144 women aged 15 years and older treated in hospital emergency departments during 2002. These injuries were compared with data from 31,733 men collected in the same system. Injuries were classified by age, disposition (e.g., treated and released, hospitalized), person type (e.g., occupant, pedestrian), body area injured, and type of injury (diagnosis). The 31,144 injuries represented an estimated 1.8 million transportation injuries to women in the United States. The majority (93.6%) of injured women were treated and released. Data were divided into five categories: motor vehicle occupant, pedestrian, pedal cyclist, motorcyclist, and all other transportation-related injuries. An estimated 1,495,884 female occupants were injured during 2002. Women (1,280) had a higher occupant injury rate per 100,000 population than men (1,127). Men had higher rates as pedestrians, pedal cyclists, and motorcyclists. This analysis demonstrates the heavy burden of transportation injury among women, along with notable differences in injury severity and injury patterns.

The need for personal vehicles to meet daily requirements for independent living has risen as the U.S. population has spread beyond urban areas. The convenience of personal vehicles has allowed the distance from where one lives and works, shops, and enjoys leisure time to grow. Additional time on the road increases the risk of crashes and their accompanying injuries. In 2003 there were 97.9 million female licensed drivers (*1*), driving an average of 44 min a day (*2*).

Transportation ranks among the leading causes of death and nonfatal injury for women in the United States (*3*). Evans (*4*) has shown that in comparable crashes, women are at greater risk of death than are men of the same age; this relationship appears to hold true for persons in the mid-teen years through the late fifties. In addition to the risk of death, after major trauma women are at greater risk for lower quality-of-life outcomes and increased psychologic sequelae such as depression (*5, 6*). These findings point to an important health threat to women in the United States. Although the number of transportation-related deaths has been well studied, the extent of nonfatal injury has garnered less attention. The purpose of this study was to assess the size of the burden of nonfatal transportation-related injury among women in the United States.

Data Sources and Methods

Data were obtained from the National Electronic Injury Surveillance System-All Injury Program (NEISS-AIP) operated by the U.S. Consumer Product Safety Commission. This system consists of a nationally representative sample of hospital emergency department visits `from 66 hospitals. Data were collected from medical records, and the most severe injuries were recorded. The most severe injury was based on the principal diagnosis as recorded on the emergency department record. Data were weighted by the inverse of the probability of selection to provide national estimates; only the initial visit for any nonfatal injury was recorded. Visits were excluded if there was no diagnosis of injury—for example, pain only—or if the victim was pronounced dead on arrival.

This study includes injuries categorized as transportation-related sustained by motor vehicle occupants (drivers and passengers), pedestrians, pedal cyclists, and motorcyclists. National estimates were based on weighted data from 31,144 nonfatal transportation-related injuries among women aged 15 years and older treated in emergency departments during the period from January to December 2002. Data on these injuries were compared with data from 31,733 men collected in the same system. Injuries were classified by age, disposition (e.g., treated and released, hospitalized), person type (e.g., motor vehicle occupant, pedestrian), primary body area injured, and type of injury (primary diagnosis). Population data were from postcensal bridged-race population estimates. Confidence intervals were designed to take into account the complex survey design and sample weights.

FINDINGS

Demographic Characteristics of Sample

The 31,144 injuries represented an estimated 1.8 million nonfatal transportation-related injuries to women in the United States during 2002. More than half of the injuries (53.4%) were among those aged 25 to 54, 6.3% were among teenagers aged 15 to 19, and 8.0% were among women aged 65 and older. The age distribution for men was similar. The majority (91.8%) of those injured were treated and released, although a slightly higher proportion of women were treated and released (93.6%) than men (90.1%). Consequently, women showed a lower proportion (4.7%) of hospitalizations than men (7.6%). These hospitalizations represented more than 86,000 women with severe transportation-related injuries (Table 1). The proportion hospitalized was consistently low at 3% to 4% until ages 55 to 64, when the proportion hospitalized began to rise with age, reaching a high of 18.1% among women aged 85 and older.

Data from the emergency department visits were divided into five categories: motor vehicle occupant, pedestrian, pedal cyclist, motorcyclist, and all other transportation-related injuries. Most (74.0%) injuries were to motor vehicle occupants, although the proportion differed for women (81.8%) compared with men (66.3%). An estimated 1,495,884 female motor vehicle occupants were injured during 2002 (Table 1).

The proportion of pedestrian injuries was similar for women (3.0%) and men (4.0%); however, there were differences in the proportion of pedal cyclists (women, 2.7%; men, 8.8%) and motorcyclists (women, 1.3%; men, 7.8%). Although the proportion of each of these categories of injuries was less than 5% among women,

TABLE 1 Weighted Estimates of Nonfatal Injuries Treated in Emergency Departments by Age and Sex, United States, 2002

	Females			Males		
Characteristic	Sample Size	Weighted Estimate	95% Confidence Interval	Sample Size	Weighted Estimate	95% Confidence Interval
	31,144	1,828,442	1,540,964–2,115,921	31,733	1,878,056	1,600,406–2,155,705
Age						
15–19	5,078	298,204	243,925–352,483	5,376	320,401	265,470–375,333
20–24	4,743	279,047	225,801–332,293	5,100	306,230	252,432–360,028
25–34	6,869	392,331	328,946–455,717	7,595	433,804	369,469–498,139
35–44	6,015	349,756	289,152–410,360	6,213	363,109	312,461–413,757
45–54	3,970	233,772	195,260–272,285	3,742	221,002	187,215–254,789
55–64	2,148	129,032	105,988–152,075	1,873	114,338	93,917–134,759
65–74	1,195	74,964	61,982–87,946	1,014	64,055	53,066–75,043
75–84	855	54,114	41,673–66,555	645	42,716	33,490–51,942
85+	271	17,221	12,967–21,475	175	12,400	8,923–15,876
Disposition						
Treated/released	28,875	1,711,471	1,439,144–1,983,798	28,079	1,692,615	1,450,763–1,934,468
Hospitalized	1,870	86,175	48,961–123,389	3,115	143,144	76,827–209,461
Transferred	226	18,884	14,015–23,753	311	27,370	20,614–34,126
Other*	173	11,913	7,026–16,799	228	14,926	9,809–20,044
Type						
Occupant	25,928	1,495,884	1,240,092–1,751,675	21,959	1,245,314	1,048,166–1,442,462
Pedestrian	1,059	55,210	42,575–67,846	1,393	75,475	57,039–93,911
Pedal cyclist	743	49,989	31,988–67,989	2,625	165,868	122,707–209,030
Motorcyclist	342	23,408	18,112–28,704	2,147	146,559	113,314–179,804
Other transport**	3,072	203,952	175,553–232,350	3,609	244,839	206,350–283,329

*Includes observation only and unknown disposition.

**Includes all other transportation-related injury such as off-road vehicles, buses, nonmoving vehicles (hand in car door), boats, etc.

the estimated number of injuries was substantial: 55,210 as pedestrians, 49,989 as pedal cyclists, and 23,408 as motorcyclists (Table 1).

Types of Injury

Body Part

Overall, nearly half (44%) of those injured sustained head or neck injuries, 47% among women and 42% among men. Upper and lower trunk injuries were more prevalent than leg or foot or arm or hand injuries. The head and neck area was most commonly injured, but this amount differed by age group, with the proportion declining with age. For example, 49% of women 15 to 19 years old sustained head or neck injury as their most severe injury compared with 42% among those 55 to 64 and 28% among those 85 and older. The upper trunk was the second most common area injured but this injury was more likely with increasing age: 13% among women 15 to 19, 17% among those 45 to 54, and 23% among those 85 and older. This general pattern also was seen among men (Table 2).

Diagnosis

The five most common types of nonfatal transportation injury were strains and sprains followed by contusions and abrasions, fractures, lacerations, and internal injury (Figures 1–5). This ranking was similar for women and men, although the proportions differed. Women were more likely to sustain strains and sprains (48%) than men (37%) (Figure 1), whereas the proportions of contusions and abrasions were similar (women 29%, men 27%) (Figure 2). Men had more fractures (12%) than women (7%) (Figure 3).

The distribution of injury types differed by age. Strains and sprains were more common in younger age groups and represented more than half of the injuries among women ages 20 to 54, a third of the injuries among women ages 65 to 74, and less than a quarter of the injuries among women ages 75 and older. The proportion of fractures increased with age, reaching a high of 24% among women 85 and older. Internal injuries

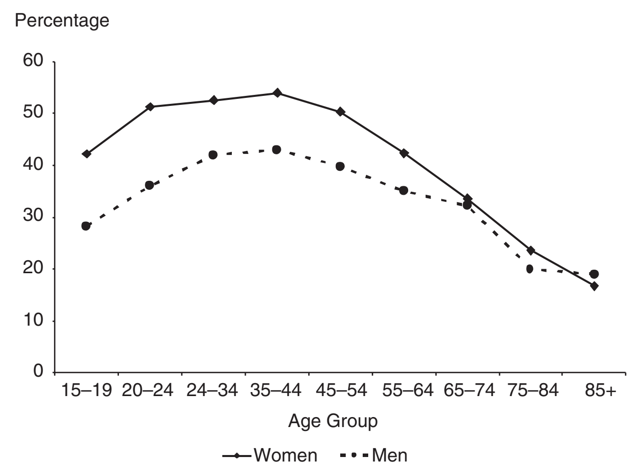

FIGURE 1 Most common types of nonfatal injury for persons treated in emergency departments, United States, 2002: strains and sprains.

TABLE 2 Proportion of Nonfatal Injuries Treated in Emergency Departments by Body Part, Age, and Sex, United States, 2002

	Body Part Injured					
	Head/Neck	Upper Trunk	Lower Trunk	Leg/Foot	Arm/Hand	Other/Unknown
Females						
15–19	49	13	12	13	11	2
20–24	51	13	14	11	11	1
25–34	48	14	15	11	10	2
35–44	47	15	15	12	10	2
45–54	46	17	13	13	9	2
55–64	42	22	10	15	10	2
65–74	36	21	12	17	13	2
75–84	34	24	13	15	12	2
85+	28	23	12	14	23	1
Males						
15–19	44	13	8	16	17	2
20–24	44	14	12	15	13	2
25–34	41	16	14	15	12	2
35–44	41	18	15	14	11	2
45–54	39	20	14	14	11	2
55–64	42	20	12	12	12	2
65–74	43	24	11	11	10	2
75–84	38	23	12	12	12	2
85+	39	26	10	12	11	2
Both sexes	44	16	13	14	12	2

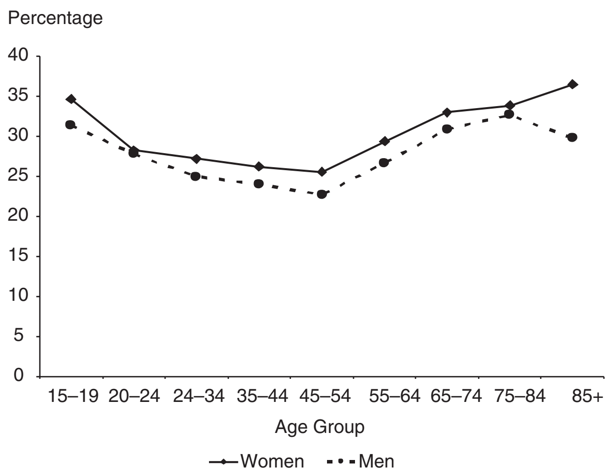

FIGURE 2 Most common types of nonfatal injury for persons treated in emergency departments, United States, 2002: contusions and abrasions.

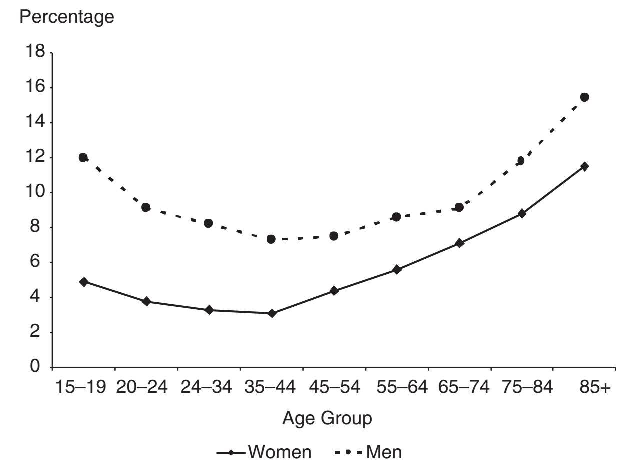

FIGURE 4 Most common types of nonfatal injury for persons treated in emergency departments, United States, 2002: lacerations.

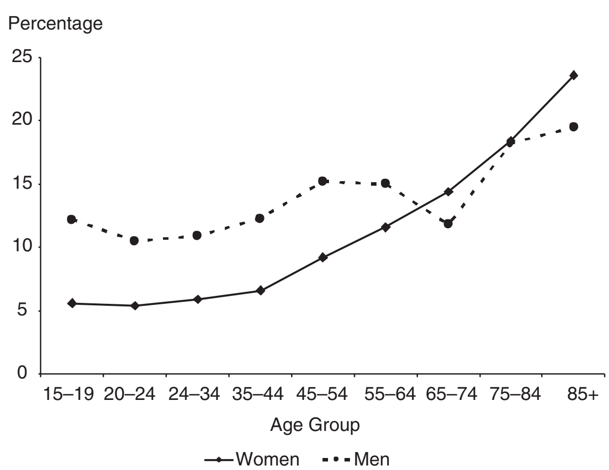

FIGURE 3 Most common types of nonfatal injury for persons treated in emergency departments, United States, 2002: fractures.

FIGURE 5 Most common types of nonfatal injury for persons treated in emergency departments, United States, 2002: internal injuries.

were most common among women ages 75 to 84 (7%) and lowest among women 85 and older (4%) (Figure 5).

Nonfatal Injury Rates

Nonfatal injury rates per 100,000 population varied by category (e.g., occupant, pedestrian) and by sex. The overall transportation injury rate was higher among men (1,700) than among women (1,565). Motor vehicle occupants had higher rates of injury than pedestrians, pedal cyclists, motorcyclists, and all other transportation-related categories. Women (1,280) had a higher occupant injury rate than men (1,127), but men had higher injury rates for all other categories (pedestrian, pedal cyclist, motorcyclist, and other transport). The pedestrian injury rate was 1.5 times higher in men than women (68 versus 47), the pedal cyclist injury rate was 3.5 times higher in men (150 versus 43), and the motorcyclist injury rate was 6.5 times higher in men (133 versus 20) (Table 3).

Discussion of Results

This analysis demonstrates the heavy burden of transportation-related injury among women in the United States, along with notable differences in injury severity and injury patterns. The 1.8 million injuries represent an average 5,000 women a day treated at hospital emergency departments for transportation-related injuries; the majority, nearly 1.5 million, were motor vehicle occupants. Although most women were treated

TABLE 3 Nonfatal Injury Rates for Persons Treated in Emergency Departments by Type of Person and Sex, United States, 2002

	Weighted Estimate	Injury Rate per 100,000 Population	95% Confidence Interval
Females			
Occupant	1,495,884	1280	1061–1499
Pedestrian	55,210	47	36–58
Pedal cyclist	49,989	43	27–58
Motorcyclist	23,408	20	16–25
Other transport*	203,952	175	150–199
Overall	1,828,442	1565	1319–1811
Males			
Occupant	1,245,314	1127	949–1305
Pedestrian	75,475	68	52–85
Pedal cyclist	165,868	150	111–189
Motorcyclist	146,559	133	103–163
Other transport*	244,839	222	187–256
Overall	1,878,056	1700	1448–1951
Both sexes			
Occupant	2,741,883	1206	1009–1403
Pedestrian	130,796	58	44–71
Pedal cyclist	215,901	95	69–122
Motorcyclist	170,011	75	58–91
Other transport*	448,910	198	170–225
Total	3,707,502	1631	1387–1875

*Includes all other transportation-related injury such as off-road vehicles, buses, nonmoving vehicles (e.g., hand in car door), boats, etc.

and released, an estimated 86,000 were hospitalized and another 18,000 were transferred for more specialized care. These 100,000+ women with more serious injuries were not evenly distributed across age groups; the proportions of both hospitalized and transferred increased with age.

The head and neck were by far the most commonly injured areas for women, and this proportion decreased with age. Strains and sprains were the most common diagnoses, and this proportion also decreased with age. Taken together, these results imply that problems such as whiplash are frequent and might be expected less frequently among older women. This finding is consistent with previous research (*7, 8*) and a separate analysis of the NEISS-AIP database that found that women and younger persons were at higher risk of whiplash injury (*9*). An alternative explanation may be the nature of the data collection system, which records only the most severe injury. If older women have other injuries that are more severe than neck strain, the distribution of neck strain would be skewed toward younger age groups.

The finding that women aged 75 to 84 had the highest proportion of internal injuries whereas those 85 and older had the lowest was surprising. It may be that because the incidence of hip fracture rises dramatically with age, the most severe injury would be recorded (the hip fracture) and the proportion of recorded internal injuries would decline. Alternatively, women in the oldest age group may be more likely to die of internal injuries and not be recorded in this database of nonfatal injury.

There were differences in injury rates by sex. Men had higher rates of injury in all categories except motor vehicle occupant. Rates were based on age- and sex-specific population estimates, so there was no adjustment for exposure to the traffic environment. It is likely that men have higher rates because of their increased exposure as pedal cyclists, motorcyclists, and off-road vehicle users (all-terrain vehicle users were included in the "other transport" category).

There is also evidence that men have higher rates of risk-taking behavior (*10, 11*) and that they are less likely to seek care than women. If men are less likely to seek care for injuries that do not necessarily require care, strains and sprains, for example, their proportion of injuries that typically require care, say fractures, would be higher. This theory is consistent with the finding here that men had a 60% higher proportion of fractures than women.

There are both disadvantages and advantages to the use of the NEISS-AIP for the study of transportation-related injury. The NEISS-AIP database provides national estimates but cannot provide state or local estimates; therefore, analyses of potential geographic variations in injury distributions are not possible. In addition, certainly nonfatal injuries treated in outpatient clinics and physicians' offices will not be captured in this system. Last, variables other than age also affect the severity and outcome of injury. Emergency department medical records did not consistently include information about restraint use, seating position, alcohol use, or medication use. Enhancements to the data collected in emergency departments would improve the ability to develop effective prevention programs. For example, more complete information on seating position would enable estimates that are specific to drivers and to passengers instead of a combined occupant category. If it was found that drivers had a different pattern of injury, programs to address driver issues could target drivers instead of using a broader occupant approach. Targeted programs tend to increase efficiency. The main advantage of the NEISS-AIP is that the large sample size and representative nature of these data allow for excellent estimates of the public health burden of nonfatal transportation injury among women. Moreover, these medical data can reveal the most important injuries by age group and serve to guide prevention efforts.

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POLICY AND PLANNING

Market Research on Gender-Based Attitudinal Preferences and Travel Behavior

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The attitudinal differences between men and women are examined in terms of how attitudes toward everyday travel vary by gender and to what extent differences in travel behavior can be explained by attitudinal differences. How differences in attitudes and behavior between men and women vary across socioeconomic groups is also addressed. Data for this study came from four attitude-based household surveys in which nearly 40 attitudinal questions were asked to measure respondents' sensitivity to a broad range of experiences that they may encounter during their daily travel and their attitudes toward characteristics of the different travel modes they consider for their travel. The ratings of the attitudinal statements were analyzed to determine whether there is a gender difference; they were also used to segment the survey respondents into distinct market groups according to shared travel attitudes. This study shows that there is significant gender difference in travel attitudes, though the relative rank order of ratings provided by the female respondents was similar to that of the male respondents. It is important to provide a mix of strategies that would be most effective for different market segments with a range of attitudinal preferences and socioeconomic characteristics.

