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Travel Patterns in 2015 of Older Adults in the United States and the Implications for Mobility and Traffic safety

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ABSTRACT

Objectives: With an ever increasing population of older adults (65+ years) in the United States, a better understanding of this population's travel patterns is needed to improve travel mobility and transportation safety. In this study, we described the travel patterns in 2015 of older adults in the United States.

Methods: Travel patterns of older adults (65-74 and 75+ years) were compared with younger adults (25-64 years) by frequency and proportions of daily trips. The daily trips of different age groups were estimated using the 2015 American Time Use Survey.

Results: The percentages of daily travelers were 88% for adults (25-64 years), 75% for adults (65-74 years), and to 68% for adults (75+ years). While the percentage of privately owned vehicle (POV) drivers and average time of driving POVs decreased, the percentage of POV passengers increased as adults aged. Females were less likely to drive POVs and had less average daily driving time, but they were more likely to ride in POVs and had longer average daily riding times than their male counterparts across all age groups. Older adults' were more likely to travel in the mornings and early afternoons (8:00 AM to 3:59 PM) while younger adults were more likely to travel in the late afternoons and early evenings (4:00 PM-7:59 PM).

Conclusions*:* Privately owned vehicle use is the predominant mode of transit in the United States. As adults age, the percentages of daily travelers and POV drivers decrease. This pattern is more apparent among females than males.

Keywords: privately owned vehicles, mobility, passengers, average of driving time

ARTICLE SUMMARY

Strengths and limitations of this study

- This study used the most recent 2015 American Time Use Survey (ATUS) dataset to identify travel patterns of older adults.
- Older adults' travel patterns were evaluated using multiple measures including the percentage of each mode of transit for daily trips (e.g., privately owned vehicles (POVs) and bus) and the average times of driving POVs and riding in POVs.
- Some information of older adults' daily trips is not available in the ATUS, such as the distance travelled per trip, limiting the ability of this study to evaluate the distance per trip for older adults.
- As adults age, their tendency to drive POVs decreases and to ride as a passenger increases. The limited use of busses may require more complete studies and designs of public transit systems to meet the older adults' mobility needs.

1 BACKGROUND

Older adults (65 years or over) were more likely to be severely injured in a motor vehicle collisions compared to younger adults. [1-3] Older adults also had one of the highest crash rates per unit of exposure (e.g., vehicle miles of travel).[4 5] In addition, both the absolute and proportional growth of the older population have increased continuously from 2010 to 2014.[6] The population of older adults in the United States (U.S.) is expected to exceed 86 million by 2050.[7] Thus, older adults' vulnerability in traffic crashes and their increased population have posed significant concerns regarding their transportation safety and mobility. To improve transportation safety and mobility for older adults, comparisons of travel patterns with younger counterparts may reveal important insights. Numerous studies have investigated the travel patterns of older Americans using the National Household Transportation Survey (NHTS).[8-12] These studies found that mobility patterns were characterized by a major reliance on privately owned vehicles (POVs) across gender and age groups with lower proportions of cyclists and pedestrians. A detailed summary of travel trends was produced by Santos, et al. [9] using the 2009 NHTS which identified older adults (65+ years) as spending the least amount of time in a vehicle, either as a driver or as a passenger. Additionally, older drivers had the least average annual miles per licensed driver compared to other adult drivers.[9] Compared to previous generations, the current generation of older adults are maintaining their driver's licenses longer, postponing retirement, and more mobile.[13-16] Therefore, identifying older adults travel patterns using more recent data is important due to the potential shifts in travel behaviors.

This study aimed to identify travel patterns of the older adult population using the more recent 2015 American Time Use Survey (ATUS) dataset, which has not been widely used to estimate travel exposures. Specifically, this study described the mobility patterns of the older adult population compared with the younger adult population via frequencies and proportions of daily trips. While using these different measures of travel exposure, the study's findings highlighted some similarities to previous studies (e.g., Santos, et al. [9] using the 2009 NHTS), and identified new mobility patterns of older adults. Understanding these mobility patterns will add to the existing knowledge of older adult travel behaviors

and may be useful in policymaking, transportation planning, or road design to help accommodate the aging U.S. population.

2 METHODS

2.1 Data Source

The 2015 American Time Use Survey (ATUS), an annual nationally representative survey by the U.S. Census Bureau, was the primary data source for this cross-sectional analysis. One of the functions of the ATUS is to discern how U.S. residents 15 years or older spend their time on daily activities. The respondents of the 2015 ATUS were weighted for their selection probability, day of the week responded (i.e., weekday or weekend), and response rate. All ATUS survey data were collected through computer-assisted phone interviews. The ATUS methodology has been described in detail elsewhere.[17]

One section of the ATUS was a time-use diary, which was used to record respondents' daily activities, starting at 4:00 AM on the previous day and ending at 4:00 AM on the interview day. For each activity, the respondents were asked to provide information regarding the duration of the activity, who accompanied the respondent, and where the activity took place. For our study, if the place of an activity was coded as "blank", "do not know", and "refused to answer", the whole record of that activity was removed from the analysis. Modes of transportation initially included privately owned vehicles (POVs) (as both a driver and passenger), walking, biking, riding in a bus, train, boat, taxi, plane, or other modes. Other modes of transportation in the survey referred to unspecified modes of transportation. Privately owned vehicles in this study referred to cars, trucks, or motorcycles.

