Passenger Usages of the Intermodal Transportation System: An Analysis of the 2009 National Household Travel Survey Data

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ABSTRACT

The research on intermodal transportation is vast, but most of the efforts have been on the freight side. The research on passenger intermodal transportation is much less comprehensive. It is essential to understand passenger usage of the intermodal transportation system because passengers are the biggest users of transportation systems. This research provides a first look at passenger intermodal transportation in the U.S. by using the 2009 National Household Travel Survey (NHTS) data, which provide for the first time the intermodal usages by passengers. This research provides descriptive statistics on total trips, trips by different travel modes and trip purposes, and different travel modes by trip purposes. This research further investigates the association of these intermodal transportation measures to possible factors by using Poisson and negative binomial regression models. The findings suggest that the majority of trips were made by personal vehicles, but trip purposes varied greatly. Household income and urban residency positively shaped the numbers of total trips, travel modes, and trip purposes. Homeownership, household size, and the number of household drivers also shaped these intermodal transportation measures, although the direction of the effect varied. Future research could focus on demographic variations of passenger intermodal transportation.

Key words: intermodal transportation, passenger, travel modes, trip purposes, NHTS, demographics

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INTRODUCTION

The research on intermodal transportation is vast, although most of the efforts have been on the freight side. The research on passenger intermodal transportation is much less thorough—largely due to the lack of a comprehensive dataset for effectively studying it (*1,2*). It is essential to understand passenger usages of the intermodal transportation system because passengers are the biggest users of transportation systems, and passenger benefits are one of the important factors, if not the most important factor, in transportation planning and decision making.

Passenger intermodal transportation generally refers to the movement of people from one travel mode to another (*3*). A limited number of studies using this definition of passenger intermodal transportation focuses on accessibility and sustainability (*1,2,4*). Goetz and Vowles (*1*) discuss mechanisms to improve accessibility to passenger intermodal transportation and propose that making airports the hub of transportation systems will facilitate increases in use of multiple forms of passenger transportation. Although the lack of connectivity between types of modes has been used to explain the slow progress in passenger intermodal transportation (*5*), the suggestion put forth by Goetz and Vowles (*1*) seems appropriate for long-distance trips rather than short trips. Similarly, Szyliowicz (*4*) noted the importance of an intermodal transportation system as a means to reduce the negative effects of personal vehicle travel, noting the barriers to the creation of passenger intermodal transportation system. Paez (*2*) examined the link between accessibility and the distribution of economic development, concluding that greater access to intermodal transportation is not a sufficient explanation for economic development. A report published by the National Commission on Intermodal Transportation (*5*) highlighted the need for freight and passenger intermodal systems. The report noted the obstacles that had prevented the progress of such systems and outlined recommendations to achieving such a goal. The report also pointed out that economic development was closely linked to the sophistication of the freight intermodal transportation, but that the slow progress for passenger intermodal transportation was more closely tied to federal government funding, as well as the collaboration between government agencies at various levels.

Some research has examined passenger intermodal transportation more broadly, primarily focusing on walking and public transportation facilities (*6*). Public transportation tends to be accessed by walking, thus walking should be included as a travel mode in studies of passenger intermodal transportation. Similarly, Besser and Dannenberg (*7*) studied walking to public transportation facilities, focusing on the positive effects of walking from a health perspective.

Most research on passenger transportation focuses on a single mode (e. g., air, rail, bus, personal vehicle). In the United States, personal vehicle travel is the most common mode of transportation (*8*), and it is considered a key factor to contribute to transportation expenditures among all household costs (*9*). As a result, much research on personal vehicle travel has focused on the concerns of personal vehicle travel, including gas emissions and pollution, traffic congestion, motor vehicle crashes, declining social capital, energy consumption, and social isolation, among others (*2,4,10*).

Travel behaviors and patterns have been more widely studied over the past 50 years and are affected by a number of characteristics, including age (*8,11*), gender (*8*), race/ethnicity (*8,12*), household size and type (*13*), household income (*8*), population density and neighborhood type (*13,14*). Urban residents are more likely than non-urban residents to take trips by public transit, walking, or biking (*14*). Urban blacks are also more likely than whites to use public transit and walking (*14*). Households with children tend to take more trips than households without children, although there is variation based on neighborhood type and household size and type (*14*). These factors are controlled when examining passenger intermodal transportation in this study.

In this study, we adopt the broad definition of passenger intermodal transportation and consider different travel modes, trip purposes, and their combinations. Doing so can provide preliminary understanding of passenger usage of intermodal transportation; it is also necessary before studying passenger intermodal transportation based on its narrow definition.

OBJECTIVE

The objective of this research is to provide a preliminary understanding of the use of passenger intermodal transportation in the United States using the 2009 National Household Travel Survey (NHTS). The NHTS provides comprehensive information on travel behaviors and patterns in the United States. The NHTS data from 2001, 1995, 1990, 1983, 1977, and 1969 have generated thousands of studies related to traffic safety, congestion, environment, energy consumption, demographics, bike and pedestrian usage, transit planning, policy and mobility, and others. More importantly, the 2009 NHTS data provide for the first time the intermodal usages by passengers. This helps fill the gap of literature on passenger intermodal transportation.

SCOPE

In this study, we focus passenger intermodal transportation more broadly on the use of multiple modes of transportation used by travelers to reach a destination, rather than on the connectivity of travel modes from the operational research perspective as conducted in the freight intermodal research. Understanding passenger usages of multiple modes of transportation is a necessity before studying the connectivity of travel modes by passengers. Our definition allows for the inclusion of multiple travel modes (e.g., walking) that could be excluded under the standard definition of intermodalism.