Many studies have shown that women's travel behavior is significantly different from men's. Gender differences in travel behavior have been studied extensively (Taylor and Mauch 1997; Rosenbloom and Burns 1994; Gordon et al. 1989; Hanson and Johnston 1985; Madden 1981; Madden and White 1980). The cause of these behavioral differences has been the subject of a variety of research studies. Most of the literature focuses on the traditional interpretation of women's travel as constrained by their roles in child rearing and the spatial entrapment of women that limits their employment opportunities (Waddell 1996). There is also research on travel attitudes, with many studies suggesting a causal relationship between travel attitudes and travel behavior (Fazio 1986; Proussaloglou and Koppelman 1989; Ajzen 1989).

The attitudinal differences between men's and women's travel behavior and preferences are examined in this study. The data came from four household surveys designed for transit market research analysis. Nearly 40 attitudinal questions were asked in each survey as a way to measure respondents' sensitivities to a broad range of travel experiences and their attitudes toward characteristics of the different transportation modes. The ratings of the attitudinal questions were analyzed to examine whether there are significant differences between men and women in terms of travel attitudes. They were also used to segment survey respondents into distinct market groups by using advanced statistical analysis and to test whether there is a significant gender difference among different market segments.

Methodology

Sophisticated market research is at the heart of successful business strategies. Interest has been increasing in the use of market research in transit studies as evidenced by a number of recent studies under the Transit Cooperative Research Program (TCRP) on transit markets of the future, transit ridership initiatives, and integration of market research into transit management. However, transit studies have traditionally relied on geography, socioeconomic characteristics, and travel behavior in seeking to understand the demand for transit among different groups. Categorizing travelers into these groups is valuable for understanding the transit market and is one of the reasons why this study—and others—continue to analyze survey data by demographic and travel behavior dimensions. However, to better understand the reasons why travelers choose different modes for everyday travel, an approach is needed that breaks away from these stereotypes and instead determines the attitudes that drive their mode choice.

A market research approach is introduced here that is based on household surveys for four market research studies, including one in San Diego, two in the San Francisco Bay Area, and one in the Salt Lake City area in Utah. All four household surveys include socioeconomic, travel behavior, and attitudinal questions. Each survey respondent was asked to provide ratings that reflected the level of agreement with each attitudinal statement on a scale of 0 to 10, in which 0 means strong disagreement, 10 means strong agreement, and 5 means neutral. The ratings of all the attitudinal statements were analyzed to examine whether there are significant gender differences. The attitudinal ratings were also used to segment survey respondents into market groups according to shared travel attitudes, to analyze how travelers' specific attitudes drive their preferences for transit services, and to examine gender differences of various market segments.

A market research approach was developed that uses structural equation modeling (SEM) to simultaneously identify the attitudes of travel behaviors and the causal relationships among travelers' socioeconomic profiles, travel attitudes, and travel behavior. The attitudinal-based market analysis was conducted in the following four steps:

Step 1. Use factor analysis to identify traveler attitudes: Factor analysis was used to classify the attitudinal variables so as to reduce their number and detect the structural relationships between these attitudinal variables while retaining the explanatory power of each manifest attitudinal statement.

Step 2. Use SEM to link traveler attitudes to demographic characteristics: Socioeconomic and demographic variables are related to the attitudinal factors by using SEM, which serves purposes similar to those of multiple regression analysis but in a more powerful way. Both manifest and latent variables can easily be brought into SEM models, which are estimated simultaneously rather than sequentially.

Step 3. Use cluster analysis to segment the traveler market: Distinct market segments based on people's attitudes toward travel are identified. The core concept of market segmentation is to view a market as distinct segments rather than one homogeneous group. Those within the same segment share similar attitudes toward travel behavior, whereas those in different segments hold different views.

Step 4. Apply the SEM and market segmentation models to the general population: The survey-based models are applied to the general population in the study areas to estimate the population in different market segments at the geographic level. Thus, not only the attitudinal preference of each market segment is known but also where each market segment is distributed geographically.

The SEM approach is a powerful tool to improve the understanding of travel behavior and to improve transit service. Applications of SEM to travel behavior research date from around 1980, but the method was not widely used in transportation research until the late 1990s, when the application of SEM started to expand (Golob 2001). This approach can significantly increase the ability to answer important questions for better transit planning such as what attitudes and preferences drive each market segment's choice for local travel options and what strategies would be most effective for each market segment.

In all four case studies, the basic market segmentation approach was similar to the process described earlier; in each case, however, the segmentation schemes varied in terms of the dimensions used to segment, and the application that was used to estimate potential transit usage was different.

Case Studies

Gender-based market research results are presented from four case studies of different transit agencies.

San Diego Association of Governments

A two-part study was undertaken in early 2000 for the Metropolitan Transit Development Board in San Diego and in 2003 for the San Diego Association of Governments to analyze transit programs (Proussaloglou et al. 2001). The study used data collected in September 2003 from a random sample of 1,304 households in the San Diego area. Seven attitudinal statements showed a gender difference of over 0.5:

1. Women feel less safe than men do:

–Women do not feel comfortable walking in a parking garage at night, whereas men do (3.97 for women and 6.70 for men).

–Women marginally feel comfortable walking in the Gaslamp Quarters during the night, whereas men feel much more comfortable in doing so (5.51 for women and 7.21 for men).

–Women are more likely to avoid traveling to certain areas in the region because they are unsafe (6.31 for women and 5.10 for men).

–Both men and women feel comfortable walking in downtown San Diego during the day, but the degree of safety sense is much stronger among men (7.39 for women and 8.34 for men).

2. Women are more sensitive to time but more willing to trade time for comfort in traveling.

–When making a trip, women are more likely to be in a hurry than men (5.95 for women and 5.43 for men).

–Women are more willing to change the form of travel if it would save time (5.18 for women and 4.65 for men).

3. Men are more likely to agree with the statement "the type of transportation that people use reflects their social status" (5.13 for women and 5.83 for men).

Three attitudinal factors—sensitivity to personal travel experience, sensitivity to personal safety, and need for flexibility and speed—were used to segment the market, resulting in six distinct segments (ovals, Figure 1). A comparison among these market segments highlights the concentration of female respondents in the segments Cautious Runabouts and Flexible Flyers. The Cautious Runabouts segment consists of exclusively female respondents with an overrepresentation of middle-aged part-time workers and homemakers. The segment is characterized by both its very high need for flexibility and speed and its greater concern about personal safety compared with any other segment. With women accounting for 80% of its members, the Flexible Flyers segment is for travelers who have a high need for flexibility and speed but are not sensitive to their personal travel experiences and have a high sensitivity to personal safety. This segment has high concentrations of female homemakers between 30 and 45 years old.

Intrepid Trekkers and Conventional Cruisers are two segments dominated by men. Intrepid Trekkers is a segment with 100% of males younger than 45. Its members exhibit a relatively high need for flexibility and speed, a medium level of sensitivity to their personal travel experience, and generally no concern with personal safety.

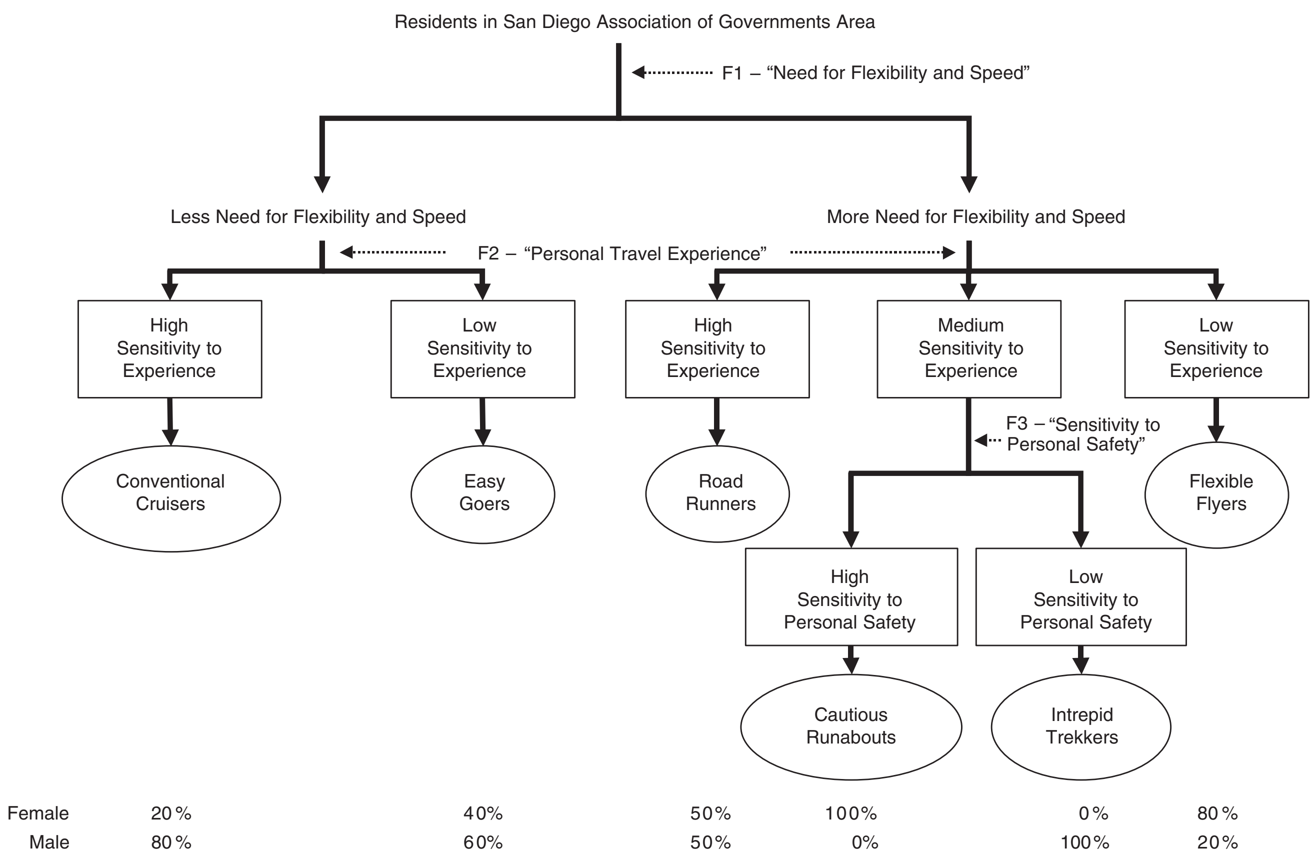

FIGURE 1 Market segmentation for San Diego Association of Governments.

Conventional Cruisers do not show a particular need for flexibility and speed, but they are highly sensitive to their personal travel experience. An analysis of the socioeconomic profile of the Conventional Cruisers segment indicates that it has a lower average age and a much larger percentage of car availability with higher-than-average incomes.

San Mateo County Transit District

This case study aimed to support the long-range transportation plan for the San Mateo County Transit District (SamTrans) (Zhou et al. 2004). Data were collected in fall 2002 on a random sample of 526 in the SamTrans service area. It included 42 attitudinal variables, most of which are similar to the ones in the Water Transit Authority (WTA) survey (discussed later). A comparison of average attitudinal ratings reveals the following key gender differences:

1. Women feel less safe than men:
   – The statement with the highest gender difference is "I avoid traveling through certain areas because they are unsafe" (6.9 for women and 5.3 for men).
   – The statement with the second-highest gender difference is "I would feel safe walking to the bus stop or train station" (6.57 for women and 8.07 for men).
   – Both men and women generally feel safe walking around the destination, but the average rating for women (7.52) is much lower than that of men (8.39).
   – Men and women agree with the statement "I feel safe using public transportation," but again the rating for women (7.19) is lower than that of men (7.88).
   – Neither women nor men worry about getting in an accident when traveling, but men's average rating (3.78) on this statement is lower than that of women (4.39).
2. Women are more sensitive to stress:
   – Women rank much higher on the statement "Having a stress-free trip is more important than reaching the destination quickly" (6.41 for women and 5.72 for men).
   – Women are more likely to avoid traveling at certain times because it is too stressful (6.18 for women and 5.56 for men).
3. Women's schedules are more constrained than men's:
   – Women have a more fixed schedule (6.77) than men do (5.86) as reflected in the statement "I need to make trips according to a fixed schedule."
   – Women tend to use the most convenient form of transportation regardless of cost (7.51 for women and 6.89 for men).
   – Women have the higher need to arrive at a destination by a specific time (8.19 for women and 7.60 for men).

The attitudinal statements were grouped into eight attitudinal factors: privacy and comfort, productive use of time, safety and familiarity, time and flexibility, easy-going and environmentally friendly attitudes, value of time, reliability and control, and fixed schedule constraints. Three of the factors with the highest statistical reliability—value of time, privacy and comfort, and schedule constraints—were used in the market segmentation (Figure 2). Diligent Chargers, Tense Trekkers, Cautious Amblers, and Rigid Flyers are four market segments with a very high concentration of women. Both Diligent Chargers and Rigid Flyers have a high value of time and highly fixed schedules, whereas Tense Trekkers have a low value of time but highly fixed schedules. Shy Cruisers is a segment with a high proportion of male respondents, with flexible schedules, a high value of time, and need for a high level of privacy. The other three market segments (Wary Runabouts, Solo Ramblers, and Outgoing Multitaskers) have a nearly even distribution of the two genders.

Gender was an important variable for the SamTrans model, which was based on 10 different socioeconomic variables, including sex, children per household, number of workers and number of vehicles in the household, employment status, education level, marital status, age, and household income and size. As a note of caution, it is important to avoid assigning an individual to a segment solely on the basis of demographic characteristics. For example, both Diligent Chargers and Rigid Flyers have a large cohort of upper-income, married women with children. Nonetheless, these two segments have key differences across personal safety, time flexibility, and their attitudes toward privacy and comfort. Simply identifying someone as an upper-income married woman does not help in identifying appropriate services—the underlying attitudes and preferences are more important. The strength in predicting segment membership comes from using all 10 socioeconomic characteristics in conjunction with attitudinal preferences.

San Francisco Bay Area WTA

This case study was to assist the San Francisco Bay Area WTA in evaluating expanded ferry service (Outwater et al. 2003) on the basis of data collected in fall 2001 from a random sample of 852 potential ferry riders.

The average ratings of attitudinal statements were calculated and compared for each gender group. There was not much gender difference in the 30 attitudinal statements. However, more differences start to emerge when one looks at gender and age together. Research has con-

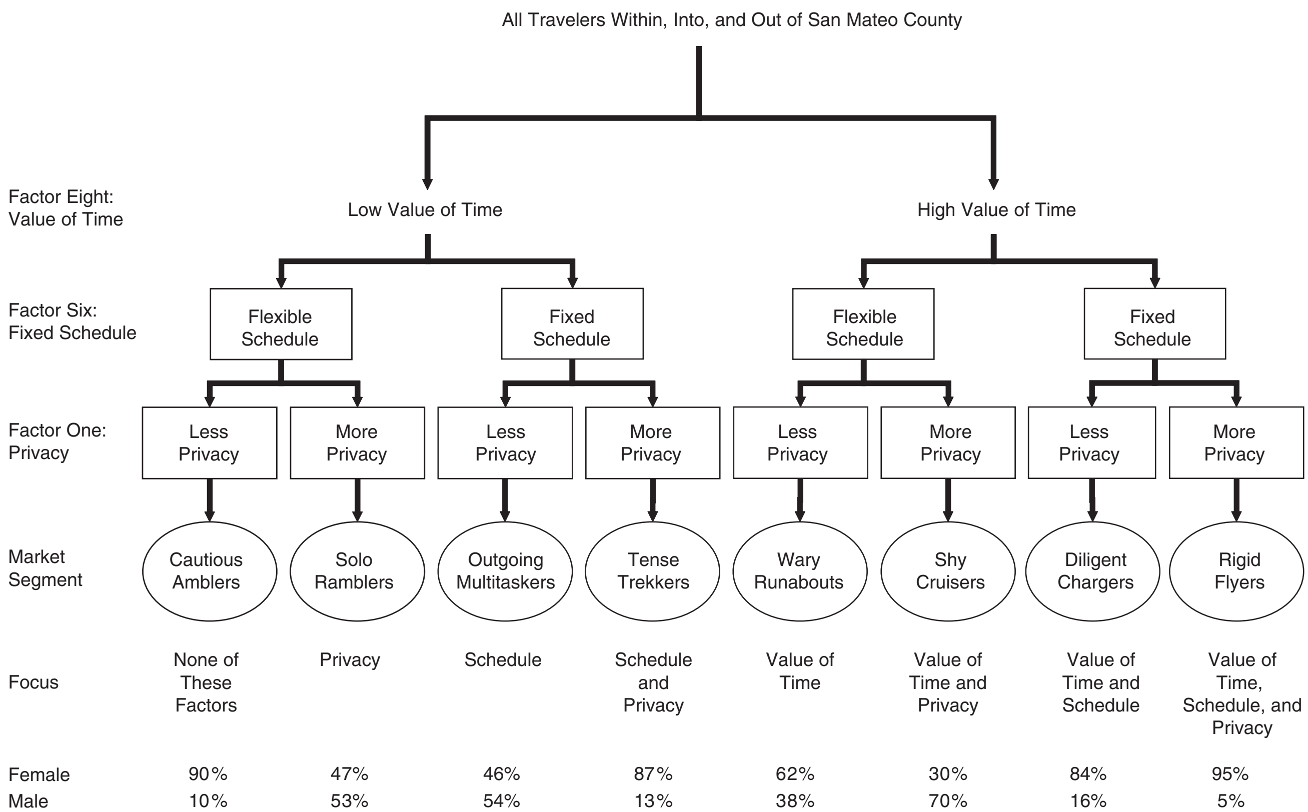

FIGURE 2 Market segmentation for SamTrans.

cluded that although gender differences in travel behavior exist at every age level, they are especially pronounced among older respondents (Spain 1997). The same pattern appears to be applicable in this research. Respondents 65 and older show the highest gender difference in attitudinal ratings, with more than one-third of the attitudinal statements having ratings differences greater than 1.5 and almost all statements with a gender difference of more than 0.5. The other age group that shows significant gender difference is people younger than 18. There is not as much gender difference for all other age groups.

The 30 attitudinal statements were grouped into six attitudinal factors: desire to help the environment, need for time savings, need for flexibility, sensitivity to travel stress, insensitivity to transport cost, and sensitivity to personal travel experience. An SEM model was developed to relate the six attitudinal factors with the 30 attitudinal statements and socioeconomic variables including household size, number of children under 18, household vehicle ownership, number of workers, age information, income level, and education level. Unlike the SamTrans study, gender turned out to be an insignificant variable in the WTA attitudinal models; therefore, it was dropped from the SEM model.

The scores for all attitudinal factors were calculated, and cluster analysis was used to segment all potential ferry riders on the basis of three of the attitudinal factors: desire to help the environment, need for time savings, and sensitivity to stress. Figure 3 shows how each of the three attitudinal factors was used to divide survey respondents into two groups, one with modest sensitivity and one with strong sensitivity to environmental issues, resulting in a stratification of eight market segments. Each market segment is identified with a descriptive name that invokes the primary drivers behind the travelers' attitudes. For example, Joe Six-Pack was the name of the segment whose members show no interest in environmental issues, do not care about time savings, and have a low level of stress in their daily lives. At the bottom of Figure 3 is the gender breakdown of each market segment. It was clear that there are few gender differences by market segment, although there is a slightly higher female population among the Anxious Ambler segment (57% are women) and Reserved Recycler segment (56% are women), both of which show a high level of stress and do not care about time savings. The other six market segments have a nearly even distribution between men and women.