In this analysis, trips were defined as movement from one point to another using any given mode of transportation. For example, if an individual stated that he/she left his/her house and drove to the grocery store, this was counted as one trip. Later, after the individual finished grocery shopping, the return trip was counted as another trip. Adults (25-64 years) were the majority of road users and often considered as reference group. [18-20] Older adults' travel patterns and behaviors were compared with those

25-64 years. For our study purposes, ages were categorized by group as (1) 25-64 years, (2) 65-74 years, and (3) 75+ years.

2.2 Statistical Analysis

Travel patterns were evaluated after stratification by age and gender using percentage of each mode of transit for daily trips, the percentage of users of each transit mode per day, the average times of driving POVs and riding in POVs, and the percentages of driving POVs in different time periods during a day. The travel behaviors of weekdays and weekends were also compared in this study. Due to the multistage stratification property of the ATUS, the balanced repeated replication was used to estimate the variance and the 95% confidence interval (95% CI) for each estimate that could be developed. The detailed information of balanced repeated replication variance has been described elsewhere [21 22].

3 RESULTS

The 2015 ATUS study population included 5,634 females and 4,297 males (25 years or older). The sample age group distribution was as follows: 7,519 (25-64 years), 1,484 (65-74 years), and 928 (75+ years). Normalized to the US population, survey results showed adults (25-64 years) took 23.95 billion daily trips, adults (65-74 years) took 3.22 billion daily trips, and those (75+ years) took 1.81 billion daily trips. Among those trips, the percentage of daily driving trips in privately owned vehicles (POVs) decreased as adults aged, while the percentage of daily riding trips in POVs increased with age (Table 1). Specifically, the percentages of daily driving trips in POVs for adults (25-64, 65-74, and 75+ years) were 77.6% (95% CI: 76.5-78.8%), 72.9% (95% CI: 69.3-76.5%), and 68.9% (95% CI: 64.8-73,1%), respectively. The percentages of daily riding trips in POVs for the same age groups were 12.4% (95% CI: 11.6-13.3%), 18.6% (95% CI: 16.1-21.2%), and 24.5% (95% CI: 20.8-28.2%), respectively. The percentages of daily walking trips among all trips across the three age groups ranged from 5.2% to 7.0%. The percentages for all other modes of daily transportation including bus, bicycle, train, boat, taxi, plane, and other were each $\leq$ 1% to negligible.

Table 1. Distribution of daily trips by mode of transit using the 2015 American Time Use Survey, United States population

Transit Mode	Age: 25-64		Age: 65-74		Age: 75+	
	%	95% CI[a]	%	95% CI	%	95% CI
POVs[b] (Drivers)	77.6	(76.5 - 78.8)	72.9	(69.3 - 76.5)	68.9	(64.8 - 73.1)
POVs (Passengers)	12.4	(11.6 - 13.3)	18.6	(16.1 - 21.2)	24.5	(20.8 - 28.2)
Walk	7.0	(6.4 - 7.7)	5.8	(3.9 - 7.8)	5.2	(3.7 - 6.8)
Bus	0.9	(0.7 - 1.2)	1.1	(0.6 - 1.6)	0.4	(0.0 - 0.9)
Bicycle	0.4	(0.2 - 0.6)	0.1	(0.0 - 0.3)	0.2	(0.0 - 0.4)
Train	1.0	(0.7 - 1.3)	1.1	(0.0 - 2.3)	0.0	(0.0 - 1.2)
Boat	0.0	(0.0 - 0.0)	0.1	(0.0 - 0.2)	0.2	(0.0 - 0.5)
Taxi	0.3	(0.2 - 0.4)	0.1	(0.0 - 0.2)	0.2	(0.0 - 0.5)
Plane	0.0	(0.0 - 0.1)	0.1	(0.0 - 0.2)	0.1	(0.0 - 0.3)
Others[c]	0.1	(0.0 - 0.2)	0.1	(0.0 - 0.3)	0.1	(0.0 - 0.4)
Total	100.0		100.0		100.0	

[a] CI, confidence interval; [b] POV, privately owned vehicles; [c] unspecified mode of transportation

Since walking and driving and riding in POVs were the most common forms of transportation across all adult age groups, we analyzed all daily US travelers by age and gender distribution per transportation mode (Table 2). For adults (25-64 years), 87.7% (95% CI: 86.7-88.7%) of them travelled per day, while this percentage decreased as adults aged [74.9% (95% CI: 72.6-77.2%) for adults (65-74 years) and to 67.7% (95% CI: 63.9-71.4%) for adults (75+ years)]. While the percentages of all travelers by male (88.0%) and female (87.3%) were similar for adults 25-64 years, the divide began to widen for adults 65-74 years (73.5% for females; 76.5% for males). The divide continued to widen with age to where males (75+ years) accounted for 73.1% vs. 63.8% for females. The percentage of POV drivers per day decreased as adults aged. The percentage of males driving POVs was higher than for females per each age group. By 75+ years the percentage of adults driving POVs for males was 58.4% (95% CI: 52.1-64.7%), one and one-half times more their female counterparts [37.9% (95% CI: 32.8-43.1%)] (Table 2). With the decrease in the percentage of aging POV drivers, the percentage of older POV passengers increased by 7%. The percentage of POV passengers for all adults (25-64 years) was 16.7% (95% CI: 15.7-17.7%) , increasing to 19.8% (95% CI: 17.3-22.2%) and 23.9% (95% CI: 20.2-27.5%) for adults 65-74 years and 75+ years, respectively. Since males were more likely to drive POVs, males represented a lower percentage of POV passengers than females per age group. Additionally, older adults (65-74 and

75+ years) had lower percentages of walkers compared to those (25-64 years), [7.0% (95% CI: 5.3-8.6%) and 5.5% (95% CI: 3.6-7.3%) compared to 10.4% (95% CI: 9.6-11.2%), respectively] (Table 2).