METHODOLOGY

Data were obtained from the 2009 NHTS, which has been developed and maintained by the Federal Highway Administration. Data were collected by household, by person (age 5 or older), by vehicle, and by travel day from March 2008 to May 2009. We restructured the travel day dataset to reflect the number of trips, travel modes, and trip purposes, along with travel time and distance for each trip. This restructuring allowed us to merge the travel day dataset and the person dataset. It also allowed us to determine the number of different travel modes and trip purposes per person in a single day. Persons with no reported trips on the travel day were excluded from the analysis.

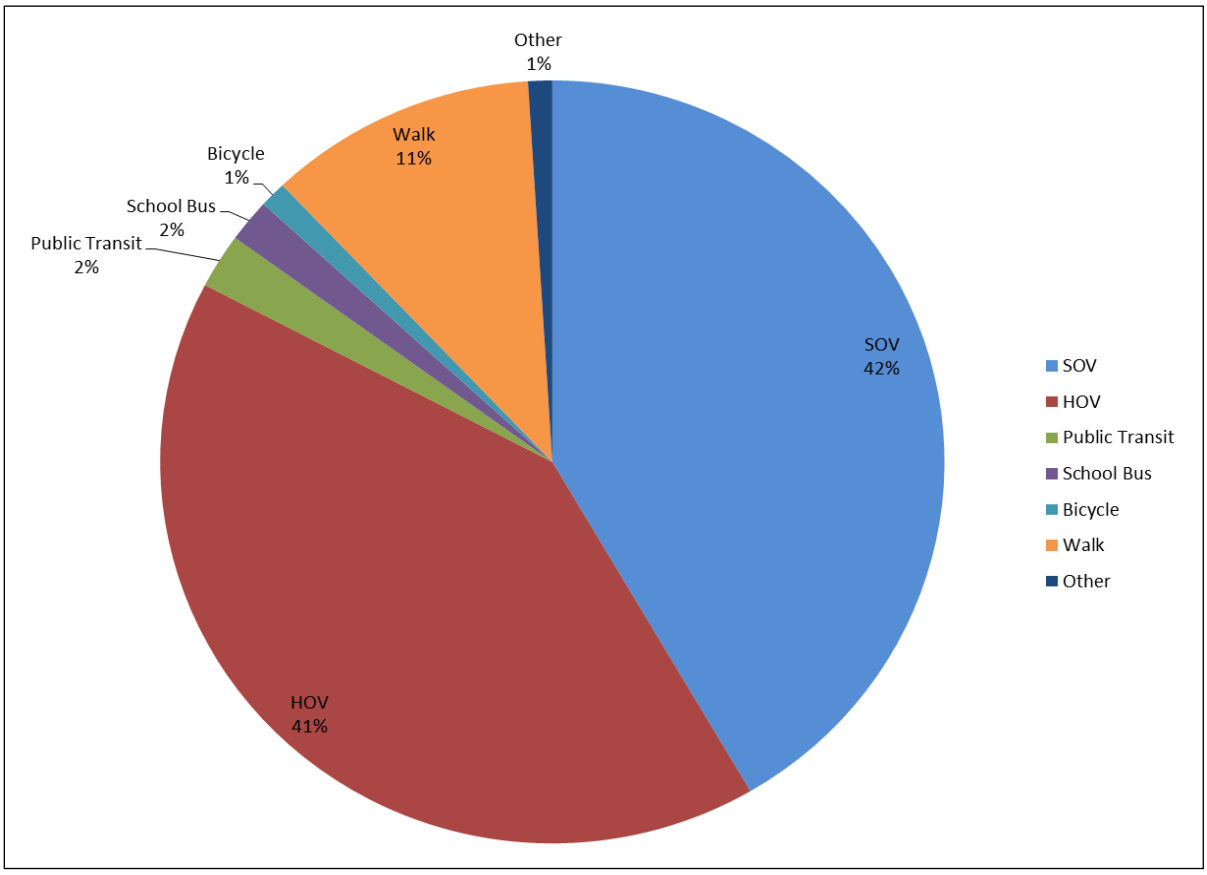

Figure 1. Distribution of Travel Modes

To construct travel mode variables, the data were recoded to reflect five different mode types: personal vehicle (consisting of car, van, sport utility vehicle, pickup truck, other truck,

recreational vehicle, motorcycle, and light electric vehicle); school bus; public transportation (consisting of any bus except school, any train, and streetcars or trolleys); non-motorized transportation (consisting of walking and bicycling); and other modes. Travel mode usage was shown in Figure 1. For informational purposes, we segmented personal vehicle into single occupancy vehicle (SOV) and high occupancy vehicle (HOV). SOVs indicate that an individual drove alone for a particular trip, while HOVs refer to at least two persons in the vehicle for the trip (Pucher & Renne, 2003). Overall, personal vehicles (SOVs and HOVs) were the travel mode for almost 83 percent of trips. Non-motorized transportation is also segmented into bicycling and walking. Non-motorized transportation was used for about 12 percent of trips, with walking accounting for the overwhelming majority of non-motorized trips.