Utah Transit Authority

This study was to help the Utah Transit Authority in identifying the best strategies to increase their transit

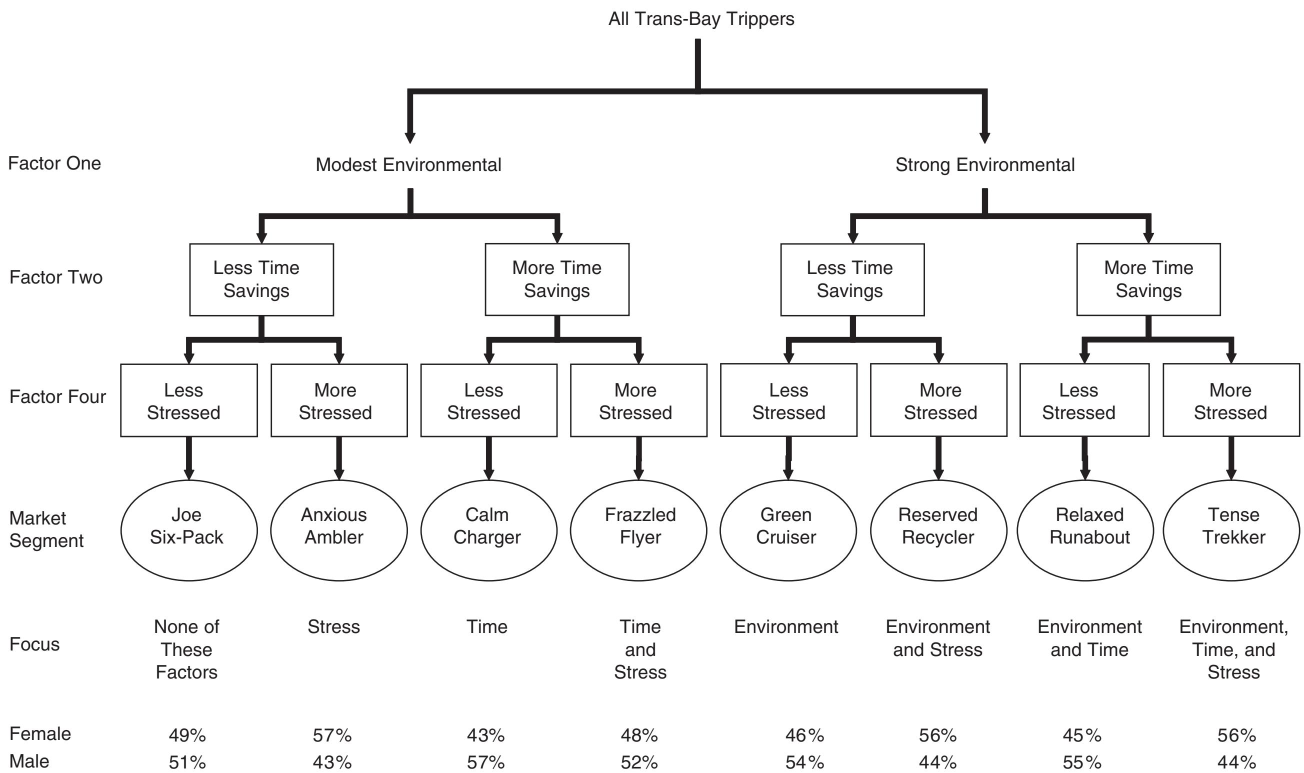

FIGURE 3 Market segmentation for WTA.

ridership on the basis of data collected in 2003 from a random sample of 522 households, including 38 attitudinal questions. Ten of the attitudinal statements have a gender difference of more than 0.5:

1. Women feel less safe than men:
   –Women avoid traveling through certain areas because they are unsafe (5.60 for women and 3.91 for men).
   –Both men and women feel safe walking near home and at destinations, but the degree of safety is much higher among men (6.81 for women and 8.30 for men).
   –Both men and women feel safe using public transportation, but men feel much safer (6.73 for women and 7.91 for men).
   –For the statement "I don't mind traveling with strangers," the women's rating (5.07) is lower than that of the men (6.08).
   –Neither men nor women worry about getting into an accident when they travel, although men (4.54) are much less concerned about it than are women (3.71).
2. Women are likely to avoid traveling at certain times because it is too stressful (5.72 for women and 4.47 for men).
3. Both men and women prefer to be the driver when traveling with others. With an average rating of 6.83, men have a stronger preference than women (5.51).
4. Men are more likely to change their form of travel if it would save time (6.30 for women and 6.95 for men).
5. Women are more likely to take the fastest form of transportation regardless of cost (6.98 for women and 6.40 for men).
6. Having privacy during travel is important, but more important to women than to men (6.58 for women and 5.95 for men).

Three of eight attitudinal factors (sensitivity to time, need for fixed schedule, and willingness to use transit) were used in the market segmentation (Figure 4). Anxious Amblers, Cautious Flyers, and Cautious 9 to 5ers are the three segments with a much higher percentage of women. Anxious Amblers have very low willingness to use transit, flexible schedules, and low sensitivity to travel time. However, this segment also shows high sensitivity to safety and privacy and is the segment most sensitive to stress and comfort. Nearly two-thirds are women, mostly retired at age 65 or older. Cautious Flyers have low desire to improve air quality and lowest willingness to use transit, a high desire for productivity,

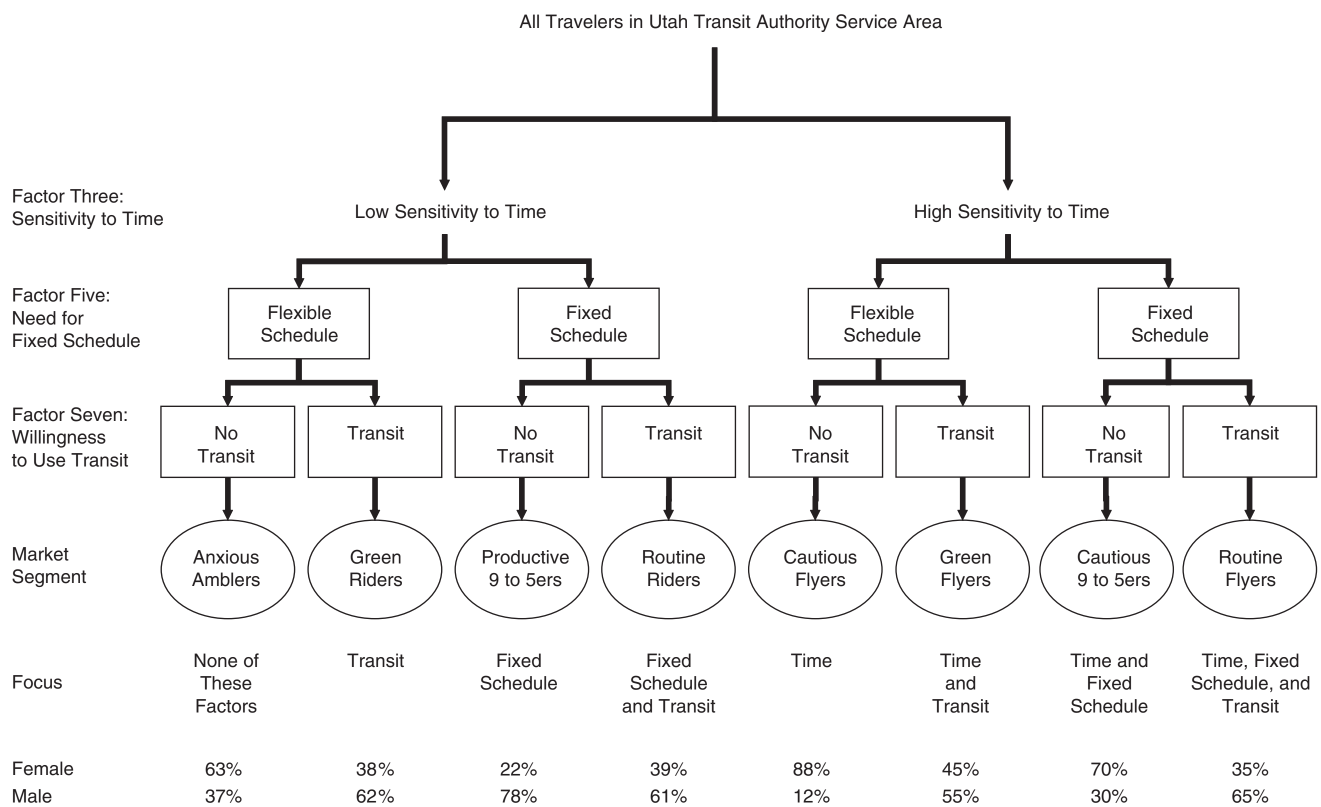

FIGURE 4 Market segmentation for Utah Transit Authority.

high sensitivity to safety and privacy, but low sensitivity to stress and comfort. This segment also has flexible schedules but exhibits a high sensitivity to travel time. The majority of this segment are young married women with children, and most of them belong to one-worker households. Cautious 9 to 5ers is the segment with the lowest desire to help the environment and a low willingness to use transit. It exhibits the highest desire for productivity and reliability, fixed schedules, and a high sensitivity to time. It is the segment most sensitive to safety and privacy but not to stress and comfort. Most of those in this segment are young and middle-aged working women.

Productive 9 to 5ers, Routine Flyers, and Green Riders are the segments with a high concentration of male population. Productive 9 to 5ers is a segment with a low desire to help the environment, low willingness to use transit, low sensitivity to time, fixed schedules, and low sensitivity to stress and comfort but a high desire for productivity and reliability and high sensitivity for safety and privacy. All members of this segment are employed either full time or part time. Routine Flyers have a strong desire to help the environment and a high willingness to use transit. They also have fixed schedules, high desire for productivity and reliability, and the highest sensitivity to time although they are not very sensitive to safety and privacy and exhibit low sensitivity to stress and comfort. Most of those in this segment are young and middle-aged men who are married with children. Green Riders is a segment with high desire to improve air quality and the highest willingness to use transit. They have a low desire for productivity and reliability, low sensitivity to time, and very flexible schedules. This is the market segment that is least sensitive to safety and privacy with a high sensitivity toward stress and comfort.

Conclusion

For many years, the transportation profession has analyzed problems and designed solutions in terms of traveler attributes and levels of service by competing modes. However, these traditional planning practices often fail to uncover the attitudes that drive decision making, much less design services in a way so that these decision-making "hot buttons" are hit. Although demographic characteristics provide a portrait of who is or is not using a particular service, these characteristics are not helpful in understanding the key attitudes and perceptions that lead to mode choice. In this paper, the relationship among these attitudes and perceptions is the key piece of information that was used to define market segments, help define transit agencies' desired market position, and identify the services and strategies that are critical to achieve that position in the marketplace.

This research indicates that market segments often cut across social and economic groupings. Nevertheless, common socioeconomic characteristics may be a convenient and sometimes accurate proxy for a market segment defined by the shared attitudes of its members. Such a generalization, however, poses a strong temptation to oversimplify: not all Road Runners are rich and middle-aged and not all Easy Goers are poor and old. Only the most rigorous market segmentation modeling practices can help to answer important questions such as what the markets are for local travel modes and what attitudes and preferences drive each market segment's choice for local travel options. The answers to these two questions will help to provide insights into a most important question for transit service marketing, that is, what strategies would be most effective for each market segment? Transit agencies can target specific segments for their services or products on the basis of potential riders' attitudes and preferences.

These market research results show that there is a significant gender difference in travel attitudes. Women tend to have higher sensitivity to safety and stronger desire for a stress-free ride. They are more constrained by fixed schedules and more likely to think of transit as a means of helping the environment. However, the relative rank order of ratings provided by women respondents was similar to the relative ratings given by men. This finding suggests that despite the greater intensity shown by women respondents, the same dimensions of service proved to be important to both groups.

The study also shows that gender differences are affected by socioeconomic and demographic status. Age, marital status, education level, employment status, household size, number of children, number of workers, number of vehicles, and annual household income influence travelers' attitudes. Last, it should be noted that people have different attitudes toward different types of transit service. For example, for those who live in the San Francisco Bay Area, attitudes toward ferry services by WTA may be different from attitudes toward bus services provided by SamTrans. The understanding of these differences can help provide insights into important questions for transit service marketing and help to design a mix of strategies that would be most effective for different market segments with a range of attitudinal preferences and different socioeconomic characteristics.

Acknowledgments

The authors thank the following for their support: Dave Shumacher and Jeff Martin of the San Diego Association of Governments; Corinne Goodrich of SamTrans; Steve Castleberry of the San Francisco Bay Area Water Transit Authority; and David Hubert, Steve Swan, Gerry Pachucki, Gary Kitchen, and Paul Bay of the Utah Transit Authority.

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Integration of Gender Equality into Transport Policy and Practice in Sweden

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To evaluate how policy makers have applied gender equality in Swedish transport policy and practice, two studies are compiled. The first briefly summarizes how gender equality has been integrated into transport policy in Sweden from 1997 to 2002. The second addresses the practical integration of gender equality into the transportation sector. Results are presented from a study that focuses on differences between women's and men's experiences with road infrastructure; on preferences regarding different parts of the road system; and on the priority rankings of the different goals in the transportation sector such as accessibility, effectiveness, safety, regional development, and a good environment. Interviews were held with 47 experts, users, professional driving instructors, and inspectors. In general, women have a more cooperative approach to road system infrastructure and the problems therein, and men are more individualistic. However, there are also noteworthy differences among age, socioeconomic group, and residential location. This study is a first step toward gathering knowledge that can be used on a practical level to attain a more gender-equal transportation system in Sweden.

What is a gender-equal transportation system? How can it be obtained? Such questions have come to Swedish transportation departments in response to legislation enacted in 2001 that made gender equality the sixth goal of transport policy. The gender equality goal is worded in the following way: "The transportation system shall be designed so that both women's and men's travel needs are satisfied; women and men shall be given the same possibilities to influence the system's design, formation and administration; and women's and men's values shall receive equal consideration" (Proposition 2001/02:20).[1] Anyone familiar with the intricacies of transport and gender might nod contentedly at such a formulation. Even given the limitations of political rhetoric, this proposal was able to address three important cornerstones for gender mainstreaming and transport, namely, concrete differences between women's and men's travel needs, gendered attitudes and valuations of transportation facilities, and gendered distribution of power and influence within the sector. If gender mainstreaming is defined as "efforts to scrutinize and reinvent processes of policy formation and implementation across all issue areas to address and rectify persistent and emerging disparities between men and women" (True and Mintrom 2001, 28), then the Swedish example should stand out as exemplary. However, can such a formulation rectify differences between women and men in actuality? Given this political triumph, can gender mainstreaming be considered successful with regard to the Swedish transportation sector?

Unfortunately, the questions still remain as to what a gender-equal transportation system actually entails and how it can be attained in practice. The aim of this paper is to present both a policy-oriented and a practical approach to attaining more gender equality in the trans-

[1] All of the translations in this paper are by the author.

port sector. The results of two research projects dealing with the implementation of gender mainstreaming will be presented. The first briefly reviews the process by which gender equality was integrated into transport policy in Sweden from 1997 to 2002 [a more in-depth presentation may be found elsewhere (Polk 2004)]. The second, which forms the main body of the paper, presents condensed results from a descriptive interview study that focuses on differences between women's and men's valuations of road system infrastructure.[2]

Gender Mainstreaming in Swedish Transport Policy

It is important to understand the contours of the gender mainstreaming debate. Gender will be used here to refer to the socially constructed differences between individuals that are specifically linked to or generalized in terms of differences between women and men. However, gender is not just about women and men. It also works through and with other social categories such as socioeconomic group, age, and race. It is a theoretical concept that encompasses many different social factors and processes, from individual behaviors and structural organization to the meanings and symbols manifest in everyday life. A researcher in tourism notes the importance of recognizing that "all processes involved in transport are constructed out of gendered societies: thus gendered ideologies are important components of access to, and the nature, use and impacts of transport" (Hall 2004, 246). Specific examples are found in traditional masculine and feminine stereotypes surrounding the professional roles women and men have in the transportation sector, in how the media portray women and men in their relations to the car, and in whose opinions and expertise underlie decision making and planning. Gender equality, in the same vein, will refer to the alleviation of gender discrimination and its political ramifications such as who is envisioned as the typical user, as the experts, and as competent for making and influencing planning and policy decisions.

As is well known, gender equality has a long and rather successful history in Swedish politics. The first gender equality law, from 1993, demanded that a gender perspective pervade all policy and planning in the public sector. The incorporation of gender into the transportation sector began to take form in 1994, when the Swedish parliament adopted a national directive requiring that all committees and working groups include an analysis of how their proposals affect gender equality (Direktiv 1994:124). Within the transportation sector, this directive was applied as part of the overall process of designing policy for a sustainable transportation system. In this process, one of the expert groups called in 1996 dealt specifically with gender equality. The resulting final background report on transportation policy, *A New Course in Transportation Policy*, has one chapter that addresses gender equality [Swedish Government Official Report (SOU) 1997:350].

In that chapter, gender equality is exemplified with quantifiable differences between women and men. The main topics taken up are travel patterns and women's and men's representation in the sector. Those differences that are cited—women traveling shorter distances by slower modes and being underrepresented in decision making—are explained as being due to traditional social relations such as women taking more responsibility for the household and children. However, what this report does not discuss is that there are also significant differences between the travel patterns of women and men who are fully employed, single, and have no children (Polk 1998). A recurring problem with integrating the wider concept of gender equality into transportation policy from the beginning of this process has been oversimplification. The reports often simply equate "gender equality" with "women" and limit differences between women and men to those that can be quantified. In general, the reasons underlying power relationships within the sector, as well as the symbolic associations of masculinity and femininity with movement, technology, and personal identity, are markedly absent in the early documents dealing with transportation policy in Sweden.

The next step in gender mainstreaming occurred in 1998, when a governmental proposition resulted in the appointment of an advisory council, the Gender Equality Council, to collect information and suggest measures for attaining gender equality within the transportation and information technology (IT) sectors (Proposition 1997/98:56). Its final report, *Gender Equality—Transportation and IT*, was presented in June 2001 (SOU 2001:44). This report presents an in-depth analysis of both the individual and institutional levels within the transportation sector. Here governmental responsibility for gender equality is seen in how socioeconomic modeling, public bidding, and political representation and decision making in all of the various parts of the transportation sector, including those outside the political realm, such as business interests, could best implement or even enforce gender equality (SOU 2001:44). The report defines gender equality in an encompassing fashion. It does not equate "women" with "gender equality" in any of the discussions. However, even given this breadth, the reasons that underlie how and why gender has had and still has such an influence in the transportation sector are lacking. The Gender Equality Council report furthermore gives little or no attention to the symbolic level of analysis, especially to the gendered connotations of what cars, movement, and mobil-

[2] This project was funded by the Swedish Road Administration.

ity mean to women and men and to Swedish society in general. Nor does it emphasize the differences in women's and men's travel patterns and attitudes that could result in a greater proclivity of women to conform to a sustainable transportation system (Polk 2003).