Table 2. Daily travel of United States population (2015): percent of all travelers and percent travelers per mode of transit by age and gender

	All Travelers		POV[a] Drivers		POV Passengers		Walkers	
	%	95% CI[b]	%	95% CI	%	95% CI	%	95% CI
Ages 25-64								
Female	87.3	(86.0 - 88.7)	70.1	(68.3 - 71. 9)	22.2	(20.7 - 23.7)	11.2	(9.9 - 12.5)
Male	88.0	(86.5 - 89.6)	77.4	(75.5 - 79.3)	10.9	(9.6 - 12.2)	9.6	(8.5 - 10.7)
Both	87.7	(86.7 - 88.7)	73.7	(72.4 - 74.9)	16.7	(15.7 - 17.7)	10.4	(9.6 - 11.2)
Ages 65-74								
Female	73.5	(70.6 - 76.5)	53.4	(49.8 - 57.0)	27.9	(24.4 - 31.4)	5.7	(4.0 - 7.3)
Male	76.5	(72.6 - 80.4)	67.0	(62.3 - 71.7)	10.3	(6.8 - 13.9)	8.5	(5.4 - 11.5)
Both	74.9	(72.6 - 77.2)	59.7	(57.0 - 62.4)	19.8	(17.3 - 22.2)	7.0	(5.3 - 8.6)
Ages 75+								
Female	63.8	(58.9 - 68.8)	37.9	(32.8 - 43.1)	28.9	(23.9 - 33.8)	5.1	(2.8 - 7.4)
Male	73.1	(67.5 - 78.7)	58.4	(52.1 - 64.7)	16.8	(11.2 - 22.4)	6.0	(2.9 - 9.0)
Both	67.7	(63.9 - 71.4)	46.5	(42.4 - 50.5)	23.9	(20.2 - 27.5)	5.5	(3.6 - 7.3)

[a] POV, privately owned vehicles; [b] CI, Confidence Interval

* As one adult might use multiple modes of transportation per day, the summation of the percentages of POV drivers, POV passengers, and walkers per row was not necessary to be equal to 100.0%.

The most common mode of transportation in the US is the privately owned vehicle (POV). Differences in the average daily driving and riding times in POVs were analyzed by gender and age group and shown in Table 3. The average daily driving time in POVs decreased as adults aged [55.7 min (95% CI: 53.9-57.5 min), 38.6 min (95% CI: 35.4-41.8 min), and 28.4 min (95% CI: 24.3-32.6 min) for adults in groups 25-64, 65-74, and 75+ years, respectively. Additionally, adult females drove less but rode longer times in POVs than their male counterparts per age group. However, differences between age groups in average riding times in POVs were negligible (i.e., within each reported CI) (Table 3).

Table 3. Distribution of daily driving and riding times in POVs by gender and age group, United States population, 2105.

	POV[a] Drivers		POV Passengers	
	mean (min)	95% CI[b]	mean (min)	95% CI
Ages 25-64				
Female	50.1	(47.8 - 52.3)	15.1	(13.6 - 16.6)
Male	61.6	(58.7 - 64.4)	7.4	(5.7 - 9.0)
Both	55.7	(53.9 - 57.5)	11.3	(10.2 - 12.5)
Ages 65-74				
Female	32.6	(28.8 - 36.4)	18.0	(14.4 - 21.6)
Male	45.5	(40.5 - 50.6)	5.7	(3.6 - 7.9)
Both	38.6	(35.4 - 41.8)	12.3	(10.2 - 14.5)
Ages 75+				
Female	18.9	(15.5 - 22.3)	14.5	(12.0 - 17.0)
Male	41.7	(40.5 - 50.6)	8.0	(5.2 - 10.8)
Both	28.4	(24.3 - 32.6)	11.8	(10.0 - 13.6)

[a] POVs, Privately Owned Vehicles; [b] CI, Confidence Interval

To understand the travel patterns per age group for weekdays (Monday-Friday) versus weekends (Saturday-Sunday), we analyzed the data by number of traveling and driving trips per day and the percentages of POV drivers (Table 4). Adults (25-64 years) did slightly more traveling and driving trips per day during the week than on weekends. Again, for adults (65-74 years), the average number of traveling trips on a weekday was slightly greater than that on weekends. However, the average difference in the number of traveling and driving trips between weekday and weekend were not apparent for adults (75+ years). Additionally, the percentages of travelers and POV drivers were also not apparently different between weekday and weekend across all age groups, due to the overlapping CIs. The percentage of daily trips per time intervals throughout the day is analyzed for each age group (Figure 1). Older adults (65-74 and 75+ years) took more trips in the mornings and early afternoons (between 8:00-11:59 AM and 12:00-3:59 PM) than other time periods, while adults (25-64 years) took more trips in the late afternoons and early evenings (between 4:00-7:59 PM) (Figure 1).