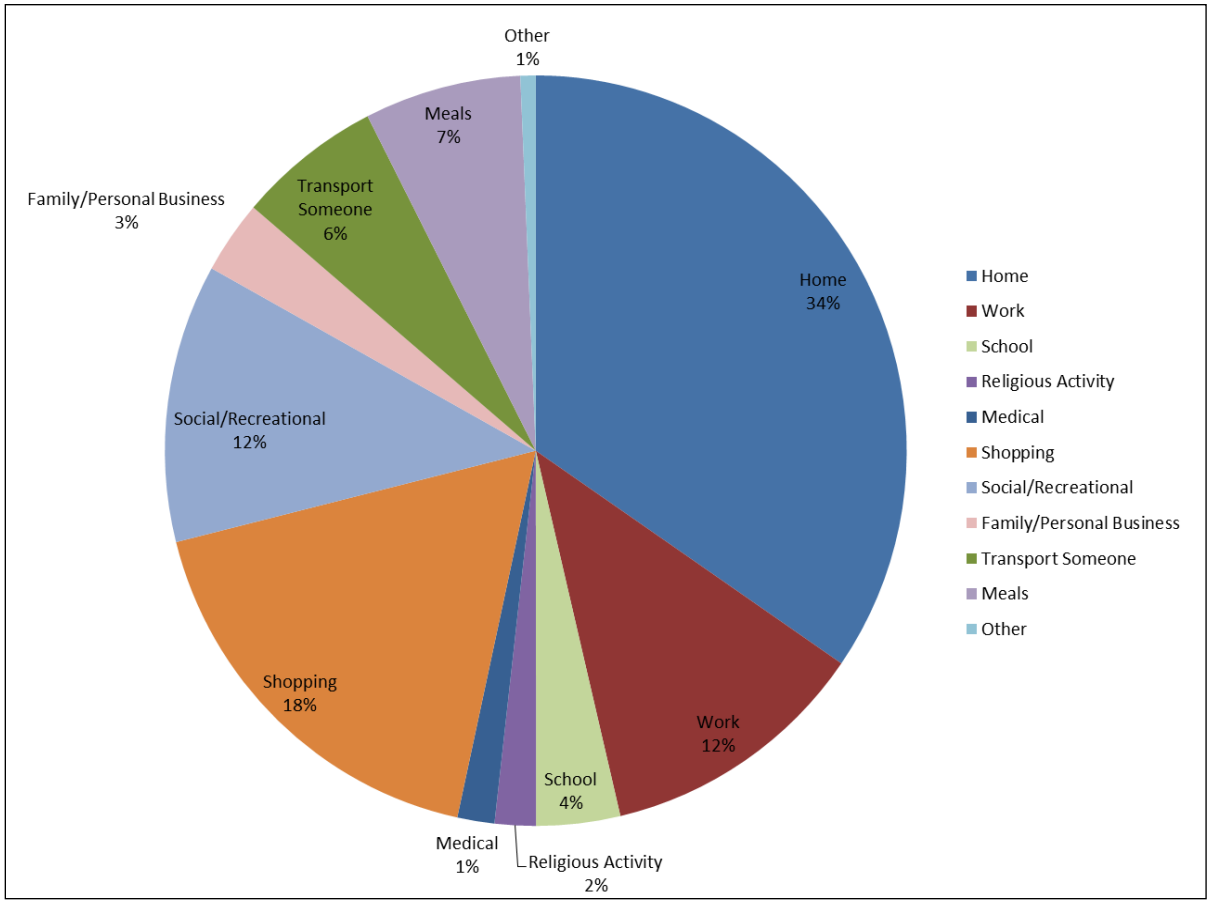

Figure 2. Distribution of Trip Purposes

The data were also recoded into 11 trip purposes: home, work, school, religious activity, medical/dental services, shopping, social/recreational, family or personal business, transporting someone, meals, and other trip purposes. Figure 2 showed the distribution of trips by purpose. Trips to home accounted for 34 percent of the total trips, followed by shopping at 18 percent. Trips for work and social/recreational each accounted for 12 percent of total trips.

While most trips rely on a personal vehicle, there was variability in the travel mode used by trip purpose, as shown in Figure 3. At least 90 percent of trips for the purposes of religious activity, shopping, and transporting someone relied on a personal vehicle. Public transportation use was largest for trips for some other purpose. School bus use had its largest share of trips for school. Biking had its largest share for trips for social/recreational purposes, while walking had large shares for trips for social/recreational, family/personal business, and some other purposes.