On the whole, the most important contribution of the Gender Equality Council's report is the recommendation that gender equality have a more prominent position in transport policy. This recommendation occurred in October 2001, when gender equality was added as the sixth goal of Swedish transport policy (Proposition 2001/02:20). Following this decision, a number of documents were written, three of which deal with public transportation and with transport problems and solutions in the Stockholm region (SOU 2001:51; SOU 2001:106; SOU 2002:11). Though supposedly under the auspices of the gender equality goal, none of these examples maintain the standards set by the Gender Equality Council. Gender is either decidedly lacking or mentioned in a simplistic fashion. For example, throughout the text when gender is mentioned it is equated with women and gender equality with public transportation. Thus although gender mainstreaming has taken on a prominent role in official Swedish transport policy on one level, it has not been followed by any real integration in subsequent work. However, this legislation has encouraged more attention to what gender equality could entail in practice. The interview study discussed later, for example, was designed and developed in close collaboration with the Swedish Road Administration (SRA) to implement the gender equality goal in its ongoing work.

Gender Mainstreaming in Practice

In order to work with the practical integration of gender mainstreaming within the transportation sector, it is important to ask what a gender-equal transportation system is. The legislation cited by way of introduction gives some guidance. A gender-equal transportation system is envisioned as one in which women and men are equally represented in decision making and planning, women's and men's travel needs are equally satisfied, and women's and men's values are given comparable weight. These criteria appear rather straightforward, yet a number of questions arise: How can the gendered distribution of power and influence in the sector be evaluated? What criteria can be used to judge whether women's and men's travel needs are adequately satisfied? More important, what do gender-equal travel patterns look like? What do "values" mean in this context? And finally, if consensus can be reached regarding what a gender-equal transportation system actually entails, how can it be attained?

Two main theoretically and empirically distinguishable issues are raised in the gender equality goal. The first emphasizes the gendered distribution of power and influence in the public sector. The success of this emphasis, it is reasoned, will ensure that concrete differences between women and men will be thoroughly integrated into all decisions and planning when women and men participate equally. However, even given equal participation, the classic liberal approach to gender equality has faced well-known limitations, such as glass ceilings and other types of limited access to power and influence. All in all, an equal number of women and men increases but does not ensure women's equal participation. For example, all of the governmental committees cited in the previous section had an equal number of women and men, but this fact did not change how superficially gender was dealt with in a majority of the reports. It is therefore essential to separate gender distributions of power from the inequalities that exist between women and men that are a result of their unequal status and position in society. In other words, within transport policy, structural and organizational distributions of power must be analyzed and dealt with separately from differences in individual needs and experiences related to transportation. The second of the two issues raised in the goal formulation addresses this latter point by highlighting the role of concrete differences between women's and men's travel behavior and valuations of the transport sector. This is the starting point for the following interview study, which maps out gender differences in valuations through targeting experiences with road system infrastructure.

Gender Analysis of Swedish Road Infrastructure

The overall goal of this study is to identify concrete differences in women's and men's relations to road system infrastructure that could lead to the formulation of specific proposals to increase gender equality. The research question is, do women and men have the same experience, preferences, and opinions regarding the design of road system infrastructure in Sweden? More specifically, this study deals with women's and men's experiences with road infrastructure, with preferences regarding different parts of the road system, and with their priority ranking of the transport policy goals of accessibility, effectiveness, safety, regional development, and a good environment.

Interview Study

The interview study started with a series of in-depth interviews with employees from SRA in September 2003.

Next, transport users, professional driving instructors, and inspectors were interviewed during fall 2003. A total of 47 interviews were held.[3] The user interviews will form the main body of the following results. Results from the expert and practitioner interviews will be briefly summarized.

Interviews with Experts and Practitioners

SRA is the national authority with overall sector responsibility for road transport in Sweden. It is responsible for designing and applying road regulations as well as for the planning, construction, operation, and maintenance of state roads. Among other things, SRA works with issues such as environmental impact, traffic safety, accessibility, public transportation, commercial traffic, and contributions to regional development. Employees at SRA are perceived as experts in the context of this study.

The expert interviews were initially designed to reach a better understanding of the knowledge base surrounding gender equality that was already in place at the department. Thirteen experts were interviewed at two different times. The expert interviews were held to ascertain the overall position that individuals at SRA held regarding the new gender equality goal. A letter was sent to each interviewee a week before the interview that presented the project and gave a list of questions on gender equality that the respondents were encouraged to consider. Each interview took an hour and was recorded.

The 13 interviewed experts are employed at a unit responsible for the formation of handbooks and guidelines for road planning and construction. The first round of interviews included four women and nine men. The four women worked with natural and cultural aspects, the environment, unprotected users, and security issues in the road design handbooks. The men worked with various parts of the road system such as signs, public transportation, planning, road work, road design, bus stops, handicapped access, causal interactions, and lighting.

The preparatory questions were the following: What do you think about the latest goal for transport policy, namely, gender equality? How do you think gender equality can be integrated into the SRA work? What would a gender-equal transportation system look like? What does gender equality mean for you concretely in relationship to your work? Can you suggest any specific dimensions or aspects in your work that may have relevance for gender equality? This material was analyzed as the basis for the user interviews, which were conducted during fall 2003.[4]

Four interviews were also held with driving instructors and traffic inspectors, including two men and two women from Göteborg and Stockholm, respectively.[5] Such practitioners have extensive experience with individuals' first experiences with road system infrastructure. The questions asked dealt with their opinions regarding gender differences in knowledge, skill, interest, and learning and testing ability surrounding the driving and testing situation.

User Interviews

The user interview was designed to map gendered experiences with road system infrastructure from the perspective of the user. A few points always come up regarding gender and transport. For example, women are seen as being more safety conscious in their role as caretakers, more conscious of threats to their personal safety, more defensive in their driving skills, and more inclined to use public transportation (METRO 2004a; SOU 2001:44). The user interview was designed to test such assumptions as well as to go beyond such stereotypical generalizations by targeting other potential factors such as preferences for different types of roads, experiences while driving, and suggestions for improving road infrastructure.

The selection of individuals for the user interviews was based on demographic and geographic factors. These included age, residential location, socioeconomic group, and sex. Ages varied from 22 to 75. Half of the users were women. A majority of individuals came from the two largest cities, Stockholm and Göteborg. Rural areas and two other smaller towns were included. The interview consisted of a list of questions dealing with three areas. The first included opinions of how specific

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[3] Thirty users, 13 experts, and four practitioners were interviewed.

[4] The results of the user interviews were also summarized and presented to the same unit that was originally interviewed in spring 2004. The experts were asked to critique a preliminary version of a questionnaire that was designed to test the results of the interview study on a more representative sample. This questionnaire survey was sent out to 3,000 residents in April 2004. The results of this survey were completed in December 2004 and presented in a report to SRA in January 2005.

[5] In Sweden, obtaining a driver's license is a rather arduous process. It can cost from $1,000 to $2,000, which is spent for classes and material on theory and practical driving skills. Traffic schools with driving instructors offer this type of education. To obtain a driver's license one must first pass a theoretical test, which takes approximately 45 min and costs around $30. After this a driving test can be taken, which takes approximately one hour and costs around $100. Driving lessons cost around $50 per hour. Traffic inspectors are responsible for the driving test for licensing. They test around 1,000 potential drivers per year.

parts of the road system were designed and functioned such as traffic information, speed barriers, road work, and road maintenance; the second, with positive and negative experiences with driving; and the third, with opinions of political goals in the transportation sector.

Results of Interview Studies

Experts' and Practitioners' Opinions on Gender Differences

The expert and practitioner interviews were designed to function as a point of departure for the ensuing user analysis. Thus specific differences between women and men experts and practitioners and their opinions regarding gender equality were not the primary focus. However, as noted earlier, an equal number of women and men were included whenever discretion allowed, and differences between female and male respondents were noted. Overall, all but one of the female experts thought that gender equality is an important social goal as well as something that should be integrated into their work at SRA. The male experts, however, had a wider variety of opinions regarding the importance and place of gender equality, from very supportive to very negative.

In general, three main orientations arise when gender differences are discussed with experts and practitioners. The first and most common view is that gender differences are either nonexistent or unimportant in the context of the transport sector. This view is held by a majority of the men and two of the women. It is based on the reasoning that even though there are differences between women and men and their travel needs or preferences, such differences lack relevance and therefore have no place in the work at SRA. Such experts and practitioners believe that it is more important that all users be ensured equal accessibility regardless of sex and that this aspect is already covered in ensuring that the transport system be accessible to all. The five goals of transport policy (accessibility, effectiveness, safety, regional development, and the environment) are claimed to be much more essential than gender equality. Given limited resources, gender differences are seen to be trivial in relation to, for example, road-related deaths and global warming. Even though all of the interviewed experts and practitioners support gender equality wholeheartedly in a wider social context, a majority of the men and two of the women doubt its relevance and importance for the transport sector and for their work in particular. The gender equality goal is even seen as a waste of time by some of these experts.

The second orientation supports the position that gender equality is an important and relevant issue for the transport sector. This position is based on gender differences in travel patterns, experiences, and representation in the sector and suggests that gender differences could be used to improve the transportation system given that women are less involved in serious accidents, use the car to a lesser extent, and are more environmentally and safety conscious. Many examples were brought up regarding differences between the representation of women and men in different positions of power at SRA and in the sex segregation of work responsibilities. For example, it was noted that women are more often relegated to the "soft" areas of responsibility such as unprotected users and the needs of the physically disabled. This position of strong support for the relevance of gender equality is held by a minority of the interviewed men and by a majority of the interviewed women.

The third and most commonly held position by a majority of the interviewed men is somewhere between the two foregoing extremes. It can be summed up as a debate regarding whether there are significant differences between women's and men's relations to road infrastructure, what these differences consist of in practicality, and if they have any relevance to the work that is done at SRA.

Regarding the interviewed practitioners, none of the driving instructors or inspectors think that there are pronounced differences between women and men regarding their driving skills. There is a tendency for women to be easier to deal with as students and as test takers since men, more often than women, tend to overestimate their driving ability. On the whole, the interviewed practitioners believe that differences between women and men are in the process of change. All believe that women and men are equally competent drivers. However, it is noted that there are differences in women's and men's self-confidence while driving. In general, women are experienced as more defensive and insecure regarding their driving ability and men as less defensive and more confident.

User Interviews

The user interviews are presented in three parts: experiences with road system infrastructure, preferences surrounding how the road system functions, and opinions regarding the transportation system in general and the transport political goals.

Experiences with Road System Infrastructure

The section dealing with experiences with road system infrastructure includes questions on traffic signs (both regulatory and informative), pavement markings, physical safety measures, and speed limits. One of the main question groups dealt with safety measures, in which three topics were considered: passing lanes, traffic calming, and speed control. Roads with alternating passing lanes (referred to here as 2+1 roads) are a relatively new occurrence in Sweden.[6] They have received a great deal of monetary backing since they have shown great efficiency in reducing accidents and deaths. Although public support is also great, a number of worries are voiced in the interviews. For example, a number of women and men worry about having car trouble on such roads or an accident while in the single lane. Since there are both a wire fence dividing each lane from oncoming traffic and a side fence and no shoulder to speak of, there is no place to pull off the road in case of car trouble. One respondent, a 53-year-old man from Stockholm, sums up such views:

> I think they are really good [the passing lanes]. The only thing I wonder about is what happens if you have car trouble, especially if you have a wider car, in one of those single lanes. In some places there's barely enough room for one car, and especially when it's dark—there's no shoulder to pull off on. I think that this is a rather worrying thought. But otherwise, it's a very good system.

Regarding traffic calming, about half of the respondents, including both women and men, are positive about the use of curb extensions and speed bumps, especially around schools and crosswalks. One problem that is noted by both women and men is that they are not marked clearly enough or are used indiscriminately. The same respondent cited earlier said: "They put them in without any warning. I crashed into one by where I live. Pretty fun! I drove right into that damn cement block."

A number of women note the environmental problems that are connected with traffic calming measures due to driving patterns (braking and speeding up) and idling due to congestion. Men comment that the measures are unpredictable, need better warnings, and hinder traffic flow. None of the men note the environmental problems with such measures. In general, women point out the environmental impact and health problems (for commercial drivers, from jarring and shifting of lanes) that can be caused by speed bumps and curb extensions.

Regarding speed limits, women's and men's experiences seem to be more due to driving experience than to gender, though women support lower speed limits more than men do. For example, women are more positive about lower speed limits near schools and in residential areas. No men suggest lowering speed limits in towns. However, one young man, as well as a few young women, thinks that the base speed limit of 70 km/h on rural roads is sometimes too high. In contrast, a few women support higher speeds on motorways. Some younger men are also conscious of the safety and environmental impacts related to higher speeds.

Preferences Surrounding How Road System Functions

Another way of gaining insight into women's and men's outlook on road system infrastructure is to ask about how roads work for them. This insight includes preferences regarding factors that induce stress while driving and preferences for different types of roads. The respondents were asked to describe what situations made them stressed or irritated while driving. Most of the answers have to do with other drivers and not with the road system itself or with traffic rules. Most of the respondents are stressed or irritated by slow drivers, tailgaters, and reckless persons or those who do not follow traffic rules. The most striking difference between women and men is that relatively few women say that they get mad or irritated. An older woman (62), from a small town, replies to this query in the following way:

> No, not really ever, because I'm patient. I do think it's unnecessary for people to drive too fast, if they drive 150 km or so. I don't think that's very good or unnecessary passing and such. However, if someone drives too slowly, that doesn't bother me. Because it can be someone who doesn't see very well, you never know what the problem is so there's nothing to get mad about.

Overall, women formulate stress in terms of safety or danger. Women express fear when they describe unpleasant situations, such as being confronted with reckless driving. Men, however, express stress and irritation when they are hindered while driving. However, one noteworthy exception is a 45-year-old woman from Stockholm:

> People who drive slowly make me stressed. But it can't be helped. I'm not so bothered by people who drive too fast, and a little recklessly, that's less irritating. (Is there a specific group that drives slower?) Yes, women. (A certain age?) No, I don't think so. I think it's because women don't drive as much as men. It's often women who drive slowly.

In general, a majority of the women do not think there are differences between women's and men's driving abilities. The differences mentioned deal with differ-

[6] The term 2+1 roads refers to a two-lane road that has a passing lane on either side every 5 km. Such roads in Sweden are divided by a wire fence as well as bounded by a wire fence on each side.

ences in behavior and attitudes toward driving. For example, a 26-year old woman from Göteborg says:

> They [men] have a greater need to drive fast and there should be good roads that you can drive fast on, 'cause that's what they do. We [women] are rather satisfied and better able to adapt, I think. That's what it feels like in any case.

Regarding road choice, many different motives were mentioned. Most often they were time or distance related. The main difference between women and men was that women give more of a variety of motives regarding their road choice. Men are more inclined to state that time was the main motive. In general, men are more inclined to choose freeways for safety and time considerations. Women choose a variety of roads for reasons related to traffic flow, diversity, safety, and general pleasantness.

Opinions Regarding Transportation System in General and Transport Political Goals

As was noted by way of introduction, an important part of gender equality is the equal participation of women and men in the transport sector. Today women have less influence than men. An important question is therefore whether women would support the same measures to improve transportation as men, with regard to both long-term planning and more immediate solutions to different types of problems. The results from the interview study imply that this support may well be actual. The largest difference between women and men is that women more often suggest proposals that would improve travel for other users, such as children, the elderly, and the handicapped, as this 40-year-old woman from Stockholm states:

> I would like to divide pedestrians into two categories, adults and children, because they react so differently. Children aren't visible and they think differently . . . so, for planning they should have a special category for children. I wonder if anyone thinks this way, because I think that children always come last. If their needs came first, things would look very different.

The only men who suggest proposals that favor pedestrians or bicyclists are 30 or younger and live in the countryside or are older and have many years of experience as bus drivers or traffic inspectors. Overall, more than half of the proposals that men suggest would improve roads for cars only. In other words, the middle-aged men who were interviewed propose measures that favor their individual needs.

During the final phase of the interview the five transport policy goals were presented to the respondents: accessibility, effectiveness, safety, regional development, and a good environment. The respondents were asked to pick one or two that they believed were most important. The most striking difference between women's and men's answers is that women gave priority to the environmental goal; in second place came safety and access, most often in combination with a good environment. Only a fourth of the men gave priority to the environment and a little under half chose safety. No men between the ages of 30 and 65 gave priority to the environment. In other words, only younger and older men were concerned with the environmental goal. There is no such demographic tendency among women. Older and younger as well as richer and poorer were equally inclined to support the environmental goal.

Conclusions and Discussion

In the user interviews, two main reservations need to be noted. The first is the difficulty in unraveling gender from other background factors, and the second is the size of the sample. With such a small sample, 30 individuals, it is difficult to come to any robust conclusions regarding what is more typical for all women or for all men since there were also striking differences in terms of age, socioeconomic position, and residential location. For example, age seems to have a greater impact on men's answers. Older and younger men are more environmentally concerned than those who are middle aged. There are no such trends with the women. For example, two of the women, both from a higher socioeconomic group in Stockholm, stand out as having answers that resemble men's more than women's. Again, without a larger sample it is impossible to unravel the influence of sex from that of residential location and socioeconomic position. Rural and urban residence also clearly affect perceptions of problems with the road system and thereby what solutions are cited as most needed. Most interestingly, these demographic and geographic factors affect women less than men, thus complicating and concealing but by no means decreasing the influence of gender.

In addition to demographic and geographic factors, two polarized dimensions play an important role in orienting attitudes toward road system infrastructure. The first deals with how individuals relate to social problems—if they see them solely from their own perspective or if they also voice concern regarding how other individuals deal with similar situations. The influence of this factor is usually referred to as beliefs or value orientation from within the social psychological tradition in studying car use (Garvill 1990; Gärling et al. 1998; Jakobsson 2004; Nordlund 2002). In general individuals who are more aware of the needs of others, as opposed to their own needs, will be more inclined to have values that are more inclusive and altruistic, including proenvironmental attitudes. It has been suggested that women are socialized into being cooperative, nurturing, and aware of the needs of others in their gender roles to a greater extent than men (Beutel and Marini 1995).

The second dimension deals with how aware individuals are of the complexity of traffic-related problems. The awareness of risks, seriousness of environmental degradation, and propensity for understanding and following traffic rules vary according to experience and expertise in the sector. Among the respondents, the men who have experience as professional drivers have opinions and concerns that resemble women's more than men's. Overall, women show a tendency to be more collectively oriented and to have less experience in traffic situations. Both of these dimensions amplify women's orientation as being more socially responsible and cooperative.

In the interview results, three specific areas within road system infrastructure were identified as having a gender dimension: security and safety, experience with driving, and transport policy goals. The area dealing with security and safety shows conclusive gender differences. In the interviews, women had a much more developed consciousness regarding both their personal security and overall traffic safety. The results suggest that women experience safety as more important than men, especially with regard to unprotected users such as pedestrians and cyclists and the elderly. Women also express a greater need than men to follow traffic rules, such as speed limits, because they are safer. A difference between women and men drivers in Sweden and their safety and attitudes while driving has been noted since the 1980s (METRO 2004b; SRA 2002; Spolander 1983). In general, women drivers underestimate their driving skills, whereas men overestimate theirs (Spolander 1992). Women are also involved in fewer and less serious accidents than men (METRO 2004b). However, there is recent empirical evidence that suggests that women's driving patterns are starting to resemble men's in that women are taking more risks and are increasingly involved in traffic-related accidents (Forward et al. 1998).