Table 4. The average number of travelling and driving trips and percentage of travelers and POV drivers by age and weekday

	All Traveling Trips		Driving Trips		Travelers		POV[a] Drivers	
	mean	95% CI[b]	mean	95% CI	%	95% CI	%	95% CI
Ages 25-64								
Weekday	4.0	(3.9-4.1)	3.0	(2.9-3.1)	88.4	(87.2-89.5)	74.6	(73.1-76.1)
Weekend	3.4	(3.3-3.6)	2.5	(2.4-2.6)	85.9	(84.2-87.6)	71.4	(69.3-73.4)
Ages 65-74								
Weekday	3.4	(3.1-3.6)	2.3	(2.2-2.5)	76.5	(73.5-79.4)	60.4	(57.1-63.8)
Weekend	2.7	(2.5-3.0)	2.0	(1.8-2.3)	71.1	(65.8-76.3)	57.8	(52.4-63.1)
Ages 75+								
Weekday	2.6	(2.4-2.9)	1.8	(1.6-2.0)	67.4	(63.0-71.7)	46.6	(41.6-51.6)
Weekend	2.4	(2.1-2.7)	1.6	(1.3-1.8)	68.5	(61.6. 75.4)	46.1	(39.7-52.5)

[a] POVs, Privately Owned Vehicles; [b] CI, Confidence Interval

<<Figure 1 insert here>>

Figure 1. Distribution of daily trips according to time of day (military time) by age group for the United States in 2015.

4. DISCUSSIONS

Since Ford's Model T, American's have a long standing penchant for privately owned vehicles (POVs) [23]. How does age affect the driving habits, number or trips daily, and preferred modes of travel in our aging society? 2015 data show that most trips by Americans, regardless of their age and gender, were completed using POVs (Table 1), suggesting most adults still rely heavily on POVs for mobility as the primary mode of transportation in the US. Reporting from the 2009 National Household Transportation Survey (NHTS), Santos, et al. [9] calculated that 83.4% of trips were completed in POVs in 2009. While older adults (65-74 and 75+ years) were less likely to engage in daily travels, this population was also less likely to be POV drivers and spent less time driving POVs than younger adults (25-64 years). A similar decline in driving POVs as adults aged were also identified by Collia, et al. [8] and Boschmann and Brady [24]using the 2001 NHTS survey and the 2009 Front Range Travel Counts household survey (Colorado's Front Range, from Fort Collins to Pueblo), respectively, to describe travel patterns of older adults. Collia,

et al. [8] found that although the population of older adults represented 12.6% of U.S. population, their daily trips only accounted for approximately 10% of all daily trips completed by Americans. Additionally, Boschmann and Brady [24] found an inverse relationship between their respondents' age and the average number of trips daily, that is, as adults aged, the average number of trips daily decreased. The results of this study also showed that the percentage of adults riding in POVs for daily trips (Table 1), the percentage of POV passengers per day (Table 2), and the time spent riding in POVs (Table 3), however, did not correspondingly decrease as adults aged. Furthermore, the percentage of riding in POVs for daily trips (Table 1) and the percentage of POV passengers (Table 2) slightly increased as adults aged, indicating that older adults might regard riding in POVs as a possible compensation for their reduced likelihood of driving POVs Additionally, older adults walked a lower percentage than younger adults (Table 1), possibly due to retirement and the need to walk to work or compromised physical abilities.

Our study identified gender as a factor that influenced adults' mobility and daily travel modes (Tables 2 and 3). Older females (65-74 years and 75+ years) tended to have lower likelihood of driving POVs (Table 2) and for shorter times (Table 3), but were more frequently POV passengers (Table 2) and for longer riding times (Table 3) than their male counterparts per age group. Previous research consistently has characterized that females drive less than males.[25,26] The results of this study and previous studies depict females, especially older females, as more dependent for their mobility than their male counterparts.

Since bus transportation accounted for less 2% of older adults' daily trips (Table 1), improvements in public transit may be needed to better meet their mobility needs. As the population ages and their preference for riding in POVs for mobility increases, improvements of this population's accessibility to POVs as a passenger are necessary. Friends and family may be the primary resource, but services provided by transportation network companies (e.g., Uber, taxis, etc.) may also be able to assist older adults' mobility. Future studies should evaluate older adults' attitudes or acceptance to services provided by transportation network companies, as older adults may be reluctant to accept services supported by new technologies.[27-29] Another possible and promising solution is the implementation of

autonomous vehicles. Autonomous vehicles are capable of sensing surroundings and complete many aspects of the driving task. [30] Thus, autonomous vehicles could potentially improve older adults' mobility and travel safety. Research is needed in this area to examine older adults' acceptance and use of autonomous vehicles. [31 32]

Older adults are somewhat more likely than younger adults to drive POVs during the day (8:00 to 11:59 AM and noon to 3:59 PM; Figure 1), suggesting that older adults may purposefully avoid driving in the dark due to limited visibility or vision issues (Figure 1). Previous studies have proposed that older drivers may develop self-regulating driving behaviors, such as avoiding driving in the dark, to compensate for their diminished abilities to see or operate vehicles. [33 34]As adults aged, the differences of their travel patterns with respect the percentage of travelers and POV drivers began diminishing (Table 4). For adults (75+ year), there was no apparent difference of travel patterns between a weekday and a day of weekend in terms of the percentage of travelers and POV drivers (Table 4). This may be due to more flexibility in post-retirement time.

Study Limitations: First, since distance traveled per trip was not available in the ATUS, comparing older drivers' with younger adults' travel patterns with respect to the trip distance was not possible. Reduced cognitive and physical abilities of older adults might make them less likely to drive for long-distance trips. Second, this study only investigated one-year's data in the ATUS (2015). Future studies need to investigate older adults' travel pattern from a time series perspective and evaluate the change of older adults' travel pattern in recent decades. Lastly, while the ATUS survey is nationally representative, data contained therein do not reflect differences among individual states.