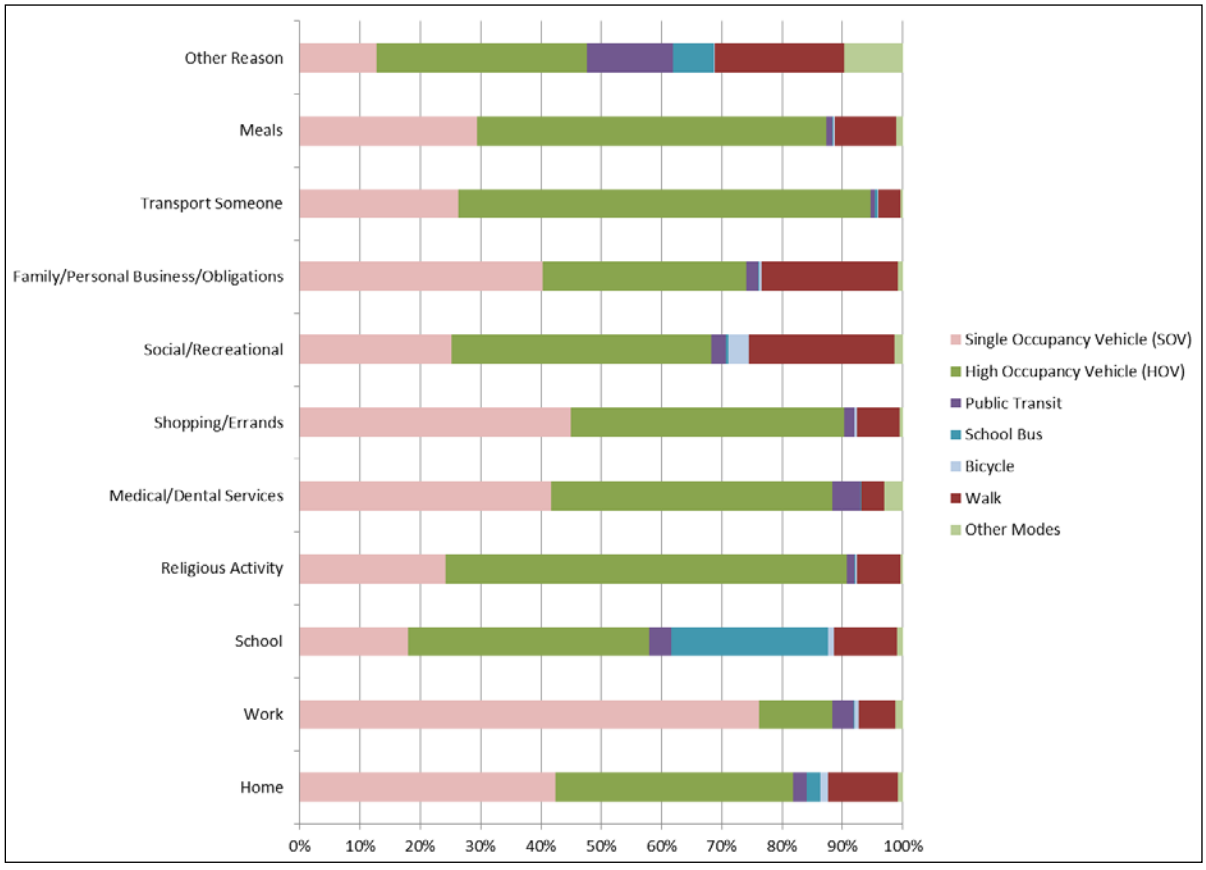

Figure 3. Travel Modes by Trip Purpose

We further investigated the association of these intermodal transportation measures to possible factors by using regression models. There were 16 response variables: trip frequency (1), the number of travel modes (1), the number of trip purposes (1), travel time (1), travel distance (1), and the number of travel modes by trip purposes (11). First, we examined the determinants of trip frequency, where the response variable was measured as the number of total trips a person took on travel day. Second, we examined the determinants that shaped the number of different travel modes used on travel day, followed by the number of different trip purposes that occurred on travel day. We also examined the determinants that shaped travel time per trip in minutes, followed by the travel distance per trip in miles. Third, for the remaining 11 response variables, which represent the number of travel modes per trip purpose, we constructed one model per response variable, for a total of 16 models.

The regression models considered 13 explanatory variables (i.e., determinants) that prior research had shown to shape travel behavior. Age, household size, number of household vehicles, and number of household drivers were each continuous variables. Female, Hispanic, black, U.S. born, worker, homeowner, and urban resident were all dummy variables. Education and income were categorical variables ranging from 1 to 5 and 1 to 18, respectively.

Descriptive statistics for both the response and explanatory variables were presented in Table 1. On average, individuals in the sample took 4.4 trips, used 1.2 different travel modes, and had 3.0 different trip purposes. Mean travel time was 20.2 minutes, while the mean travel distance was 9.8 miles. Mean travel modes by trip purpose ranged from 1.2 modes for religious activity purposes to 1.7 modes for some other purposes.

In order to select appropriate regression models for the response variables that were measured by count data, we compared their mean and variance to determine if overdispersion was present. Our analysis showed that only total trips exhibited overdispersion, suggesting that negative binomial regression was appropriate for that model. However, since overdispersion was not presented for travel modes, trip purposes, and the 11 travel modes by trip purposes variables, Poisson regression was appropriate for those models. Finally, two of

our response variables—travel time and travel distance—were not count data, so we used ordinary least squares (OLS) regression for those models. In order to compare the coefficients across different models, we presented standardized coefficients in the results section.

Table 1. Descriptive Statistics

Variables	Mean	Standard deviation	Minimum	Maximum
# total trips per day	4.424	2.451	1	27
# travel modes per day	1.215	0.456	1	4
# trip purposes per day	2.952	1.009	1	8
Travel time per trip (minutes)	20.174	31.036	1	1,439
Trip distance per trip (miles)	9.750	45.022	0.11	9,000
# modes by trip purpose				
Home	1.185	0.417	1	4
Work	1.172	0.406	1	4
School	1.380	0.564	1	4
Religious activity	1.156	0.383	1	4
Medical	1.161	0.391	1	4
Shopping	1.188	0.417	1	4
Social	1.319	0.512	1	4
Family/personal	1.300	0.491	1	4
Transporting someone	1.200	0.432	1	4
Meals	1.206	0.440	1	4
Other purposes	1.727	0.772	1	4
Explanatory variables				
Age	39.250	20.438	5	92
Female	0.503	0.500	0	1
Hispanic	0.150	0.357	0	1
Black	0.116	0.321	0	1
U.S. born	0.858	0.349	0	1
Worker	0.681	0.466	0	1
Education	3.026	1.180	1	5
Income	11.449	5.598	1	18
Homeownership	0.718	0.450	0	1
Urban	0.766	0.423	0	1
Household size	3.318	1.558	1	14
Household vehicles	2.227	1.272	0	27
Household drivers	2.130	0.921	0	9

DISCUSSION OF RESULTS

Overall Trips

Regression results for the response variables total trips, travel modes, trip purposes, travel time, and travel distance were presented in Table 2. The model for total trips indicated that several explanatory variables had a statistically significant effect on the total number of trips, net of other variables in the model. Females (relative to males), the U.S. born (relative to the foreign born), homeowners (relative to non-owners), and urban residents (relative to non-urban residents) positively predicted the total number of trips. Conversely, Hispanics (relative to non-Hispanic whites) and workers (relative to non-workers) negatively predicted the total number of trips. Education and income had positive associations with the total number of trips. Household size had a positive relationship with the total number of trips an individual took in one day, while the number of household drivers had an inverse relationship with the total number of trips taken.