The second area deals with experiences with driving. Women and men seem to have different experiences with stress and irritation in the traffic situation, which can affect their preferences for different types of roads as well as their support for proposals to improve road infrastructure. Women are more inclined to experience more stress in relation to bad lighting, drivers who speed, and icy roads. Men, however, show more irritation with hindrances such as stoplights and slow speed limits. Such differences in orientation could well play out in giving priority to different types of roads that are more geared to emphasizing safety for a majority of users as opposed to time saving and speed.

The third area is transport policy goals. In this area, as in others, women are more inclined to note other traffic users' needs as well as to emphasize political goals and proposals that satisfy a variety of users. For example, women have more positive attitudes toward safety measures that are inconvenient for them but lead to positive results for more users. Women also have a greater tendency to note the conflicts between the different policy goals, such as safety and the environment. In general, women have a more collective or cooperative orientation to road system infrastructure and men a more individualistic one.

The results of these two studies show the relevance of including gender as an analytical tool in research conducted in the transport sector in Sweden, but this action is by no means enough. The success of integrating gender equality as a political strategy is dependent on both the conceptual and the practical role of gender within the sector. This integration includes both the equal representation of women and men in decision making and planning and the incorporation of women's travel needs and opinions into the work that is carried out within the sector. Within policy, the use of gender should better acknowledge, understand, and integrate the depth and breadth of gender theory and analysis in order to adequately subsume the complexity of women's and men's relations to transportation.

Within practice, more research is needed to better understand whether and how decisions made in the sector mirror both women's and men's opinions and travel needs. This research includes women's and men's valuations of different parts of the transportation system, their attitudes toward solving transport-related problems, and their travel patterns. As the results indicate here, there are some potentially profound differences in how women and men experience road system infrastructure that could change road system planning and design. Furthermore, some groups of men (such as older, younger, and those with professional knowledge) have experience with road system infrastructure that resembles that of women. Any changes toward a more gender-equal transportation system would therefore satisfy not only women's needs and experiences but also those of the men who share such needs and experiences. It is hoped that the results presented here are a first step in mapping valuations of road infrastructure that can lead to attaining a transportation system that better satisfies the needs and experiences of a variety of users, women and men, young and old, and experienced and inexperienced.

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Gender Equality as a Subsidiary Objective of Swedish Transport Policy

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A description is given of how the Swedish government decided in 2001 to add a sixth subsidiary transport policy objective on gender equality in the transport system and developments since then. The most important steps toward gender equality in the transport system were taken in 1998, when the government proposed that a new advisory council, the Gender Equality Council for Transport and Information Technology, be appointed; in 2001, when the government decided to add the gender equality objective; and in 2002, when the Swedish Institute for Transport and Communications Analysis (SIKA) was instructed by the government to produce proposals for intermediate objectives within the transport policy objective of gender equality in the transport system. The government's next step will most likely be to give SIKA a new commission to work out intermediate objectives for gender equality to attain a transport system that is designed to meet the needs of both men and women.

A description is given of how the Swedish government decided in 2001 to add a sixth subsidiary transport policy objective on gender equality in the transport system and developments since then.

Transport Policy Objectives and Subsidiary Objectives in Sweden

Swedish transport policy is guided by an overall objective and six subsidiary objectives for different areas. The subsidiary objectives refer to more precise goals specifying the objectives for different parts of the transport policy. The subsidiary objectives are meant to help attain the overall objective. In the hierarchy of objectives there are also intermediate objectives to help attain the subsidiary objectives. These objectives were set out by the Swedish parliament, Riksdagen, during the period 1998–2001.

The overall objective for transport policy is to ensure socially and economically efficient and long-term sustainable transport resources for the public and industry throughout Sweden. The subsidiary objectives as follows:

- Accessible transport system: The transport system should be designed so that the basic transport needs of the public and industry will be satisfied.
- Positive regional development: The transport system should promote positive regional development both by equalizing differences in opportunities for development in various parts of Sweden and by counteracting disadvantages of long transport distances.
- Gender equality: The transport system should be designed so that it meets both men's and women's transport requirements. Women and men should have the same opportunities to influence the construction, design, and management of the transport system, and their values should be given equal weight.
- High transport quality: The design and operation of the transport system should allow high transport quality for the public and industry.
- Safe traffic: The long-term objective for traffic safety is that no one be killed or seriously injured as a

result of a traffic accident. The design and operation of the transport system must be adapted to the demands following from this objective.

- Good environment: The design and operation of the transport system should be adapted to the requirement of a good living environment for everyone, in which nature and the environment are protected from damage. The effective management of land, water, energy, and other natural resources must be promoted.

The long-term objectives are to remain in effect for an extended period of time. They are to stand for continuity and a long-term perspective in transport policy. There is no internal order of priority between the long-term objectives. Ultimately, all subsidiary objectives are to be achieved.

In the short term, it will sometimes be necessary to rank the subsidiary objectives by priority. This ranking should primarily be accomplished by means of intermediate objectives that are realistic, taking into consideration available resources, technical possibilities, and international commitments, and they are to be coordinated.

Organization of Swedish Transport Sector

The Swedish government has relatively small ministries compared with those in many other European countries. Instead of large ministries, there are many Swedish expert agencies that provide the government with material for decision making. One such expert agency is the Swedish Institute for Transport and Communications Analysis (SIKA), responsible to the Ministry of Industry, Employment and Communications. SIKA analyzes and presents data and establishes a basis for planning in the transport and communications sector. The institute provides the actors in the sector with statistics, descriptions of the present situation, forecasts, and descriptions of consequences. SIKA has an annual commission from the government to evaluate how transport policy objectives are attained and is also engaged in developing the objectives and how they can be quantified and measured.

Sweden also has four transport agencies (Figure 1): the National Rail Administration (*Banverket*), the National Road Administration (*Vägverket*), the Swedish Maritime Administration (*Sjöfartsverket*), and the Civil Aviation Administration (*Luftfartsverket*), which are responsible for each mode of transport. The agencies in Sweden are governed by a governmental brief (*instruktioner*) and annual governmental guidelines included in the agency's budget document (*regleringsbrev*). The governmental brief regulates the agency's purpose and includes the agency's main tasks in a long-term perspective. The governmental brief is usually not changed very often.

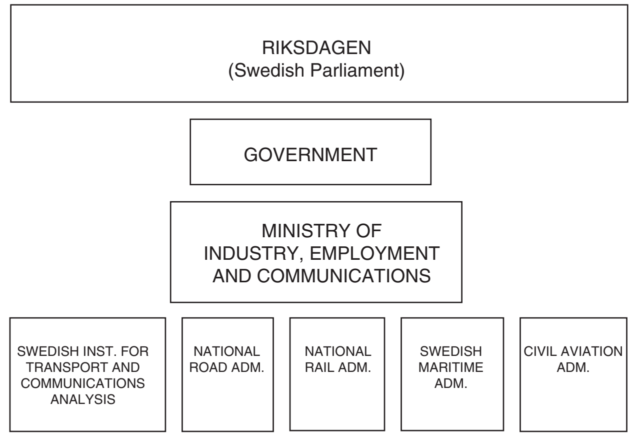

FIGURE 1 Organization of Swedish transport sector.

In December every year the agencies receive the annual budget document, including the governmental guidelines, for the coming year. The governmental guidelines consist of the main tasks in the short term and sometimes special commissions for the agency to carry out.

History of Integration of Gender Equality into Transport Policy in Sweden

The fact that the Swedish government has relatively small ministries also affects the work assigned to parliamentary committees. In Sweden, the preparation of a new government bill usually starts by the appointment of a committee to work with the question and to make recommendations in a report, whereas in other European countries, the work mainly takes place inside the ministry.

In 1988 the government set objectives for the representation of men and women in parliamentary committees, executive boards, and steering committees. In 1995 the proportion of women in parliamentary committees was 38%, which increased to 42% in 1998. In 2001 the representation of women was 41%.

In 1994 the Swedish parliament adopted a national directive requiring that all committees and working groups include an analysis of how their proposals affect gender equality (Direktiv 1994:124[1]). The aim of this directive was to require the active mainstreaming of gender equality in all sectors of Swedish society. This 1994 directive can be seen as the first step in the process to incorporate a gender perspective into the transport sector.

[1] Translated by Polk (2004a).

New Course in Transport Policy

The first parliamentary committee within the transport sector after the 1994 directive was the Committee for Communications (*Kommunikationskommittén*). Its mission was to present a national long-term plan for new infrastructure and communications in Sweden, and the committee's final report on transport policy, *Transport Policy for Sustainable Development* [Swedish Government Official Report (SOU) 1997:35], was the main input to the government bill (Government Bill 1997/98:56).

In this process, one of the expert groups called in dealt specifically with gender equality, and the final report includes some proposals concerning gender equality. The report states:

> The whole of transport policy is thus to be permeated by equal opportunities. All proposals and decisions are to be preceded by analyses of their consequences for men and women. A more equal distribution of power is needed in planning and decision-making. . . . The sexes are very unevenly balanced in present-day infrastructure and transport planning. (SOU 1997:35, 64)

Transport Policy for Sustainable Development

In 1998 the Swedish parliament adopted a transport policy decision based on Government Bill 1997/98:56, which replaced the previous transport policy decision from 1988. The underlying concept is that transport policy is a means of achieving important goals in society. It should contribute to socially, culturally, economically, and ecologically sustainable development. Together with the overall objective there were five subsidiary objectives: accessible transport system, positive regional development, high transport quality, safe traffic, and good environment.

In Government Bill 1997/98:56, appointment of a new advisory council is proposed, the Gender Equality Council for Transport and IT (Information Technology) (*Jämit–Jämställdhetsrådet för transporter och IT*) (Government Bill 1997/98:56, 71). The council was to investigate the connections between gender equality and the communications sector. The topics noted as important for the transport sector were physical planning, traffic planning, strategies for the environment, safety, and use of transport technologies as well as competence and recruiting within the sector.

Gender Equality: Transport and IT

In the committee directive the council was asked to elucidate problems and propose measures to strengthen gender equality within the transport and IT sectors. This mission included collecting knowledge dealing with gender equality and the areas in focus; stimulating the development of methods for gender analysis; discussing gender equality with regard to security, decision making, and planning; and analyzing the decision-making and planning processes within the state, municipalities, and the private sector (Direktiv 1999:83, 4).

The final report is the most thorough example of integration of gender equality into the transport sector in Sweden; the report presents and analyzes a lot of relevant facts about the gender equality situation in the transport sector. The council also delivers a list of proposals to the government. The most important proposal was, of course, the new transport policy objective: gender equality in the transport system. Other proposals concerned methods for analyses and presentation of gender equality in the transport sector.

In the referral process a majority of the referral bodies were positive toward a new transport policy objective concerning gender equality in the transport system, although several of the referral bodies preferred that gender equality be analyzed within the other subsidiary objectives and that the overall objective include gender equality instead of there being a new subsidiary objective.

Infrastructure for a Long-Term Sustainable Transport System

In December 2001, the Swedish parliament established the sixth subsidiary objective for achieving the transport policy objective of ensuring an economically efficient, sustainable transport system for citizens and businesses throughout the country.

The sixth subsidiary objective was formulated as follows: The transport system should be designed so that it meets the conditions and travel needs of both women and men. Women and men are to have the same opportunities to influence the initiation, design, and administration of the transport system and their values are to be given the same weight.

Results So Far

As mentioned earlier, the subsidiary objective on gender equality was established in December 2001. This part of the paper will deal with the governmental directives to the transport agencies and SIKA and other activities by the transport agencies, SIKA, or other organizations.

Government's Annual Guidelines and Commissions to Agencies

As mentioned earlier, the government agencies in Sweden are governed by a governmental brief (*instruktioner*) and annual governmental guidelines given in the agency's budget document (*regleringsbrev*). In December every year the agencies receive the annual budget document, including the governmental guidelines, for the coming year.

For most of the transport agencies, the annual budget document for 2002 did not include any special commissions concerning the new objective of gender equality in the transport system. In the annual budget document for SIKA there were two separate commissions concerning gender equality: to produce proposals for intermediate objectives within the transport policy objective of gender equality in the transport system and to clarify how effects of infrastructure measures can be analyzed and presented regarding men, women, and children.

Intermediate Objectives for Gender Equality in the Transport System

In 2002 SIKA was instructed by the government to produce proposals for intermediate objectives within the transport policy objective of gender equality in the transport system. SIKA submitted the report in October 2002 (SIKA Rapport 2002:5).

There are different aspects of the subsidiary objective of gender equality in the transport system. In the report various principles for approaches to gender equality are discussed. SIKA's discussion is quoted below:

> It is possible to conceive of the subsidiary objective as meaning that *the transport system should be adapted to make women's and men's present travel easier.* However, this approach is not self-evident, since it could be argued that we are in this way confirming an unequal social behaviour, expressed, for instance, by men using a car to travel to work, and women being responsible for journeys related to care and purchasing. It is possible that an adaptation of the transport system to today's transport could favour women as a group in the short perspective. However, in the long-term, there is a risk that this adaptation will disadvantage women and perhaps also counteract the general efforts for gender equality in society.
>
> Neither is an approach wholly self-evident that entails that *present social behaviour is to be changed by measures in the transport system*, among other reasons because this involves a focus on the symptoms of inequality rather than the basic causes of these deficiencies. Changes in the transport system cannot be an effective way of reducing gender equality problems in society. In our view, the transport system must substantially be developed in step with society as a whole. However, we do not see any difficulties in principle or in-built contradictions with an approach that entails that *planning and decision-making structures are changed so as to give equal weight to women's and men's values*. This involves several types of measures: More and more women at every level and function in the transport sector where they are underrepresented; Identifying informal structures of this kind, which are interwoven in the design and administration of the transport system and that can be assumed to work against a more equal transport system; Developing rules and approaches that ensure that consideration is always given to gender equality aspects in the planning, decision-making and administration of the transport system. (SIKA Rapport 2002:5, 5–6)

The report also presents some background facts on women's and men's patterns of travel and activity, values, and the transport sector as a workplace. In the report SIKA also has some recommendations to the government to strengthen gender equality in the transport system, even though the recommendations on intermediate objectives mainly have the character of process targets. SIKA also made proposals for future work to establish more detailed intermediate objectives.

The SIKA recommendations are as follows:

- Planning instructions should be developed for a more secure transport system;
- Targets should be set for the proportion of women in different functions in transport agencies and central agencies in the sphere of transport;
- Major measures that are planned and implemented in the transport system are to be analyzed from a gender-equality perspective, showing the effects on women and men;
- A systematic review should be made of the documentation, working methods, and procedures applied throughout the transport sector;
- More research should be initiated on typical female and male perspectives and evaluation of transport-related issues;
- More female researchers should be encouraged to work within the field of transport research; and
- Transport agencies and other authorities should carry out information and training programs to clarify gender-equality issues.

Effect of Report on Intermediate Objectives

The SIKA report had quite an impact on the Swedish transport sector. It was the first report on gender equality in the transport sector after the objective was established, and the results were presented and discussed in several seminars during fall 2002. The report also resulted in special commissions in the 2003 budget guidelines for transport agencies. A third sentence (shown in italics) was added to the objective when it was formulated to authority-specific objectives:

> The transport system shall be designed so that it meets both men's and women's transport requirements. Women and men shall have the same opportunities to influence the construction, design and management of the transport system, and their values shall be given equal weight. *The objective is an even distribution of power and influence between men and women within every mode of transport.*

One commission to the transport agencies was to present the proportion of men and women taking part in working groups and other collaboration groups within or organized by the authority. Another commission was for the transport agencies to analyze men's and women's usage and impact on the development and management of the transport system. The analysis should concern travel patterns, travel times, choice of travel mode, travel costs, access to information, and number of killed and seriously injured in the transport sector. The results of the commissions are to be reported in the annual follow-up report of the Swedish transport policy objectives.

Effects of Infrastructure Measures for Different Groups of People

In 2002 SIKA was instructed by the government to clarify how effects of infrastructure measures can be analyzed and presented regarding men, women, and children. The SIKA report to the government was made in March 2003 (SIKA Rapport 2003:5). This commission was also a result from the Gender Equality Council's final report.

The main issue in the SIKA report dealt with an evaluation of the national transport analysis model system that SIKA and the transport agencies use in long-term infrastructure planning and whether the model system was able to present the effects of infrastructure measures for men and women, different age groups, and different income groups.

The results were that the model system evens out the differences between age groups and between men and women when it is used for forecasting, which makes the analysis less distinct. The model system is not developed to present the effects according to different income groups, which is a problem since the value variances between income groups were stated as the most important factor in the analysis of different groups. An explanation for this shortcoming is that the differences in values are not captured in the model system. When it comes to the overall, average results, the model system presents reasonable results.

Development of the model system to ensure that the results for different groups are better presented is costly and would take several years. The work would also be a pioneer work since there is no such model system anywhere else in the world (SIKA Rapport 2003:5, 4).

Follow-Up on Swedish Transport Policy Objectives

2003

The development of the objective of gender equality in the transport system was reported for the first time in the annual follow-up report to the government in May 2003, concerning 2002. The main concern in the report is the lack of data when it comes to the objective of gender equality. The report states that too little knowledge is available to be able to say anything about the development of gender equality in the previous year. There is a need to acquire more knowledge about what is meant by a transport system with equal opportunities, and there is a need to improve the methods of measuring progress.

The report presents the activities by the transport agencies, the current situation in the executive boards and other steering committees according to the number of men and women, and how the travel patterns differ for men and women today.

Activities during 2002 included the following:

- The National Road Administration (*Vägverket*) initiated applied research on how a gender equality perspective affects the road transport system. A strategy was proposed to increase the security aspects concerning sexual violence in the road transport system. The agency's policy and knowledge documents were also investigated from a gender equality perspective.
- The National Rail Administration (*Banverket*) produced a preliminary study on how to integrate the objective of gender equality into the rail administration and the Civil Aviation Administration (*Luftfartsverket*) studied the proportion of men and women in organizations and companies within the aviation sector.
- The Network for Women in Transport Policy (*Nätverket för Kvinnor i transportpolitiken*) was established in 2002 to make a contribution to attainment of the gender equality objective.[2] The network organizes

[2] This network consists of about 100 members, both men and women, working in all parts of the transport sector and in the whole of Sweden. The network is financed by grants from the National Rail Administration and the National Road Administration and through member fees.

meetings to which decision makers are invited and interviewed about their work toward gender equality in the transport system and at which the members can meet and discuss issues concerning the gender equality objective.

2004

In the SIKA 2004 follow-up report on transport policy objectives to the government, it is stated that the government has strengthened the requirements for transport agencies to analyze and present the situation concerning men and women in the transport sector (SIKA Rapport 2004:3). There are more commissions in the different budget proposals, the *regleringsbrev*, to the transport agencies, and the commissions require more thorough analysis. There is still a lack of information, which means that the transport agencies are not able to respond to the requirements yet. Two publications about how to analyze and present statistics from a gender-equality perspective were published during the year, and although men dominate in boards, higher posts, and working groups throughout the entire transport sector, the number of women working as head of office or as part of the executive board in transport agencies is slowly increasing.

The transport agencies analyzed data on travel patterns within the different parts of the transport sector, and understanding of the differences between men's and women's travel behavior is increasing, at least in an overall perspective. The transport agencies are also carrying out different kinds of surveys to present the share of men and women on executive boards and in other decision-making groups.

The National Road Administration is the transport agency with the largest budget for research and development in the transport sector, and in 2003 the agency financed a study on how women's experiences and values in public transport can be linked to transport system planning and evaluation. Another study financed by the National Road Administration deals with the differences in attitudes between men and women when it comes to the design of the road transport system (Polk 2004b). The National Road Administration also published a report on how to involve more women in the road transport system planning process.