In conclusion, driving and riding in privately owned vehicles (POVs) were the most popular transit choices among most Americans, regardless of age and gender groups. As adults age, their tendency to drive POVs decreases but to ride as a passenger increases. The decrease in the percentage of POV drivers is more apparent among older females than males. A more complete study of public transit systems should be implemented, to determine if the limited use of city busses for travel/trips across age groups may be supplemented with other public or commercial transportation options. A better

understanding of older adults' travel patterns will equip transportation system designers, traffic safety engineers, and policy makers to develop strategies to assist in determining transportation needs, providing transit options, and improving the transportation safety for older adults and the general public.

KEY MESSAGE

What is already known on this subject

- Older adults (65+ years) spent less time in a vehicle, either as a driver or as a passenger and had fewer annual miles per licensed driver, compared to other adult drivers.
- Identifying older adults travel patterns using more recent data is important due to the shifts in travel behaviors.

What this study adds

- Based on the results of 2015 American Time Use Survey, as adults aged, the percentages of daily trips and daily driving trips decreased. This pattern was more apparent among females than males.
- As adults aged, travel modes began to switch from driving a car to riding as a passenger, particularly for older females.

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Data sharing statement: All the data used in this manuscript can be accessed on the website of the Bureau of Labor Statistics at the United States Department of Labor.

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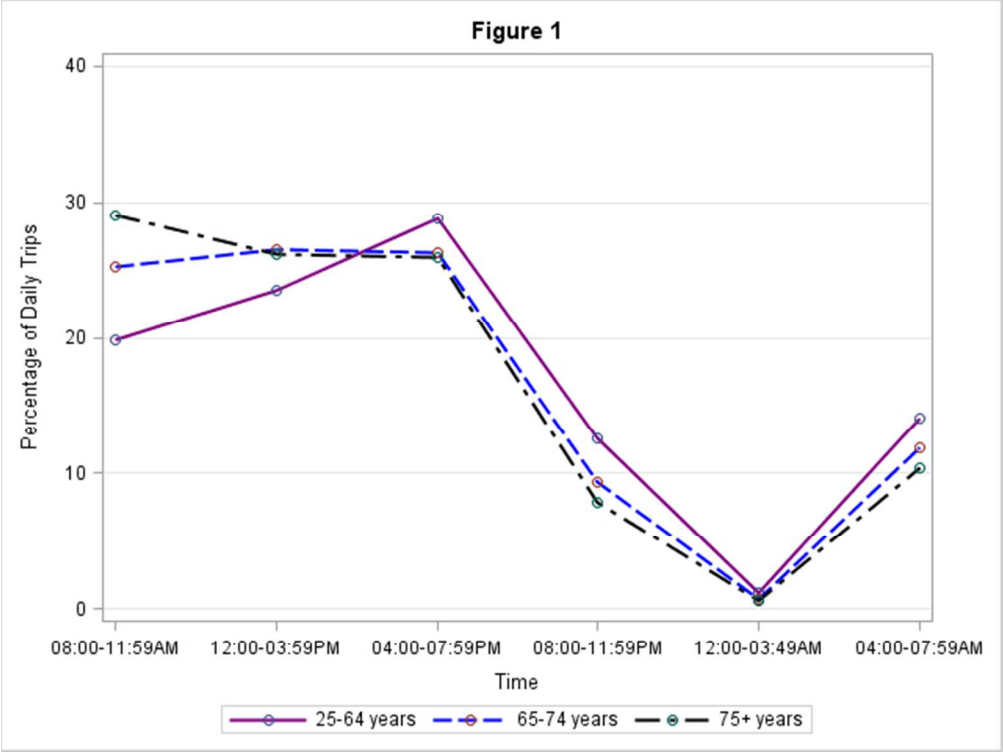

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STROBE 2016 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	P2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	P2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	P4, line 2-19
Objectives	3	State specific objectives, including any pre-specified hypotheses	P4, line 20-26
Methods			
Study design	4	Present key elements of study design early in the paper	P5, line 6-20
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5, line21-26
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	P5, line 6-11
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P6, line 4-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	P5, line 6-11
Bias	9	Describe any efforts to address potential sources of bias	P6, line 4-10
Study size	10	Explain how the study size was arrived at	P6, line 13-15
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	P6, line 4-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	P6, line 4-10
		(*b*) Describe any methods used to examine subgroups and interactions	P6, line 4-10
		(*c*) Explain how missing data were addressed	P5, line 15-17
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed	

		Case-control study—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	P6, line 13-17
		(b) Give reasons for non-participation at each stage	Not avaialble
		(c) Consider use of a flow diagram	Not available
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	P7, Table 1 P8, Table 2 P9, Table 3 P10, Table 4
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Not applicable
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	P7, Table 1 P8, Table 2 P9, Table 3 P10, Table 4
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	P7, Table 1 P8, Table 2 P9, Table 3 P10, Table 4
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicatble
Discussion			
Key results	18	Summarise key results with reference to study objectives	P10, line 11-12 P11, line 5-11 P11, line 12-18 P11, line 19-20 P12, line 5-7

Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	P12, line 14-20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P10-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	The U.S.
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P13, line 9-12

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Travel Patterns of Older Adults in the United States During 2015: Implications for Mobility and Traffic Safety

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Travel Patterns of Older Adults in the United States During 2015: Implications for Mobility and Traffic Safety

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ABSTRACT

Background: With an ever increasing population of older adults (65+ years) in the United States, a better understanding of this population's travel patterns is needed to improve travel mobility and transportation safety.