The model for different travel modes used in one day indicated that age, household size, and the number of household vehicles had negative relationships with the number of modes used. Blacks (relative to non-Hispanic whites) and homeowners (relative to non-owners) were less likely to use several different travel modes. Income and the number of household drivers had positive relationships with the number of different travel modes.

In the model for different trip purposes, age, the number of household vehicles, and the number of household drivers had negative relationships with the different number of trip purposes. Females (relative to males), workers (relative to non-workers), homeowners (relative to non-owners), and urban residents (relative to non-urban residents) took more trips with different purposes on average. Conversely, Hispanics (relative to non-Hispanic whites) and the U.S. born (relative to foreign born) each had fewer different trip purposes on average. Education, income, and household size had positive relationships with the number of different trip purposes.

Table 2. Standardized Regression Coefficients

Variables	Total trips	Travel	Trip	Travel time	Travel distance
	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)
Age	0.038	–0.439***	–0.209***	0.018*	0.001
	(2.22E–4)	(1.57E–4)	(1.46E–4)	(0.032)	(0.028)
Female	0.210***	–0.060	0.379***	–0.040***	–0.042***
	(0.006)	(0.004)	(0.004)	(0.904)	(1.165)
Hispanic	–0.076**	–0.019	–0.089**	0.008	–0.020***
	(0.010)	(0.007)	(0.007)	(1.442)	(1.303)
Black	–0.049	–0.105*	–0.014	0.015*	0.001
	(0.004)	(0.004)	(0.003)	(0.734)	(0.737)
U.S. born	0.588***	–0.315	–0.552**	–0.134***	–0.087**
	(0.005)	(0.004)	(0.003)	(0.728)	(0.870)
Worker	–0.468**	–0.113	0.710***	0.169***	0.091**
	(0.006)	(0.004)	(0.003)	(0.770)	(0.884)
Education	0.766***	0.062	0.658***	0.074***	0.058***
	(0.001)	(0.001)	(0.001)	(0.191)	(0.164)
Income	0.448***	0.368***	0.538***	0.036***	0.040***
	(0.001)	(3.50E–4)	(0.002)	(0.073)	(0.085)
Homeownership	0.105***	–0.067*	0.157***	–0.017*	0.023***
	(0.009)	(0.006)	(0.006)	(1.239)	(1.124)
Urban	0.213***	0.279***	0.175***	–0.031***	–0.046***
	(0.007)	(0.005)	(0.004)	(1.032)	(1.193)
Household size	0.254***	–0.097*	0.109*	0.005	0.001
	(0.003)	(0.002)	(0.002)	(0.439)	(0.421)
# Household vehicles	0.017	–0.621***	–0.076	–0.008	0.043***
	(0.004)	(0.002)	(0.002)	(0.502)	(0.542)
# Household drivers	–0.236***	0.123**	–0.126**	0.017	0.001
Regression models	Negative	Poisson	Poisson	OLS	OLS

Notes: *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$;

Coef. = Coefficient;

SE = Standard Error.

Age had a positive relationship with travel time. Females (relative to males), the U.S. born (relative to foreign born), homeowners (relative to non-owners), and urban residents (relative to non-urban residents) had shorter travel times on average. Alternatively, blacks (relative to non-Hispanic whites) and workers (relative to non-workers) had longer travel times on average. Education and income had positive associations with travel time.

For travel distance, females (relative to males), Hispanics (relative to non-Hispanic whites), the U.S. born (relative to foreign born), and urban residents (relative to non-urban residents) traveled shorter distances on average. Conversely, workers (relative to non-workers) and

homeowners (relative to non-owners) traveled longer distances on average. Education, income, and the number of household vehicles had positive relationships with travel distance.

Home

Table 3 showed the standardized regression coefficients for the 11 response variables that measured the number of travel modes used by individual trip purpose. Age had an inverse relationship with the number of travel modes used to go home, suggesting that reliance on a single mode of transportation, such as a personal vehicle, potentially increased with age. Blacks used fewer travel modes to go home than non-Hispanic whites. This finding was surprising because blacks were more likely to use alternative travel modes compared to other racial/ethnic groups (Pucher & Renne, 2003). However, our findings suggested that blacks with home trips were more likely to use a single travel mode than were non-Hispanic whites. The U.S. born, on average, used fewer travel modes to go home than did the foreign born, potentially due to social norms regarding vehicle ownership and use in the U.S. Similarly, homeowners, compared to non-homeowners, used fewer travel modes to home on average. This finding may be due to household ownership being higher in suburban communities; thus homeowners were less likely to be reliant on alternative transportation modes and more likely to have access to personal vehicles. Household size had an inverse relationship with the number of travel modes used to go home, suggesting that persons from larger households were more likely to use a single travel mode. Similarly, the number of household vehicles had a negative association with the number of travel modes used to go home, suggesting that a higher number of household vehicles reduced household members' reliance on multiple transportation modes. Urban residents, relative to non-urban residents, used more travel modes to go home, potentially reflecting greater access to or use of alternative transportation modes among urban residents. Household income had a positive association with the number of travel modes used to go home. This finding may potentially indicate that persons with higher incomes may have the resources to travel home more frequently during the day. Finally, the number of household drivers had a positive relationship with the number of travel modes used to go home.