The conclusion in the follow-up report is that although more effort is spent in surveys and research concerning gender equality in the transport system, the situation in 2004 is still that women's perspectives and values are not represented when it comes to planning, decision making, and management of the transport system.

What Will Happen Next

Although Swedish transport agencies have started to finance studies and publish reports on gender equality, they still have not grasped the full meaning of a gender equality perspective. This situation is understandable—gender equality is not so easy to explain or to understand and a more concrete idea of what gender equality is and how to attain it in the transport system is needed. Everyone involved in the transport sector must know what gender equality is before an equally gendered transport system can be established.

In a way, it could be said that a governmental strategy to establish an objective of gender equality in the transport system to attain a gender-equal society as a whole, including the transport system, has not been successful. There is still a dominance of men in the transport sector, and most of the decisions concerning planning, designing, or managing the transport system are taken without a proper gender analysis.

But after all, the objective of gender equality is a long-term objective, and it has only been an objective for 3 years. If one compares it with the other long-term objectives, one could say that the efforts to attain a gender-equal transport system in Sweden are promising. Awareness of gender equality in the transport sector is growing, and there is a change in the approach toward new employees at transport agencies. The number of employees with university degrees in the humanities and social sciences is increasing, whereas the share of engineers is decreasing. This development will probably both increase the share of women working at the transport agencies and strengthen the possibilities to analyze transport issues with a gender perspective.

The government's next step will most likely be to give SIKA a new commission to work out intermediate objectives for gender equality to attain a transport system that is designed to meet the needs of both men and women. Establishment of intermediate objectives within the gender equality objective will probably make the objective of gender equality in the transport system more concrete and easier to work toward.

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Women's Travel
Can the Circle Be Squared?

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During the 1990s, the travel patterns of women in Great Britain exhibited some profound changes. Women of all ages are increasingly likely to hold driver's licenses and have full access to a car as the main driver. Three-fourths of the increase in car traffic since 1990 can be attributed to women. These changes have been influenced by major changes in the employment of women. For many women with children, a car is considered a necessity to help manage home and work responsibilities. Women have been able to expand their travel horizons, but there may be a cost to bear for society as a whole, with increasing congestion in many urban areas and on interurban roads. Bus service may become less viable, and opportunities for the remaining people who do not own a car may be reduced. Some tentative projections of further changes in car ownership and use by women over the next 10 to 15 years and their effect on traffic are provided. Can what seems to be impossible be achieved—can the circle be squared—so that the liberation that the car brings to many women can be enjoyed without the negative effects of increased congestion and environmental damage for society as a whole?

The Great Britain[1] Department for Transport (DfT) has the overall goal of "transport that works for everyone." To that end, it works in partnership with others to

- Tackle congestion,
- Improve accessibility,
- Reduce casualties,
- Respect the environment, and
- Support the economy.

It will be demonstrated here how many women have enjoyed improved accessibility as a result of their increased use of cars. Trends in how and why women in different age groups travel are examined, especially for travel to work. Then the effect of women's increased travel on traffic congestion is estimated, and the effect on the other objectives is considered. In conclusion, consideration is given to whether it is possible to square the circle, achieving what seems to be impossible—enjoyment of the liberation that the car brings to many women without the negative effects of increased congestion and environmental damage for society as a whole.

Setting the Scene: Women's Changing Access to Cars

In Great Britain, bus use was overtaken by car use in the mid-1950s. Since then car ownership has grown steadily, and many families now consider cars to be a necessity rather than a luxury. Initially, men were more likely to be the sole driver of a single-family car, and the stereotype of a man using the only car for work and leaving other household members to rely on public transport during the day was probably true for much of the second half of the twentieth century. By 1990, 23% of households had two or

[1] Great Britain includes England, Wales, and Scotland.

more cars, and this proportion had increased to 29% by 2002. The rise of the second car has mainly benefited women, as will be shown.

Data Sources

This paper is based mainly on evidence from the long-running British National Travel Survey (NTS), which is described in more detail in the section on data sources at the end of the paper.

Driver's Licenses

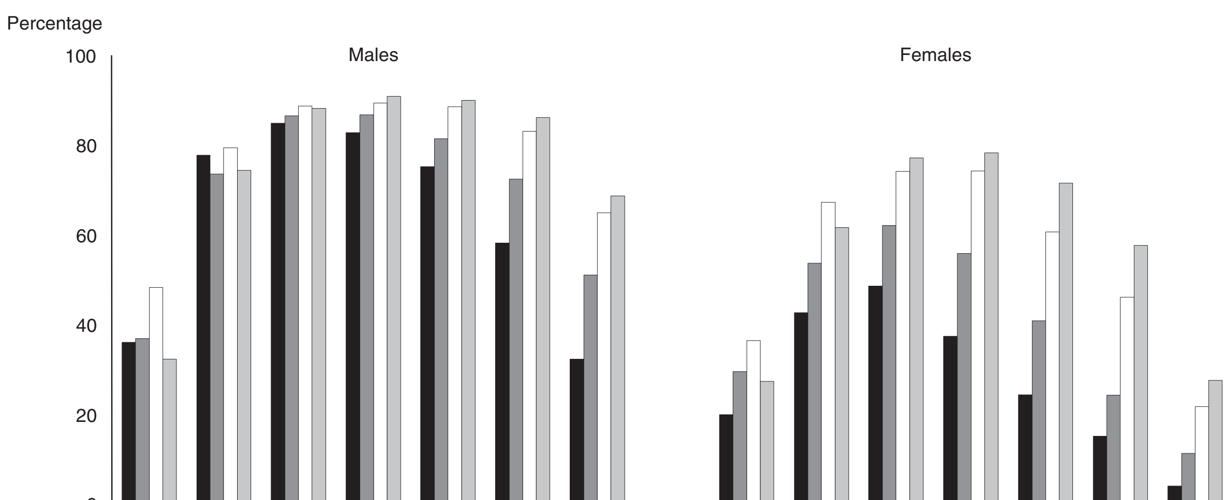
Diminishing gender differences in car access are clearly shown by considering proportions of people with driver's licenses. In 1975–1976 only 29% of women aged 17 and older and 69% of men held full licenses, a difference of 40 percentage points. A decade later, in 1985–1986, the corresponding figures were 41% of women and 74% of men. The most recent figures for 2002–2003 show 61% of women had full licenses compared with 81% of men, a difference of only 20 percentage points.

These trends are shown in more detail for different age groups in Figure 1. There is a strong cohort effect. Until the end of the 1990s, each generation of young women was more likely to be able to drive. Women drivers in their middle age moving into retirement have rapidly increased the number of older drivers. However, there remains a much greater disparity between the sexes among drivers over the age of 70, partly because this group contains more very old women than men.

A change has recently become apparent, with fewer young people (of both sexes) now holding licenses. Various reasons have been suggested: driving tests are now more difficult, with the introduction of a theory test in Great Britain; more young people are students and cannot afford cars; and insurance costs are high for drivers under 25. This phenomenon has also been noted elsewhere in Europe (*1*).

It is also noticeable that young women's levels of driver's license holding are no longer catching up quite as quickly with men's levels as in the last few decades of the twentieth century. For example, among those aged 30 to 39 in 2002–2003, there was a difference of 11 percentage points in driver's license holding between men (88%) and women (77%). This difference was the same in 1998–2000. Overall, men's license holding for all ages (17+) appears to have leveled off since the early 1990s at around 80%. It is possible that women's license holding may also level off when the current cohort effect has worked its way through to the oldest age groups.

Another factor slowing the increase in license holding among women may be increasing ethnic diversity. In some minority groups, women are less likely to work and less likely to drive. It will be interesting to monitor employment and car access trends in more recent immi-



	17–20	21–29	30–39	40–49	50–59	60–69	70+		17–20	21–29	30–39	40–49	50–59	60–69	70+
1975/1976	36	78	85	83	75	58	32		20	43	48	37	24	15	4
1985/1986	37	73	86	87	81	72	51		29	54	62	56	41	24	11
1995/1997	48	79	89	89	88	83	65		36	67	74	74	61	46	22
2002/2003	32	74	88	91	90	86	69		27	62	77	78	71	58	27

FIGURE 1 Driver's license holders by age and sex for various periods.

grant groups as these women become more assimilated within the wider community.

It is possible to speculate on the maximum future level of driver's license holding in Great Britain by looking at the situation in the United States. Rather than a comparison of Great Britain with the whole of the United States (which is much more sparsely populated), a more realistic comparison is with New York State.[2] In 2001, the maximum level of drivers[3] recorded by the U.S. National Household Travel Survey (2) for ages 51 to 60 was 92% for men and 80% for women. These levels are only a little higher than those for men (91%) and women (78%) in their forties in Great Britain, which reinforces the view that levels of license holding may not grow much more when the cohort effect noted earlier has worked through completely to the older age groups.

Who Drives the Sole Family Car?

In the British NTS, the person who drives the most mileage in each car is designated the main driver of that car. Usually, a two-car household will have two main drivers, and so on. The personal access to a car of each household member is classified as main driver, other driver, nondriver in a household with a car, and no household car.

Figure 2 shows the changes in personal car access during the last decade. The proportion of women who are main drivers has increased from 31% to 45%. In contrast, for men this proportion has stayed at 64%. Interestingly, for men the proportion of other drivers has increased.

Two different trends have increased car availability for women. The first, as noted earlier, is the increase in households with two or more cars. The second, illustrated in Table 1, is more interesting, showing increased access to cars even in one-car households.

In single-car households in 2002–2003, with two or more adults (Table 1), 65% of men are main drivers, rather more than twice the proportion of women (27%). A decade ago, the ratio was closer to four to one: 72% of men in these single-car households were main drivers but only 19% of women. However, many women in single-car households (often pensioner households) are still nondrivers, although this proportion is declining.

In households with two or more cars, about 80% of women were main drivers in 2002–2003, which shows clearly how women benefit from the second household car. This proportion also increased considerably during the 1990s.

Economic Activity

Figure 3 shows that differences in economic activity are one of the main reasons for the remaining differences between personal car access. There is much less difference in car access between men and women who are working full time—71% of men and 64% of women were main drivers in 2002–2003; 58% of women working part time were also main drivers.

The main differences between men and women were among those who were retired or permanently sick, where less than a fourth of women were main drivers. This difference is likely to be because many retired women have never held a driver's license, and car availability is lower in such households.

Employment Changes

According to the Office for National Statistics *Labor Market Trends*, between 1992 and 2002 there were increases of 11% in the number of women working both full time and part time. For men, the increase in full time workers was only 2%, but an increase of 46% in part-time male workers (from a low base) gave an overall increase of 5% in the number of working men.

Single Mothers

Single mothers are even less likely to have access to cars than the average adult woman, but their car access has improved considerably. At the beginning of the 1990s, only one-fourth had a car, but this proportion had increased to nearly a half by 2002–2003. It should also be noted that single mothers as a proportion of women aged 17+ in the NTS sample increased from 3% to 5% during this period.

In contrast to a slight decline of 4% in the average number of trips made by women overall (see section on trends in women's travel), the number of trips by single mothers increased by 6%. During this period there was a strong shift from trips on foot (reduced from 45% to 36%) and by bus (from 13% to 9%) to trips as car drivers (up from 25% to 42%). It is likely that single mothers, who are likely to have particular problems juggling

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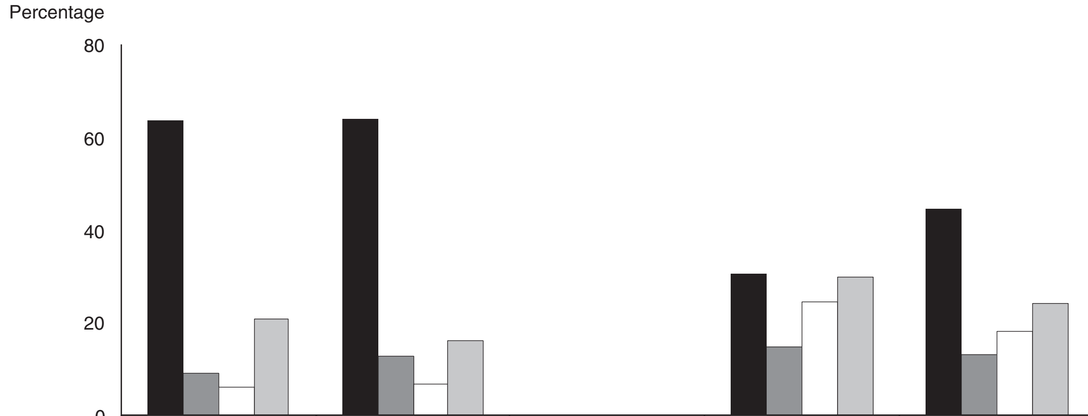
[2] This comparison was suggested by an American colleague, since it is an area with a geographic distribution of population more similar to that in Great Britain than the United States as a whole. Overall, in 2002 the population density of Great Britain was 650 persons per square mile, eight times higher than that of the United States (80 persons per square mile). For New York State, the density was about 380 persons per square mile.

[3] It should be noted that the question asked is slightly different. In Great Britain, respondents are asked if they have a license; in the United States they are asked if they are drivers, which may therefore include unlicensed drivers.



	Male 1989/91	Male 2002/3		Female 1989/91	Female 2002/3
Main driver	64	64		31	45
Other driver	9	13		15	13
Nondriver	6	7		24	18
No household car	21	16		30	24

FIGURE 2 Personal access to cars by sex: 1989–1991 and 2002–2003, age 17+.

TABLE 1 Percentage of Personal Car Access by Availability: 1989–1991 and 2002–2003

	Male				Female			
	Main Driver	Other Driver	Nondriver/ No Car	Total	Main Driver	Other Driver	Nondriver/ No Car	Total
2002/2003								
No cars	0	0	100	100	0	0	100	100
One car	65	22	13	100	27	30	43	100
Two cars	82	13	5	100	79	9	12	100
Three or more cars	82	11	6	100	81	9	10	100
All persons	65	15	20	100	47	17	36	100
1989/1991								
No cars	0	0	100	100	0	0	100	100
One car	72	18	11	100	19	30	51	100
Two cars	89	5	5	100	68	13	18	100
Three or more cars	90	6	5	100	76	10	14	100
All persons	65	10	24	100	32	18	49	100

Note: Age 17+, households with two or more adults.

child care and work responsibilities, have benefited considerably from increased car access.

Increased Car Access Improving Overall Accessibility

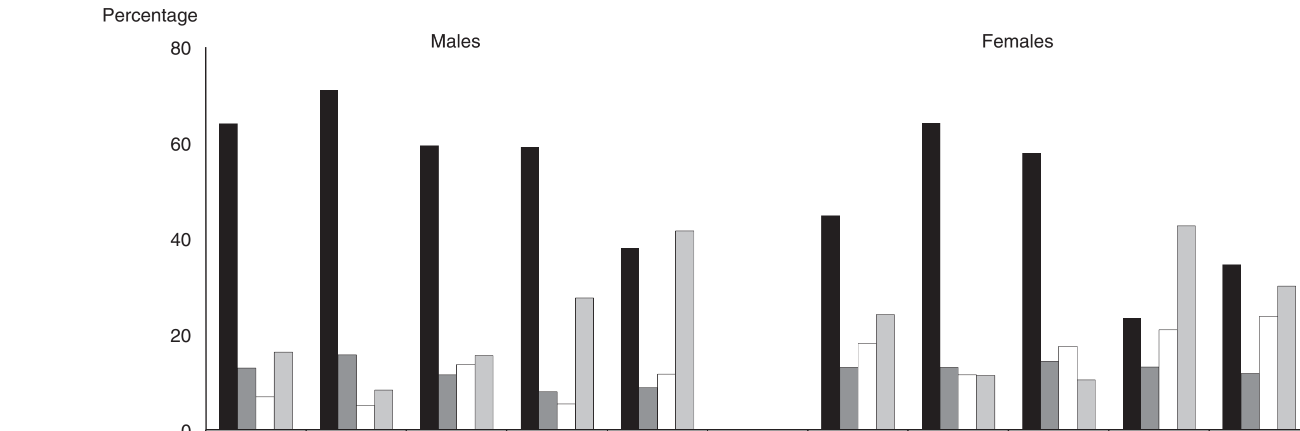
The trends in better car access for women shown in this section reflect the changing role of women in society. Men are less likely than before to dominate the use of the car in single-car households, and many more women have sole use of their own car because of the increase in households with two or more cars. Women may gain use of a car for a specific purpose, such as to drive to work or take children to school, but once they have car access, they are able to enjoy the freedom of their own transport to make a wide variety of trips, including social and leisure trips.

Trends in Women's Travel

Number of Trips

Figure 4[4] shows the trends in index form in the average number of trips made by women and men (all ages) from 1990 to 2002 for selected modes. The total number of trips made by women fell by 4% during this period, but there was a 30% increase in the number of

[4] Data are 3-year moving averages.



	Males: Total	Males: Full time	Males: Part time	Males: Retired & perm. sick	Males: Home/ other	Females: Total	Females: Full time	Females: Part time	Females: Retired & perm. sick	Females: Home/ other
Main driver	64	71	59	59	38	45	64	58	23	34
Other driver	13	16	11	8	9	13	13	14	13	12
Nondriver	7	5	14	5	12	18	11	17	21	24
No household car	16	8	16	28	42	24	11	10	43	30

FIGURE 3 Personal access to cars by sex (age 17+) and selected economic status: 2002–2003.

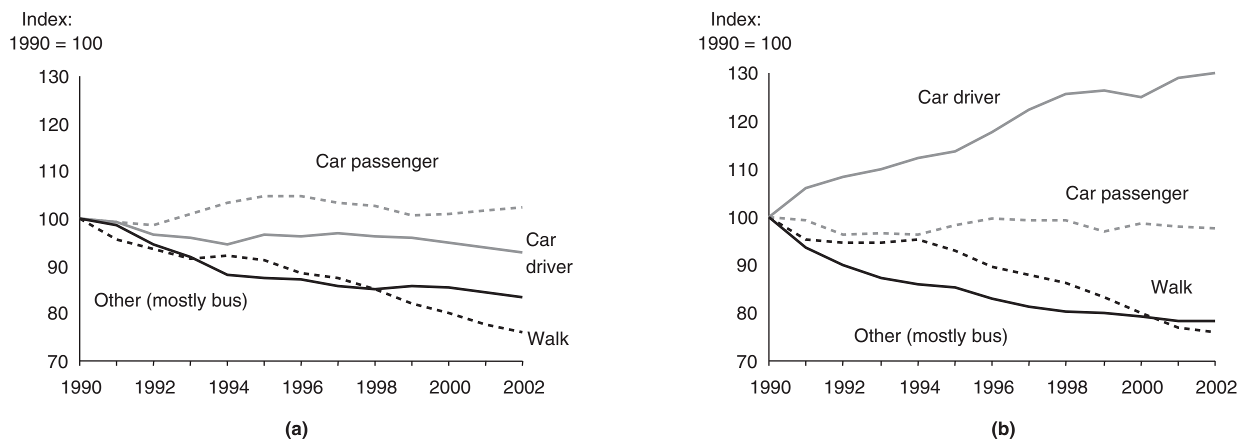


FIGURE 4 Trends in trips, 1990–2002: (*a*) males; (*b*) females.