Objective: In this study, we described the travel patterns of older adults in the United States during 2015.

Methods: Travel patterns of older adults (65-74 and 75+ years) were compared with younger adults (25-64 years) by frequency and proportion of daily trips. The daily trips of various age groups were estimated using the 2015 American Time Use Survey.

Results: The percentage of daily travelers was 88% for adults (25-64 years), 75% for adults (65-74 years), and to 68% for adults (75+ years). While the percentage of privately owned vehicle (POV) drivers and average time of driving POVs decreased, the percentage of POV passengers increased as adults aged. Females were less likely to drive POVs and had decreased average daily driving time, but t were more likely to ride in POVs as passengers and had longer average daily riding times than their male counterparts across all age groups. Older adults were more likely to travel in the mornings and early afternoons (8:00 AM to 3:59 PM) while younger adults were more likely to travel in the late afternoons and early evenings (4:00 PM-7:59 PM).

Conclusions: Privately owned vehicle use is the predominant mode of transit in the United States. As adults age, the percentages of daily travelers and POV drivers decrease. This pattern is more apparent among females than males.

Keywords: travel activities, privately owned vehicles, mobility, older adults

ARTICLE SUMMARY

Strengths and limitations of this study

- This study used the most recent 2015 American Time Use Survey (ATUS) dataset to identify travel patterns of older adults.
- Older adults' travel patterns were evaluated using multiple measures including the percentage of each mode of transit for daily trips (e.g., privately owned vehicles (POVs) and bus) and the average times of driving POVs and riding in POVs as passengers.
- Some information of older adults' daily trips is not available in the ATUS, such as the distance travelled per trip, limiting the ability of this study to evaluate the distance per trip for older adults.
- As adults age, their tendency to drive POVs decreases and to ride as a passenger increases. The limited use of busses may require more complete studies and designs of public transit systems to meet the older adults' mobility needs.

1 BACKGROUND

Older adults (65 years or over) are more likely to be severely injured in a motor vehicle collisions compared to younger adults. [1-3] Older adults also have one of the highest crash rates per unit of exposure (e.g., vehicle miles of travel)[4 5]. Additionally, both the absolute and proportional growth of the older population has increased continuously from 2010 to 2014.[6] The population of older adults in the United States (U.S.) is expected to exceed 86 million by 2050.[7] Thus, the vulnerability of older adults in traffic crashes and their increased population have posed significant concerns regarding their transportation safety and mobility. To improve transportation safety and mobility for older adults, comparisons of travel patterns with younger counterparts may reveal important insights. Several studies have investigated the travel patterns of older Americans using the National Household Transportation Survey (NHTS).[8-13] They have found that mobility patterns are characterized by a major reliance on privately owned vehicles (POVs) across gender and age groups with lower proportions of cyclists and pedestrians. A detailed summary of travel trends was produced by Santos, et al. [9] using the 2009 NHTS, which identified older adults (65+ years) as spending the least amount of time in a vehicle, either as a driver or as a passenger. Additionally, older drivers have the least average annual miles per licensed driver compared to other adult drivers.[9] However, those studies used the NHTS data up to 2009 (the most recent NHTS data was in 2009). Compared to previous generations, the current generation of older adults maintains driver licenses longer, postpones retirement, and is more mobile.[14-17] Therefore, identifying older adults travel patterns using more recent U.S. nationwide data is important due to potential shifts in travel behaviors. To our knowledge, no study has evaluated older adults' travel patterns in the U.S. on national scale, using data more recent than 2009.

This study aimed to identify travel patterns of the older adult population using the more recent 2015 American Time Use Survey (ATUS) dataset, which has not been widely used to estimate travel exposures. Specifically, this study described the mobility patterns of the older adult population compared with the younger adult population via frequencies and proportions of daily trips. Compared to the NHTS, the ATUS data provided the duration of each respondent's trips, a potentially new measure of older

adults' travel patterns. While using these different measures of travel exposure, the study's findings highlighted some similarities to previous studies (e.g., Santos, et al. [9] using the 2009 NHTS), and identified new mobility patterns of older adults. Understanding these mobility patterns will add to the existing knowledge of older adult travel behaviors and may be useful in policymaking, transportation planning, or road design to help accommodate the aging U.S. population.

2 METHODS

2.1 Data Source

The 2015 American Time Use Survey (ATUS), an annual, nationally representative survey by the U.S. Census Bureau, was the primary data source for this cross-sectional analysis. One function of the ATUS is to discern how U.S. residents 15 years or older spend time on daily activities. The respondents of the 2015 ATUS were assigned a weight based on their selection probability, the day of the week they responded (i.e., weekday or weekend), and their response rates. All ATUS survey data were collected through computer-assisted phone interviews. The ATUS methodology has been described in detail elsewhere. [18]