Table 3. Standardized (Poisson) Regression Coefficients for Trip Purposes

Variables	Home	Work	School	Religious activity	Medical	Shopping	Social
	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)
Age	–0.434***	–0.172	0.493*	–0.546**	–0.625***	–0.415***	–0.265**
	(1.595E–4)	(2.842E–4)	(7.378E–4)	(6.611E–4)	(6.124E–4)	(2.358E–4)	(2.773E–4)
Female	–0.057	–0.042	–0.168	–0.149	–0.043	–0.415	–0.111
	(0.005)	(0.007)	(0.013)	(0.019)	(0.017)	(0.007)	(0.008)
Hispanic	–0.027	–0.026	–0.015	0.374**	0.126	–0.029	–0.065
	(0.008)	(0.011)	(0.018)	(0.034)	(0.027)	(0.012)	(0.013)
Black	–0.102*	–0.119	–3.521E–4	–0.253*	–0.004	–0.100	–0.194*
	(0.004)	(0.008)	(0.009)	(0.009)	(0.013)	(0.006)	(0.006)
U.S. born	–0.373*	–0.183	0.697	–0.854	–0.297	–0.889**	1.583***
	(0.004)	(0.007)	(0.016)	(0.014)	(0.017)	(0.006)	(0.006)
Worker	–0.058	–1.100	–0.945	0.752	–0.012	0.589*	1.094***
	(0.004)	(0.013)	(0.016)	(0.014)	(0.017)	(0.006)	(0.006)
Education	0.045	0.579***	–0.788***	0.182	0.320*	0.160	0.085
	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)
Income	0.338***	0.340***	0.322**	0.515***	0.204*	0.273***	0.396***
	(3.589E–4)	(6.346E–4)	(0.001)	(0.001)	(0.001)	(0.001)	(6.142E–4)
Homeownership	–0.078**	–0.125**	0.045	–0.035	–0.107	–0.115**	–0.084
	(0.006)	(0.011)	(0.018)	(0.020)	(0.022)	(0.008)	(0.011)
Urban	0.275***	0. 266***	0.073	0.136	0.251***	0.401***	0.327***
	(0.005)	(0.008)	(0.015)	(0.015)	(0.017)	(0.006)	(0.008)
Household size	–0.100**	0.028	–0.036	–0.192	0.152	–0.046	–0.147
	(0.002)	(0.004)	(0.005)	(0.007)	(0.009)	(0.003)	(0.004)
# Household vehicles	–0.624***	–0.785***	–0.613***	–0.551**	–0.589***	–0.732***	–0.594***
	(0. 003)	(0.004)	(0.006)	(0.011)	(0.010)	(0.004)	(0.004)
# Household drivers	0.134**	0.158*	0.144	–0.039	–0.115	0.149*	0.125
	(0. 004)	(0.006)	(0.010)	(0.014)	(0.014)	(0.006)	(0.007)

Table 3 (continued)

Variables	Family/ personal	Transporting someone	Meals	Other
	Coef. (SE)	Coef. (SE)	Coef. (SE)	Coef. (SE)
Age	–0.628***	–0.278*	–0.624***	–0.570*
	(5.360E–4)	(3.887E–4)	(3.480E–4)	(0.001)
Female	–0.061	0.068	–0.126*	–0.186
	(0.014)	(0.011)	(0.009)	(0.039)
Hispanic	–0.082	–0.008	0.063	0.164
	(0.023)	(0.016)	(0.020)	(0.048)
Black	–0.194*	–0.295	–0.137	–0.299*
	(0.009)	(0.014)	(0.009)	(0.015)
U.S. Born	1.039*	–0.298	–0.617	–1.548
	(0.012)	(0.010)	(0.009)	(0.036)
Worker	0.993*	–0.157	0.493	1.326
	(0.011)	(0.010)	(0.009)	(0.038)
Education	0.042	–0.264	0.099	0.391
	(0.004)	(0.003)	(0.002)	(0.006)
Income	0. 319***	0.218	0.319***	0.338
	(0.001)	(0.001)	(7.253E–4)	(0.003)
Homeownership	–0.067	–0.049	–0.116*	0.401**
	(0.020)	(0.014)	(0.013)	(0.146)
Urban	0.394***	0.257***	0.299***	0.273
	(0.014)	(0.011)	(0.010)	(0.052)
Household size	–0.080	0.162	–0.229**	–0.243
	(0.007)	(0.005)	(0.005)	(0.015)
# Household vehicles	–0.602***	–0.688***	–0.717***	–0.633**
	(0.008)	(0.005)	(0.005)	(0.022)
# Household drivers	0.090	0.111	0.104	0.073
	(0.013)	(0.009)	(0.008)	(0.029)

Notes: *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$;

Coef. = Coefficient;

SE = Standard Error

Work

Homeowners, relative to non-owners, used fewer travel modes to get to work, likely reflecting differences in travel distances or access to alternative travel modes. The number of household vehicles had a negative association with the number of travel modes used to go to

work, likely due to household workers having access to personal vehicles. Conversely, the number of household drivers had a positive relationship with the number of travel modes used to get to work. Explaining this finding seemed less intuitive, although it potentially indicated a measurement issue as fewer household drivers may indicate that some household members did not travel to work. Both education and income had a positive relationship with the number of travel modes used to get to work. This finding may also merely be a measurement artifact, since those with a higher educational attainment and/or a higher income were likely to be in the workforce. Urban residents, relative to non-urban residents, used more travel modes to get to work. This finding may be due to greater access to alternative transportation modes in urban areas.