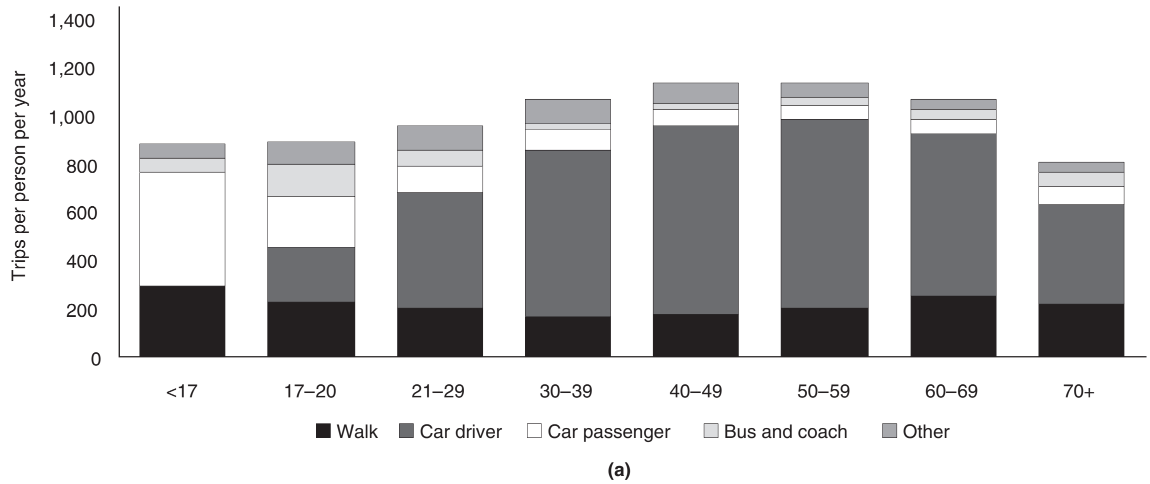
trips women made as car drivers. In contrast, the total number of trips made by men fell by 11%, including a fall of 7% in the number of trips made by male car drivers. There were declines of more than 20% in trips on foot for both men and women and by women on "other" modes (mostly bus, but also some cycling and rail trips).

Figure 5 shows trips by age, gender, and main mode of travel in 2002–2003. Women in their thirties, who are most likely to be combining work with family responsibilities, make nearly 20% more trips than men. This proportion reduces to 10% for women in their forties as family responsibilities diminish. From the age of 50, men make more trips than women.

In spite of the recent increases in car availability, on average women still make fewer trips as car drivers and more on foot, by bus, and as car passengers. There is little difference in the mode split for young men and women (aged less than 17), but the disparity increases with age, and for those over 70 about half of men's trips are as car drivers compared with only one in five of women's trips.

Trip Length and Total Distance Traveled

The length of trips made by women increased by about 18% in the 1990s with a shift to car driver trips and an



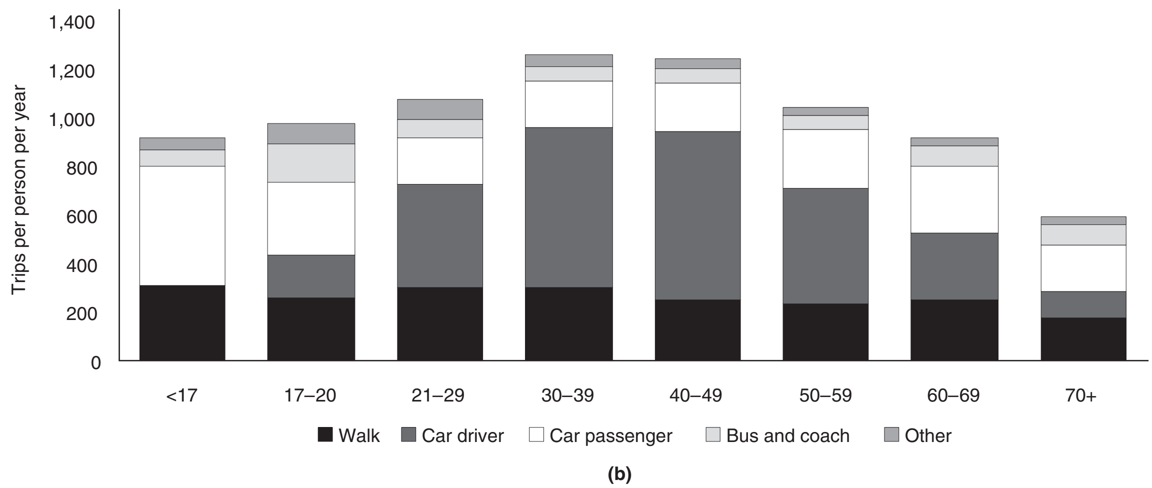


FIGURE 5 Trips by main mode and age: (*a*) males, 2002–2003; (*b*) females, 2002–2003.

increase of 13% in lengths of these car driver trips. Overall, men's trip lengths increased a little less (17%), although this difference was accounted for more by public transport trips (up 21%) than by the increasing length of car trips (up 11%).

Increasing trip lengths have led to an increase in the total distance traveled. Together with the increasing car use by women, this growth led to a huge increase of almost a half during the 1990s in the distance traveled by women as car drivers (averaged over all women), from just under 1,500 mi per person per year in 1989–1991 to nearly 2,200 mi in 2002–2003.

Women still tend to make more local, shorter trips than men. For example, about a fourth of trips made by male car drivers are more than 10 mi but only one in six for women. Interestingly, the average length of trips made by a female car driver is shorter than that for trips as a passenger. In 2002–2003 these trip lengths were 6.5 and 9.1 mi long, respectively. The reverse is true for men, with equivalent trip lengths of 10.3 and 8.9 mi. These differences can be accounted for by the type of trips women make as car drivers, with fewer long business trips and more shorter shopping and escort trips (see section on why women travel).

Bus Travel

During the 1990s, the number of bus journeys made by men declined by less than 2%, but for women the decline was nearly 17%. Since women made nearly two-thirds (63%) of the bus trips in 1989–1991, this finding implies that about 95% of the decrease in bus use can be accounted for by women. Some bus services are of marginal profitability, and continued increases in women's car travel may lead to reductions in bus availability for women who do not have access to cars, especially older women and single parents.

Why Women Travel

Trip purposes mirror how people spend their time, and women's different social and family responsibilities are clearly reflected in their travel patterns. In broad terms, women's travel can be divided into three main categories, which account for roughly equal numbers of trips overall:

- Compulsory trips, covering work, education, and escort trips (not made for an individual's own purposes but to take or accompany someone else);
- Shopping and personal business trips, including trips to the bank, library, or doctor; and
- Discretionary trips, including visiting friends, watching or participating in a sport, and going on day trips or on holiday.

Figure 6 gives details of why men and women travel for different age groups in the broadly defined groups of trips but separating out escort trips. Up to the age of 17, differences in travel purpose by gender are slight, but they become more noticeable for young people aged 17 to 20. Women make a greater proportion of shopping trips and are more likely to visit friends in their homes than are men. Men make a greater proportion of commuting and business trips. These differences persist through all age groups.

By the time women reach their twenties, escort education trips (taking children to school) are becoming more apparent, and together with general escort trips, these account for over a fourth of all trips for women in their thirties. This age group of women also makes the smallest proportion of commuting trips among those of working ages. Trips to visit friends tend to decline for both women and men aged between 21 and 49 and increase again in their fifties.

Once women are in their fifties, they are less likely to be juggling family and work responsibilities and make fewer trips than men. In particular, the number of escort

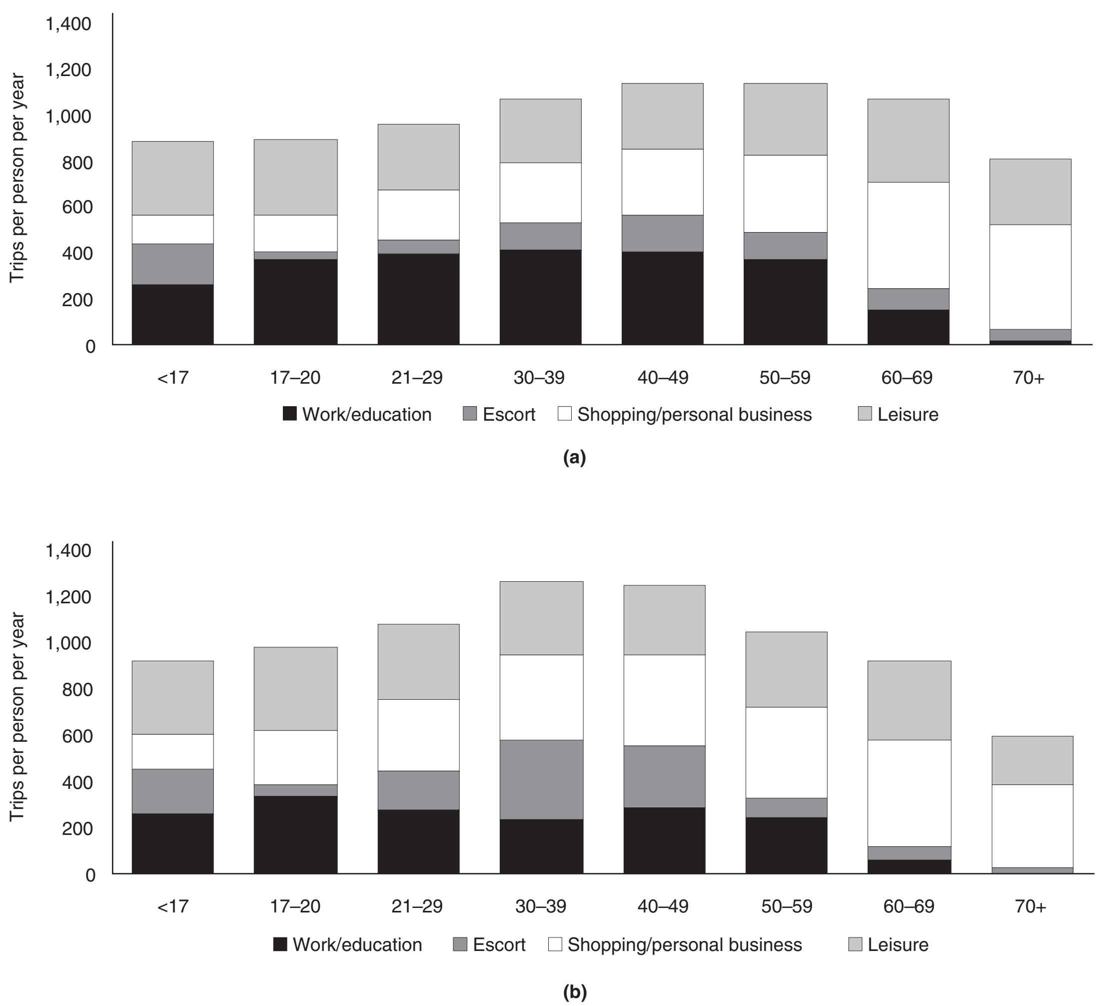


FIGURE 6 Trips by purpose and age: (*a*) males, 2002–2003; (*b*) females, 2002–2003.

trips declines considerably. For both men and women 60 and over, shopping, personal business, and visiting friends are the main trip purposes, and the trip patterns of men and women become increasingly similar at older ages.

The average trip length for women is about 6 mi, a fourth less than that for men (8 mi). This difference is mainly accounted for by work and business trips, which are considerably longer for men than for women and also account for a greater proportion of all trips. For most other purposes, men's trips are only slightly longer than women's.

Travel to Work

It is particularly interesting to look at patterns of work travel, since these illustrate women's changing economic position in society. In addition to the NTS, the Labour Force Survey (LFS) and decennial censuses provide data on travel to work, and the larger samples enable more detailed analysis.

Changes in Distance and Method of Travel

Changes in distance[5] traveled to work by women are evident from census data for England and Wales (Table 2). There has been a decrease in short trips of less than 2 km, from 34% to 28%, although this is still the most frequent trip length. In contrast, trips of more than 10 km have increased from 19% to 26% of all trips.

These changes are partly the result of the increase in the proportion of car trips (up from 46% to 55%) and partly the result of the increasing length of trips by all modes, including the car. It is not possible to identify why women now travel farther to work, but it is likely that greater car availability has allowed women to seek opportunities for better work farther from home or, conversely, that traveling farther to higher-paid work has allowed more women to buy cars. In addition, motoring costs have risen less than average earnings in recent years.

The same distance change is less apparent for men. The proportion of trips less than 2 km was almost the same in 1991 and 2001 (about 20%), with a slight decrease in intermediate-length trips and an increase in trips over 10 km from 34% to 39%. Women are still much less likely to make long trips (over 40 km) to work, accounting for only 3% of women's trips in 2001 compared with 8% of men's trips.

[5] These distances are the direct or as-the-crow-flies distances between the usual residence and workplace. Actual distances are farther. These data are only available in kilometer bands: 1 km is approximately 0.6 mi.

The increase in car travel to work from 1991 to 2001 shown in Table 2 has been at the expense of travel on foot (down from 18% to 15%) and travel by bus (down from 15% to 11%).

Travel to Work by Ethnic Group

Table 3 shows the differences in travel to work for selected ethnic groups, using data from the LFS. Two-thirds of white women usually traveled to work by car, mostly as car drivers. The corresponding proportions for the Asian and black groups were just over a half and a third, respectively.

However, it should be noted that ethnic minority populations are concentrated in large urban areas, where fewer people in general travel to work by car.

For both whites and blacks (which included black/mixed in 1992), there have been increases of about five percentage points in the proportion of car drivers from 1992 to 2002. In contrast, there has been little change in the proportion of Asian women traveling by car, which has remained at about a half.

Effects of Women's Increasing Travel on Car Traffic

It has been shown how women's increased access to cars has changed their travel patterns. Many (but not all) women have improved accessibility to the full range of work, shopping, health, and leisure opportunities. Some of the consequences of women's increasing car travel on other objectives of transport in Great Britain are discussed next.

Table 4 shows simple estimates[6] of the car traffic generated by men and women during the period 1990–2002, when the distance traveled in cars by women grew by 50% compared with 6% for men. Three-fourths of the car traffic growth from 1990 to 2002 is estimated to be attributable to the increase in travel by women driving cars.

Increasing road traffic, leading to congestion and poor air quality, is a significant problem in parts of Great Britain, especially in urban areas during peak hours. The press is inclined to blame the "school run," which is mostly still done by women, for some of this

[6] Data are 3-year moving averages of car driver distances from the NTS, which is a household survey, grossed to the full population. This is an overestimate since people not in households are likely to make fewer trips as car drivers. These data are balanced (to an unknown extent), since no allowance has been made for trips made by non-British residents. Grossed NTS data are grossed again to allow for underrecording, and so on, by about 16%, to the Great Britain Traffic Census.

TABLE 2 Percentage of Travel to Work by Women: England and Wales, 1991–2001

		With Fixed Workplace Away from Home							
	Mode of Transport	Less Than 2 km	2 km to Less Than 5 km	5 km to Less Than 10 km	10 km to Less Than 20 km	20 km to Less Than 30 km	30 km to Less Than 40 km	40 km and Over	Total
1991									
All modes (inc. other)	100	34	27	20	13	3	1	2	100
Walk	18	90	6	1	1	0	0	1	100
Bicycle	3	67	25	5	1	1	0	1	100
Car driver	46	21	29	25	17	5	2	2	100
Car passenger	11	27	36	22	11	3	1	1	100
Bus and coach	15	19	48	24	7	1	0	1	100
Rail	6	2	10	26	37	10	4	11	100
2001									
All modes (inc. other)	100	28	25	21	16	5	2	3	100
Walk	15	84	9	3	2	1	—	1	100
Bicycle	2	56	29	9	3	1	—	1	100
Car driver	55	19	26	24	19	6	2	3	100
Car passenger	8	26	34	21	12	3	1	2	100
Bus and coach	11	16	45	26	9	2	1	2	100
Rail	7	3	11	28	34	10	4	10	100

TABLE 3 Percentage of Usual Means of Travel to Work for Selected Ethnic Groups: LFS 2002

	White	Asian or Asian British	Black or Black British	All People
Males				
All car	76	65	52	75
Car driver	65	57	47	64
Car other[1]	11	9	4	10
Public transport	11	23	41	12
Walk	7	11	5	7
Other	7	1	2	6
Total	100	100	100	100
Females				
All car	67	51	35	66
Car driver	55	38	29	54
Car other[1]	13	13	6	12
Public transport	16	31	54	17
Walk	15	17	10	15
Other	2	1	1	2
Total	100	100	100	100

[1] Car passenger, or sometimes as driver and sometimes as passenger.

problem. In reality at the peak time of 8:50 a.m., less than 20% of urban traffic in the school year is caused by parents taking children to school by car (*3*) and only 12% overall during the peak hour from 8:00 to 9:00 a.m. Peak-hour travel is still dominated by work trips.

In addition to problems of congestion, it is known (*4*) that in Great Britain traffic contributes an increased share of CO_2 emissions, a greenhouse gas that many scientists consider to be associated with global warming. Women's average car mileage is still well below that of men (see section on trends in women's travel), and women are also likely to drive smaller cars than men, with lower emission levels, so it is certainly true that the greater share of emissions is currently attributable to men, but the balance is changing.

Future Effects of Women's Increased Car Travel

Formal, modeled projections of car travel are not attempted here. These projections require consideration of economic trends (such as employment), demographic trends (including household formation and its effect on car ownership), and trends in driver's license holding and trip lengths. However, some previous tentative projections of driver's license holding among older people (*5*) are updated in Table 5 by using updated official population projections for 2015[7] and adding some assumptions about license holding at younger ages:

- Cohort effects will have worked their way through to older ages, so license holding among women in their seventies will increase considerably (almost certain);
- License holding for those in their forties and fifties will have reached a ceiling, suggested by current levels in New York State (possible, see section on setting the scene);
- Women will continue to have lower levels of license holding than men (likely); and
- Young people will start driving rather later than in the early 1990s (as current trend).

The data in Table 5 imply an increase of about 19% by 2015 in the number of women holding driver's licenses compared with about 8% for men.

Official estimates from the National Transport Model (*6*) suggest total traffic growth of 22.5% from 2002 to 2015. Table 4 shows that the ratio of car traffic from men to that from women is declining, partly caused by the increase in the number of women drivers and partly by the

[7] U.K. Government Actuary's Department 2002-based population projections for Great Britain by age and sex (available from www.gad.gov.uk).

TABLE 4 Contribution of Women's Travel to Traffic in Great Britain: 1990–2002

	Car Distance pppy (miles)		Population (Millions)		Total Car Driver Distance Traveled[1] (bn miles)		Ratio Male: Female Distance	Percentage Change in Total Distance Since 1990	
	Male	Female	Male	Female	Male	Female		Male	Female
1990	4,822	1,498	27.0	28.6	156	51	3.04	–	–
1991	4,855	1,592	27.1	28.7	155	54	2.88	–1	5
1992	4,815	1,668	27.2	28.8	153	56	2.73	–2	9
1993	4,869	1,683	27.2	28.8	155	57	2.73	–1	10
1994	4,904	1,772	27.3	28.9	155	59	2.61	–1	15
1995	5,063	1,788	27.3	29.0	159	60	2.67	2	16
1996	5,089	1,871	27.4	29.0	160	63	2.57	3	22
1997	5,135	1,972	27.4	29.1	161	66	2.46	3	28
1998	5,110	2,055	27.5	29.1	162	69	2.35	4	34
1999	5,145	2,103	27.6	29.2	163	70	2.31	4	37
2000	5,114	2,098	27.8	29.3	164	71	2.31	5	39
2001	5,053	2,197	27.9	29.4	164	75	2.19	5	46
2002	4,976	2,217	28.1	29.5	165	77	2.14	6	50
			All	male	female				
Total traffic growth 1990–2002 (bn km)			34	9	26				
Percentage growth attributable:			100	25	75				

Note: pppy = per person per year.
[1] Grossed to total traffic figures.