School

Age had a positive association with the number of travel modes used to get to school. This finding seemed counterintuitive, but it was possible that persons who traveled to school used more modes. Household income also had a positive relationship with the number of modes used to travel to school, possibly reflecting that persons with higher household income were more likely to go to school. Conversely, education had an inverse relationship with the number of travel modes used to get to school, likely reflecting the transition from childhood to adulthood by working on high school and college degrees. Similarly, the number of household vehicles had an inverse association with the number of modes used to get to school, possibly indicating that access to a personal vehicle reduced use of alternative transportation modes.

Religious Activity

Age had an inverse relationship with the number of modes used to travel to religious activities, potentially suggesting that older persons were more likely to rely on a single travel mode. Blacks, compared to non-Hispanic whites, used fewer modes to travel to religious activities. This finding was unexpected, but it likely indicated that blacks in our sample took fewer religious activity trips compared to non-Hispanic whites. Alternatively, Hispanics,

compared to non-Hispanic whites, used more travel modes for religious activity trips, potentially indicating their greater reliance on alternative travel modes. The number of household vehicles also had an inverse relationship with the number of modes used to travel to religious activities, likely indicating that greater access to personal vehicles reduced the use of alternative travel modes. Household income had a positive association with the number of modes used to travel to religious activities. This finding was also surprising, given that households with higher incomes likely had access to personal vehicles. However, since the number of household vehicles was included as a control variable, this finding may simply reflect income differences in religious activity participation.

Medical

Age had a negative association with the number of travel modes used for medical-related trips. While medical-related trips likely increased with age, this finding possibly indicated that older persons relied on single mode of transportation. The number of household vehicles was a negative explanatory variable of the number of travel modes used for medical-related trips, potentially because more household vehicles reduced the use of alternative modes of transportation. Education and household income had positive associations with the number of travel modes used for medical-related trips, likely reflecting that higher levels of education or income were linked to greater access to medical care or more frequent use of medical services. Urban residents, compared to non-urban residents, used more travel modes for medical-related trips. This finding potentially reflected greater access to alternative travel modes in urban areas.

Shopping

Age had a negative relationship with the number of travel modes used for shopping trips, likely reflecting greater access to a personal vehicle. The U.S. born, compared to the foreign born, used fewer travel modes for shopping, potentially indicating that the U.S. born were more likely to travel by a personal vehicle compared to the foreign born. Homeowners, compared to non-owners, used fewer travel modes for shopping, likely reflecting differences

in travel distance to shopping places. The number of household vehicles had a negative association with the number of travel modes used for shopping trips, likely because personal vehicles were the preferred travel mode for many Americans. Household income had a positive association with the number of travel modes used for shopping trips, although this finding likely indicated differences in income rather than the number of travel modes used for shopping trips. Urban residents, compared to non-urban residents, used more travel modes for shopping, likely because of greater access to public transit and alternative travel modes. Workers also used more travel modes for shopping trips, relative to non-workers. This finding likely reflected that workers may have greater access to alternative travel modes than non-workers. Finally, the number of household drivers had an inverse relationship with the number of travel modes used for shopping trips, likely reflecting greater access to a personal vehicle.

Social/Recreational

Age had a negative association with the number of travel modes used for social or recreational trips, indicating that reliance on a single travel mode increased with age. Blacks, relative to non-Hispanic whites, used fewer travel modes for social trips. We had expected that blacks would use more travel modes than non-Hispanic whites due to greater use of alternative travel modes among blacks. However, our finding likely reflected that blacks take fewer trips for social purposes compared to non-Hispanic whites. The number of household vehicles had a negative association with the number of travel modes used for social trips, likely due to access to a personal vehicle. The U.S. born used more travel modes for social trips compared to the foreign born. This finding was unexpected as immigrants were more likely to use alternative travel modes. However, this finding may actually reflect nativity differences in the number of trips for social or recreational purposes rather than differences in the number of travel modes. Workers, compared to non-workers, used more travel modes for social trips, likely reflecting that workers had greater access to alternative travel modes than non-workers. Household income had a positive association with the number of travel modes used for social trips, likely reflecting the relationship between income and social trips. Urban residents, compared to non-urban residents, used more travel modes for social trips, likely because urban residents had greater access to alternative transit modes.

Family/Personal Business

Age had a negative association with the number of travel modes used for family or personal business, likely indicating that reliance on a single travel mode increases with age. Blacks, relative to non-Hispanic whites, used fewer travel modes for family or personal business. This finding possibly reflected that blacks took fewer trips for personal business, rather than used fewer travel modes than non-Hispanic whites. The number of household vehicles had a negative relationship with the number of travel modes used for personal business trips, indicating that access to a personal vehicle reduced use of alternative travel modes. The U.S. born, relative to the foreign born, used more travel modes for family or personal business trips, likely reflecting nativity differences in the number of family or personal business trips. Workers also used more travel modes for family or personal business trips than did non-workers, likely indicating the greater access to alternative travel modes by workers. Household income also had a positive association with the number of travel modes used for family or personal business trips. This finding also possibly suggested that persons from higher income households were more likely to travel for family or personal business trips, rather than use multiple travel modes. Urban residents, compared to non-urban residents, used more travel modes, likely indicating the greater access to alternative travel modes.