TABLE 5 Tentative Projections of License Holding to 2015

	% License Holders		Population (Thousands)		License Holders (Thousands)		
	Males	Females	Males	Females	Males	Females	Total
17–20	35	30	1,455	1,402	509	421	930
21–29	75	65	3,645	3,626	2,734	2,357	5,091
30–39	85	75	3,737	3,880	3,176	2,910	6,086
40–49	90	80	4,138	4,261	3,724	3,409	7,133
50–59	90	80	3,972	4,107	3,575	3,286	6,860
60–69	80	70	3,321	3,532	2,657	2,472	5,129
70–79	89	65	2,232	2,553	1,986	1,659	3,646
80–89	65	35	1,013	1,476	658	517	1,175
90+	20	10	173	385	35	39	73
Total age 17+ (2015)			23,685	25,222	19,054	17,068	36,123
Total age 17+ (2002)			21,883	23,550	17,670	14,399	32,069
% change 2002–2015			8	7	8	19	13

increase in the distance traveled by women car drivers. This ratio will continue to fall, though probably more slowly, perhaps to about 1.8 by 2015. Using this ratio to factor traffic growth between men and women suggests a growth of about 39% in women's car traffic to 2015, which in turn implies a growth of about 17% in average trip lengths for women. Again, it should be stressed these are not official projections. The extent of this growth is not known, but there is little doubt that future growth in traffic to 2015 will be dominated by growth in women's travel, as it has been through the 1990s.

Road Accidents

The overall trend during the last 30 years in Great Britain has been a steady fall in the overall number of killed or seriously injured (KSI) road casualties. However, as Figure 7 shows, in the late 1980s the number of female car driver KSI casualties was increasing. It was fairly steady during the 1990s but has fallen fairly sharply since about 1997.

These trends have to be set against the increasing distance traveled by women as car drivers, shown in Figure 4. It is not surprising that the number of casualties increased at a time when car mileage was increasing rapidly. It is more surprising that casualties have fallen in more recent years in spite of the continuing increase in car mileage by women.

Figure 8[8] shows the steady fall in female casualty rates per billion miles traveled. At the beginning of the

[8]Figure 8 data are 3-year moving averages. It should be noted that no allowance was made in this section for underrecording of distance in the NTS, so rates are likely to be a little higher than shown. This difference is unlikely to have any significant effect on trends over time.

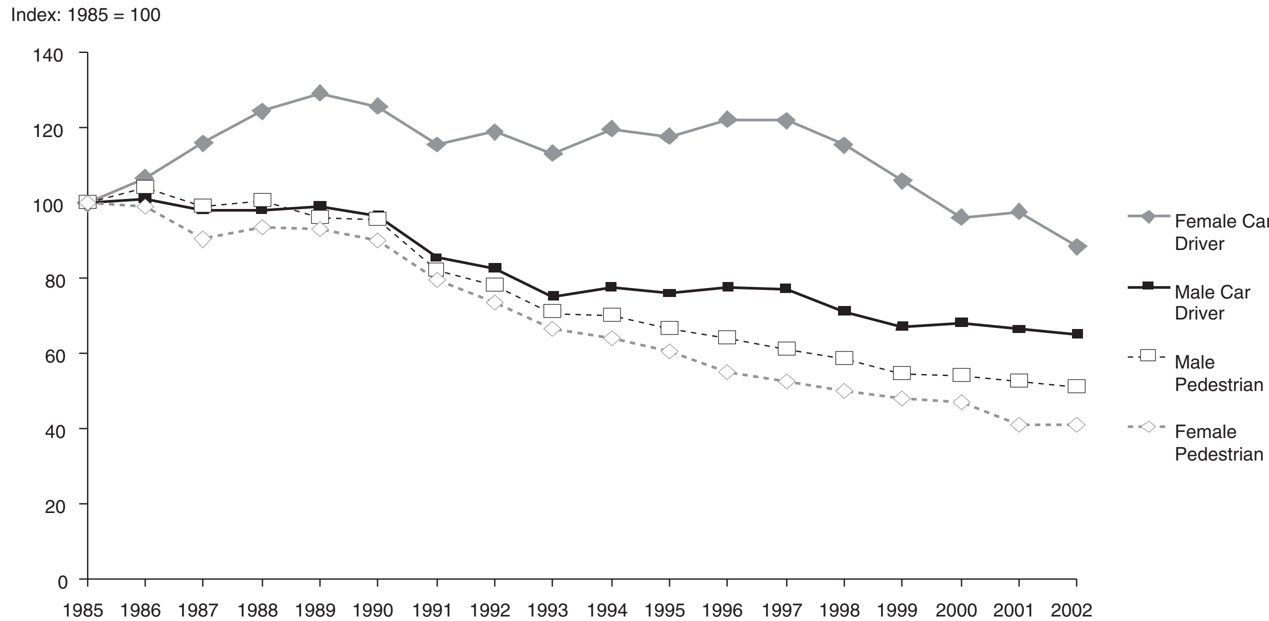


FIGURE 7 KSI car driver and pedestrian casualties by sex: 1985–2002 (age 17+).

1990s, rates were about a third higher among women than among men, but in recent years rates have become very close.

It is not within the scope of this paper to investigate the reasons for these trends in KSI rates, but it has been speculated that they may be affected by the following:

- Risk of injury to the driver, which changes with the size of car driven (7): In an accident between a large vehicle and a small one, the occupants of the smaller vehicle are more likely to be injured. Gender differences in the use of size and age of vehicles may be decreasing. Newer vehicles also have more safety features than older ones.
- Change in the age distribution of female drivers: In the earlier years, there was a higher proportion of young drivers among the female driving population (see Figure 1). An increase in older and more experienced women drivers may mean a reduction in risk.
- Differential accident rates dependent on the type of roads used and the times of day: If women's travel patterns are becoming closer to those of men, this fact may reduce the difference in casualty rates.

Table 6 shows data in more detail, including KSI pedestrian casualty rates, averaged over the years 1989–1991and 2002–2003. In addition to the fall in car driver KSI rates for both men and women, there have also been decreases in pedestrian rates. Pedestrian KSI rates per mile are considerably higher than car driver rates, so women are safer in their cars than on foot. The difference in these rates is, however, a little misleading since car trips are longer than those on foot. There is much less difference between car and pedestrian accident rates per trip, though rates per trip are still higher.

Can the Circle Be Squared?

Increasing traffic is recognized as a significant problem in Great Britain. Many urban areas and major interurban roads are congested at peak periods and in some cases throughout the day. This congestion leads to slow and unreliable journeys, both by car and by bus, and environmental problems such as increased CO_2 emissions, poorer air quality, and noise. Building new roads is not usually an option in congested urban areas and has become increasingly contentious in other areas.

Great Britain has a population density of 650 people per square mile—the third highest in Europe after the Netherlands (997) and Belgium (872). High population density in major urban areas means that many services are available nearby and provides sufficient critical mass to enable the provision of reasonably cost-effective public transport.

As has been shown, much of the increase in traffic during the 1990s was the result of women's being more likely to have the use of a car and also driving longer distances on average for each car trip.

It is not possible to turn the clock back. Car availability has widened the horizons of many women. Being able to travel faster by car has enabled working mothers

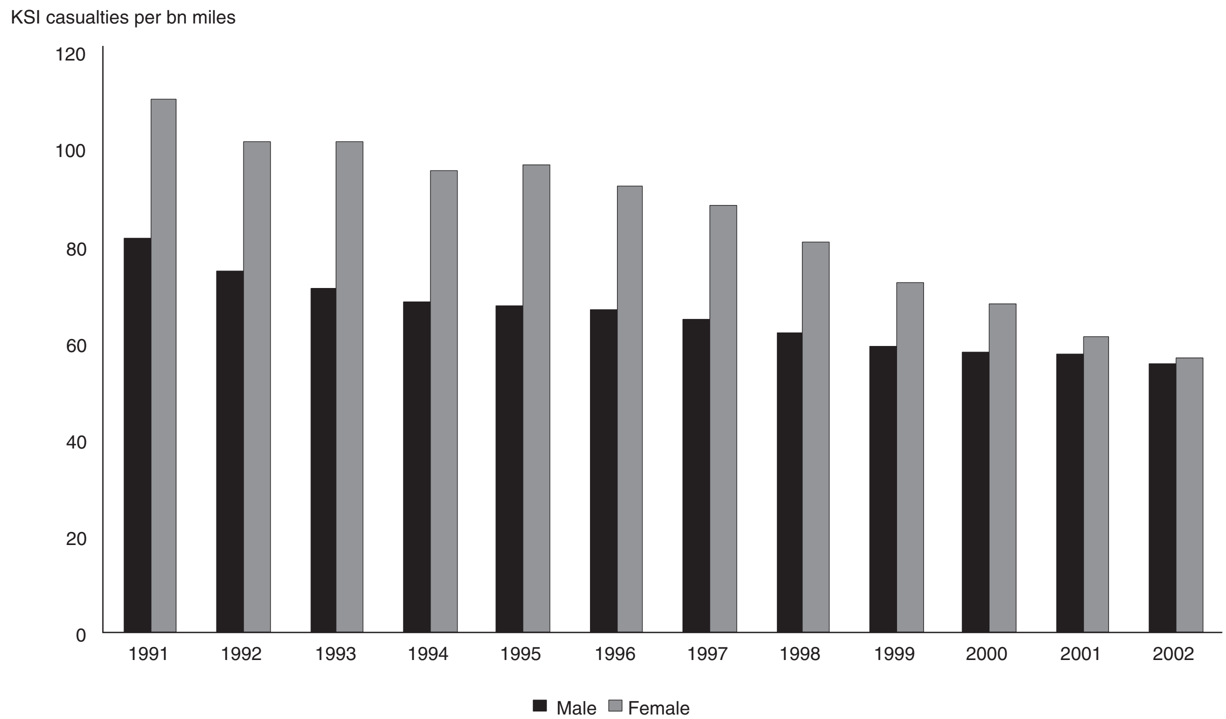


FIGURE 8 Car driver KSI casualty rates: Great Britain, 1991–2002 (age 17+).

TABLE 6 KSI Casualty Rates Age 17+

	Male		Female	
	Pedestrian	Car Driver	Pedestrian	Car Driver
1989/91				
Distance (miles pppy)	192	6,302	189	1,905
Total distance per year (bn miles)	4.0	132	4.3	43
KSI per year	5,933	11,451	4,482	5,173
KSI per bn miles	1,476	87	1,039	119
2002/03				
Distance	150	6,474	168	2,809
Total distance per year (bn miles)	3.3	142	4.0	66
KSI per year	3,273	7,737	2,080	3,574
KSI per bn miles	992	54	524	54
% change 1989/91–2002/03				
KSI per year	–45	–32	–54	–31
KSI per bn miles	–33	–37	–50	–55

Note: pppy = per person per year; KSI = killed or seriously injured.

to have time to juggle family and work responsibilities. Many women are no longer restricted to local jobs, where opportunities are limited and wages may be low. Being able to drive to work removes many of the constraints of time and availability of public transport and enables women to fit in other tasks on the way to and from work, such as dropping children at school and doing the shopping. Once women have become used to the convenience of car access, they are unlikely to stop driving simply because they reach retirement age.

However, society as a whole suffers from increased traffic, and society as a whole needs to make the best use of limited road space. There is no magic solution, but there are numerous initiatives that aim to make a difference. Informal networks of mothers taking turns to escort children to school have existed for many years; "walking buses" are now popular, in which larger groups of children are escorted safely to school on foot in organized groups. Employers are encouraged to set up workplace car-sharing schemes, though these may be less attractive to women who need to trip-chain to cope with family responsibilities. The online organization in Great Britain that arranges car sharing (www.liftshare.org) has about 70,000 members, of which 56% are men.

Many families themselves, sometimes with the help of personalized journey planning, look more critically at their own travel to make the best use of the limited resources available. As has been seen, stereotypes are gradually being overturned, and women are more likely to have the main use of a single-family car. Considerable efforts are being made in some areas to ensure that buses are more attractive to all users, and these areas have increasing patronage among both men and women.

It was recognized in the 2004 *Feasibility Study of Road Pricing in the UK* (*8*) that in the longer term, road user charging may be needed to ease the problem of Britain's congested roads. Households are then likely to start to consider the economic aspects of car use more carefully. If the fixed annual license fee for driving a car is replaced by more variable charging, women's cars, with their lower annual mileage, are likely to become a little cheaper to run. There will be a number of challenges to face in devising a fair scheme for both men and women, but as the study suggests, "Road pricing could be designed to provide . . . positive benefits for women, who are still less likely to have access to cars." These benefits include the following:

- Encouraging a vibrant car-sharing market, which could have a large positive impact on both women from ethnic minority communities and young people, who are heavily reliant on rides; and
- Providing further revenue support for buses (or taxis) and making bus journeys more frequent and reliable, which would increase the number of people using public transport and help sustain services and address fears for personal safety on underused services.

There is no single solution to the transport problems faced in Great Britain. Women's travel will continue to grow faster than men's travel in the foreseeable future. The economy as a whole should benefit from women's increased mobility, but a wide-ranging menu of solutions will be needed to minimize the impacts that increasing traffic would have on congestion and the environment. Both men and women need to take responsibility for their contribution, make smart use of their cars, and use other options when these are available.

In terms of the DfT goals mentioned in the introduction, the continuing increase in women's travel by car will have the following effects:

- It will increase accessibility for many women. However, this increased accessibility may have the effect of reducing accessibility for those who still do not have access to a car if bus service becomes less feasible and more services move to places only accessible by car, such as out-of-town shopping centers.
- It will help support the economy since more women will be enabled to contribute fully by working; however, increased traffic congestion is detrimental to the economy.
- It will not help to tackle congestion since it has been shown that the majority of recent increases in traffic can be attributed to increased car travel by women.
- It will not respect the environment since increased car travel is associated with a range of environmental problems.
- It may help to reduce casualties since women are safer as car drivers than as pedestrians, although again, increasing traffic may eventually lead to more casualties overall.
- As mathematicians proved in the 19th century, it is not possible to literally "square the circle."[9] Neither is it possible to absorb the inevitable future growth in women's travel by car in Great Britain without any consequences being suffered. All drivers, especially men who still drive further and more often than women, need to consider the effect of their travel on society and the environment as a whole.

Data Sources and Glossary

Data from the LFS and the 2001 census are available from the Office for National Statistics at www.statistics.gov.uk. DfT publications are available at www.dft.gov.uk.

National Travel Survey

Most data in this paper are from the NTS, which has run continuously since 1989, after earlier ad hoc surveys. Background demographic and transport-related information is collected by face-to-face interviews with a representative sample of households. All household members are then requested to complete detailed travel diaries for 7 days. Parents complete diaries for children. Travel distances are generally collected and reported in miles. Only travel within Great Britain is recorded.

The number of fully responding households in 2003 was about 8,300 (19,500 people), with a response rate of 60%.

In common with most social surveys, it is known that the NTS tends to be less representative of some population groups, such as young men, older people, and people living in major cities, especially London. Data are not currently weighted although, given its special travel characteristics, the London sample is boosted to allow for poorer response.

In addition, the special demands of the NTS mean that larger households, and particularly busy people, are also likely to be underrepresented. The most recent bulletin is based on 2003 data (*9*), and a technical report

[9] A Google search will reveal many websites with a discussion of the meaning of squaring the circle. One simple reference is at www.randomhouse.com/wotd/index.pperl?date=19980904.

(*10*) is available. A more in-depth publication (*11*) with 2002–2003 data (as in this paper) is also available.

LFS

Since 1992, data on usual mode of travel and the time taken to travel to work have also been available from the larger LFS in the autumn quarter. An extra question was added in 1996, allowing the car category to be split among car driver, car passenger, and sometimes driver and sometimes passenger. The larger sample size (about 55,000 responding households per quarter) allows analysis in more detail than is possible using the NTS, for example, by broad ethnic group.

Population Census

The decennial population census was last held in 2001. Data are available on household car ownership and on usual mode of travel to work (splitting car into driver and passenger). The questions asked in Scotland were slightly different from those asked in England and Wales, so results are not comparable. Since the census also asks for workplace address, it is possible to calculate the direct, or as-the-crow-flies, distance (in kilometers only) between work and home. It should be noted that some distances for walk trips are implausible. This fault could be caused by data errors or could be the result of people traveling to work from a different address from their usual (census) address, such as those who have a second home close to work in addition to their main residence.

Road Accidents

Detailed information on road accidents in Great Britain is collected by the police on common STATS19 forms. These are collated and published annually by DfT (*12*). Data have been collected in a similar format since the late 1970s, and reporting rates are considered high for serious accidents.

Glossary

Escort trips are when the main purpose of the trip is to take or accompany another person. These trips are known in the United States as "serve passenger" trips. Escort education trips are mainly to drop or collect children at or from school.

A trip is a one-way course of travel with a single purpose. Thus dropping a child at school on the way to work counts as two trips, with separate purposes of escort education and work. Minor stops—for example, to pick up a newspaper when walking to the station—are ignored. The main mode of a trip is the means of transport used for the greater part of the distance.

In this paper "bus" covers local bus trips (known as "transit" in the United States) and also a small proportion of longer-distance bus or coach trips. "Rail" covers heavy rail and also trips on the London Underground system but not on modern light-rail (tram) systems. Light rail is included in the "other" category, which includes flights within Great Britain.

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The views expressed are the author's own and do not necessarily represent DfT policy.

Integrating Gender into the Dhaka, Bangladesh, Urban Transport Project
Impact of Road Improvement Strategies on Women

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The results of a study that examined transportation improvement strategies for a major urban highway corridor in Dhaka, Bangladesh, are presented. In particular, the study focused on the impacts of different improvement strategies on transit passengers and rickshaw pullers. The primary focus of the road improvement strategy was to reduce congestion by restricting nonmotorized transport modes (such as rickshaws), which were a major part of the travel flow in the corridor. A survey was used to collect information from a variety of affected users of the road corridor, including students, workers, and residents. A smaller sample of stakeholders was interviewed on the merits of nonmotorized transport strategies in a road corridor similar to the one studied. The impacts of road improvement strategies on women were a particular focus of this research. Given the new restrictions on nonmotorized transport, travel behavior has changed. For example, women who formerly were not comfortable using public transit for cultural reasons were now forced to use local bus service. In response, some transit services have been established for women only. Rickshaw travel times have increased dramatically given new routes that bypass the urban highway. Many of those interviewed concluded that although congestion on the major road has declined, the road improvement strategies have had a negative impact on women, especially those in low- and middle-income groups, who find it extremely difficult to ride overcrowded local buses during peak hours. The study recommended that a women and family bus service be implemented that would meet the cultural challenges facing public transport. In addition, new proposals to ban nonmotorized travel (i.e., rickshaws) on other major roads in Dhaka should be assessed not only from the perspective of reducing congestion but also with an understanding of the cultural and equity impacts on different groups of society. It is recommended that nonmotorized transport considerations be integrated into urban road corridor planning and that, given the use of such transport by women, there be a substantial gender component to such considerations.

Abstract prepared by Michael D. Meyer, Georgia Institute of Technology.

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ISBN 0-309-09394-5