Transporting Someone

Age had a negative relationship with the number of travel modes used for trips to transport someone, likely indicating that use of a single travel mode increased with age. The number of household vehicles also had a negative association with the number of travel modes used to transport someone. This finding suggested that access to a personal vehicle reduced the use of alternative travel modes. Urban residents, compared to non-urban residents, used more travel modes for trips to transport someone, likely reflecting that urban residents had greater access to alternative travel modes.

Meals

Age had a negative association with the number of modes used to travel for meal trips, likely indicating that use of a single travel mode increased with age. Females used fewer travel modes for meal trips compared to males. This finding likely reflected that fewer females traveled for meal trips compared to males. Household size also had a negative association with the number of travel modes used for meal trips. While this finding could suggest that larger households may use fewer travel modes, it could also indicate smaller households were more likely to travel for meals. Similarly, the number of household vehicles had a negative association with the number of travel modes used for meal trips, likely indicating that access to a personal vehicle reduced the use of alternative travel modes. Homeowners, compared to non-owners, used fewer travel modes for meal trips, possibly reflecting that non-owners may live in areas with access to alternative travel modes. Finally, household income had a positive association with the number of travel modes used for meal trips, likely indicating that persons from higher income households took more meal trips rather than used more travel modes.

Other Trip Purposes

Age had a negative association with the number of modes used to travel for some other trip purposes. As with the previous trip purposes, this finding suggested that use of a single travel mode increased with age. Blacks used fewer travel modes for some other trip purpose compared to non-Hispanic whites. Although this finding was unexpected, it likely indicated racial differences in the number of trips rather than in the number of travel modes. The number of household vehicles had a negative association with the number of travel modes used for some other trip purposes. This finding suggested that access to a personal vehicle reduces the use of alternative travel modes. Homeowners, compared to non-owners, used more travel modes for some other trip purposes. Although this finding was unexpected, it likely reflected that home owners were more likely to travel for some other trip purposes compared to non-owners.

CONCLUSIONS

This study provided a preliminary look at passenger intermodal transportation using the 2009 NHTS data. We broadly defined passenger intermodal transportation to include multiple travel modes. We first examined the numbers of trips taken, travel modes used, and trip purposes in relate to thirteen factors. The findings indicated what personal or household characteristics influenced passenger intermodal transportation use. Among the thirteen explanatory variables included in our models, only household income and urban residency positively shaped the number of total trips, travel modes, and trip purposes. Three more explanatory variables—homeownership, household size, and the number of household drivers—also shaped the number of total trips, travel modes, and trip purposes, although the direction of the effect varied. Overall, each of our thirteen explanatory variables had an association with either the number of total trips, travel modes, or trip purposes.

We also examined how these thirteen factors were associated with travel time and distance. Eleven of the thirteen factors shaped either travel time or distance (only household size and the number of household drivers had no effect on either). Being female, U.S. born, or an urban resident negatively shaped travel time and travel distance; being in the workforce, education, and household income positively shaped travel time and travel distance. Homeownership shaped both travel time and distance, although the direction of the effect differed. Other factors influenced either travel time or distance, but not both.

Finally, we examined the factors that were associated with the number of travel modes for eleven trip purposes. The number of household vehicles was the only consistent explanatory variable, having a negative effect on the number of travel modes regardless of trip purpose. This finding seemed logical given that access to a personal vehicle reduces reliance on alternative travel modes. Age was the only other explanatory variable that consistently shaped the number of travel modes by trip purpose. Age negatively shaped multiple travel modes by trip purpose, suggesting that older persons were less likely to use multiple travel modes. We did find one exception, as age positively shaped the number of travel modes used for trips to school. Urban status positively shaped the number of travel modes for eight of the eleven trip purposes. This finding also seemed logical given that urban residents were more

likely to have access to alternative travel modes, such as public transit. Household income also positively shaped the number of travel modes for nine of the eleven trip purposes. However, this finding was not as expected. Instead, household income possibly indicated the likelihood of traveling for a specific purpose rather than indicating that persons from higher-income households used more travel modes than did those from lower income households.

RECOMMENDATIONS

While this study provided a first relatively comprehensive look at passenger intermodal transportation, the findings were preliminary. Further insights could be gained by extending this research into at least three directions. First, future passenger intermodal transportation research could benefit from gender and racial/ethnic variations in mode usages by trip purpose, primarily because the American population is undergoing demographic changes that may impact the usage of the passenger intermodal systems. For example, the Hispanic population has experienced rapid growth, becoming the largest minority group in the U.S. Hispanics are also increasing in their share of labor force participation: thus it is important to understand racial/ethnic differences in passenger intermodal transportation usage. A second area for future research should focus on socioeconomic variations in mode usages by trip purpose. It is important to understand socioeconomic variations by occupation, income, education, and homeownership/vehicle ownership because they present different needs for passengers in transportation systems and have important implications regarding access, cost, and safety for transportation planners. A third stream of future research should focus on intermodal transportation for an aging population. Although older adults take fewer trips and travel shorter distances compared to other adults (*8,11*), increases in the overall size of the older population (e.g., baby boomers), and possible longer tenure in the workforce may suggest changing travel patterns of older Americans. Overall, passenger intermodal transportation could be studied further from the perspective of demographic variations.

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

NHTS	National Household Travel Survey
SOV	Single Occupancy Vehicle
HOV	High Occupancy Vehicle
OLS	Ordinary Least Squares
Coef	Coefficient
SE	Standard Error

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