One section of the ATUS was a time-use diary (the template of the time-use diary questionnaire is located in Appendix 1[19]), which was used to record respondents' daily activities, starting at 4:00 AM on the previous day and ending at 4:00 AM on the interview day. For each activity, the respondents were asked to provide information regarding the duration of the activity, who accompanied the respondent, whether the activity was travel related, and where the activity took place. For our study, if the place of an activity was coded as "blank", "do not know", and "refused to answer", the whole record of that activity was removed from the analysis. Trips were the activities coded as travel related and defined as movement from one point to another using any given mode of transportation. For example, if an individual stated that they left their house and drove to the grocery store, this was counted as one trip. Later, after the individual finished grocery shopping, the return trip was counted as another trip. For multimodal trips with one destination, each trip was coded separately in the ATUS dataset. For example, if an individual walked to bus station and took the bus to his/her destination, this sequence of travel-related activities was

coded as two trips: one by walking and one by bus. Modes of transportation initially included privately owned vehicles (as both a driver and passenger), walking, biking, riding in a bus, train, boat, taxi, plane, or other modes. Other modes of transportation in the survey referred to unspecified modes of transportation. Privately owned vehicles referred to cars, trucks, or motorcycles. Finally, the dataset included each respondent's demographic information (e.g., age and gender) and their activity records during the dairy day. Each respondent had one or multiple activities in their dairy date. Each activity had information regarding the starting time, ending time, duration, whether the activity was travel-related (i.e., trips), and where the activity took place (which referred to the mode of transportation if the activity was travel-related). Additionally, each respondent was associated with an individual final weight and 160 replicate weights which were used to compute estimates and their standard errors respectively.

2.2 Statistical Analysis

Older adults' travel patterns and behaviors were compared with those 25-64 years, who were the majority of road users and often considered as the reference group. [20-22] Ages were categorized into the following groups: 25-64 years, 65-74 years, and 75+ years. Travel patterns were evaluated after stratification by age and gender using percentage of each mode of transit for daily trips, the percentage of users of each transit mode, the average times of driving POVs and riding in POVs (which refers to taking POVs as passengers in this and following sections), and the percentages of driving POVs in different time periods during a day. The travel behaviors of weekdays and weekends were also compared. Due to the multistage survey design of the ATUS, the balanced repeated replication method was used to estimate the variance and the 95% confidence interval (95% CI). The detailed information of balanced repeated replication variance has been described elsewhere [23 24]. Additionally, weighted logistic regressions for complex surveys were used to estimate whether an individual drove POVs or rode in POVs in on their diary day based on his/her age, gender, and residency (i.e., urban or rural area). All the analyses were conducted in SAS Enterprise Guide 9.4.

3 RESULTS

The 2015 ATUS study population included 5,634 females and 4,297 males (25 years or older). The sample age group distribution was as follows: 7,519 (25-64 years), 1,484 (65-74 years), and 928 (75+ years). Normalized to the US population, survey results showed adults 25-64 years took 23.95 billion daily trips, adults aged 65-74 years took 3.22 billion daily trips, and those 75+ years took 1.81 billion daily trips. Among those trips, the percentage of daily driving trips in POVs decreased as adults aged, while the percentage of daily riding trips in POVs increased with age (Table 1). Specifically, the percentages of daily driving trips in POVs for adults 25-64, 65-74, and 75+ years were 77.6%, 72.9%, and 68.9%, respectively. The percentages of daily riding trips in POVs were 12.4% for ages 25-64, 18.6% for ages 65-74, and 24.5% for ages 75+ years, respectively. The percentages of daily walking trips among all trips across the three age groups ranged from 5.2% to 7.0%. The percentages for all other modes of daily transportation including bus, bicycle, train, boat, taxi, plane, and other were ≤ 1% to negligible.

Table 1. Distribution of daily trips by mode of transit using the 2015 American Time Use Survey, United States population

Transit Mode	Age: 25-64		Age: 65-74		Age: 75+	
	%	95% CI[a]	%	95% CI	%	95% CI
POVs[b] (Drivers)	77.6	(76.5 - 78.8)	72.9	(69.3 - 76.5)	68.9	(64.8 - 73.1)
POVs (Passengers)	12.4	(11.6 - 13.3)	18.6	(16.1 - 21.2)	24.5	(20.8 - 28.2)
Walk	7.0	(6.4 - 7.7)	5.8	(3.9 - 7.8)	5.2	(3.7 - 6.8)
Bus	0.9	(0.7 - 1.2)	1.1	(0.6 - 1.6)	0.4	(0.0 - 0.9)
Bicycle	0.4	(0.2 - 0.6)	0.1	(0.0 - 0.3)	0.2	(0.0 - 0.4)
Train	1.0	(0.7 - 1.3)	1.1	(0.0 - 2.3)	0.0	(0.0 - 1.2)
Boat	0.0	(0.0 - 0.0)	0.1	(0.0 - 0.2)	0.2	(0.0 - 0.5)
Taxi	0.3	(0.2 - 0.4)	0.1	(0.0 - 0.2)	0.2	(0.0 - 0.5)
Plane	0.0	(0.0 - 0.1)	0.1	(0.0 - 0.2)	0.1	(0.0 - 0.3)
Others[c]	0.1	(0.0 - 0.2)	0.1	(0.0 - 0.3)	0.1	(0.0 - 0.4)
Total	100.0		100.0		100.0	

[a] CI, confidence interval; [b] POV, privately owned vehicles; [c] unspecified mode of transportation

Daily US travelers per transportation mode were produced by age and gender (Table 2). For adults aged 25-64 years, 87.7% (95% CI: 86.7-88.7%) of them travelled daily, while this percentage decreased to 74.9% (95% CI: 72.6-77.2%) as adults aged to 65-74 years and finally to 67.7% (95% CI:

63.9-71.4%) for adults 75+ years. While the percentages of all travelers by male (88.0%) and female (87.3%) were similar for adults 25-64 years, the divide began to widen for adults 65-74 years (73.5% for females; 76.5% for males). This divide continued to widen with age to where males 75+ years accounted for 73.1% vs. 63.8% for females. The percentage of daily POV drivers decreased as adults aged. The percentage of males driving POVs was higher than for females per each age group. By 75+ years the percentage of adults driving POVs was 58.4% (95% CI: 52.1-64.7%) for males, which was one and one-half times more their female counterparts [37.9% (95% CI: 32.8-43.1%)] (Table 2). With the decrease in the percentage of daily driving among older adults, the percentage of older POV passengers increased. The percentage of POV passengers for all adults between 25-64 years was 16.7%, increasing to 19.8%, and 23.9% for adults 65-74 years and 75+ years, respectively. Males were more likely to drive POVs but also represented a lower percentage of POV passengers than females per age group. Additionally, older adults (65-74 and 75+ years) had lower percentages of walkers compared to those (25-64 years), [7.0% (95% CI: 5.3-8.6%) and 5.5% (95% CI: 3.6-7.3%) compared to 10.4% (95% CI: 9.6-11.2%), respectively] (Table 2). Weighted logistic regression models were used to estimate the associations of the age (25-64, 65-74, or 75+ years), gender (male or female), and residency (urban or rural area) with the odds of daily driving and riding in POVs (Table 3). The results showed that compared to adults 25-64 years, adults 65-74 [odds ratio (OR): 0.53 (95% CI: 0.47 - 0.60)] and 75+ [OR: 0.32 (95% CI: 0.27 - 0.38)] years had lower odds of daily driving POVs. However, adults 65-74 [OR: 1.21 (95% CI: 1.01 - 1.44)] and 75+ [OR: 1.49 (95% CI: 1.18 - 1.87)] years had higher odds of riding in POVs than those 25-64 years. Males had higher odds of driving POVs than females [OR: 1.58 (95% CI: 1.40 – 1.78)] but lower odds of riding in POVs than their female counterparts [OR: 0.42 (95% CI: 0.36 – 0.48)].

Table 2. Daily travel of United States population (2015): percent of all travelers and percent travelers per mode of transit by age and gender

	All Travelers		POV[a] Drivers		POV Passengers		Walkers	
	%	95% CI[b]	%	95% CI	%	95% CI	%	95% CI
Ages 25-64								
Female	87.3	(86.0 - 88.7)	70.1	(68.3 - 71. 9)	22.2	(20.7 - 23.7)	11.2	(9.9 - 12.5)
Male	88.0	(86.5 - 89.6)	77.4	(75.5 - 79.3)	10.9	(9.6 - 12.2)	9.6	(8.5 - 10.7)
Both	87.7	(86.7 - 88.7)	73.7	(72.4 - 74.9)	16.7	(15.7 - 17.7)	10.4	(9.6 - 11.2)
Ages 65-74								
Female	73.5	(70.6 - 76.5)	53.4	(49.8 - 57.0)	27.9	(24.4 - 31.4)	5.7	(4.0 - 7.3)
Male	76.5	(72.6 - 80.4)	67.0	(62.3 - 71.7)	10.3	(6.8 - 13.9)	8.5	(5.4 - 11.5)
Both	74.9	(72.6 - 77.2)	59.7	(57.0 - 62.4)	19.8	(17.3 - 22.2)	7.0	(5.3 - 8.6)
Ages 75+								
Female	63.8	(58.9 - 68.8)	37.9	(32.8 - 43.1)	28.9	(23.9 - 33.8)	5.1	(2.8 - 7.4)
Male	73.1	(67.5 - 78.7)	58.4	(52.1 - 64.7)	16.8	(11.2 - 22.4)	6.0	(2.9 - 9.0)
Both	67.7	(63.9 - 71.4)	46.5	(42.4 - 50.5)	23.9	(20.2 - 27.5)	5.5	(3.6 - 7.3)

[a] POV, Privately Owned Vehicles; [b] CI, Confidence Interval

* As one adult might use multiple modes of transportation per day, the summation of the percentages of POV drivers, POV passengers, and walkers per row was not necessary to be equal to 100.0%.

Table 3. The odds of daily travel as drivers or passengers according to age, gender, rural residence, United States population (2015)

	POV[a] Drivers		POV Passengers	
	Odds ratio	95% CI[b]	Odds ratio[c]	95% CI
Ages				
65-74	0.53	(0.47 - 0.60)	1.21	(1.01 - 1.44)
75+	0.32	(0.27 - 0.38)	1.49	(1.18 - 1.87)
Male	1.58	(1.40 - 1.78)	0.42	(0.36 - 0.48)
Rural	1.02	(0.87 - 1.20)	1.06	(0.88 – 1.27)

a POV, Privately Owned Vehicles; b CI, Confidence Interval

*The odds ratios were calculated using weighted logistic regression models for complex surveys; the adults 25-64 years were used as a reference group for the three age groups.

Differences in the average daily driving and riding time in POVs were analyzed by gender and age group and shown in Table 4. The average daily driving time in POVs decreased as adults aged [55.7 min, 38.6 min, and 28.4 min for adults in groups 25-64, 65-74, and 75+ years, respectively. Additionally, adult females drove less but rode longer times in POVs than their male counterparts per age group. However, differences between age groups in average riding times in POVs were negligible (Table 4).

Table 4. Distribution of daily driving and riding times in POVs by gender and age group, United States population, 2105.

	POV[a] Drivers		POV Passengers	
	mean (min)	95% CI[b]	mean (min)	95% CI
Ages 25-64				
Female	50.1	(47.8 - 52.3)	15.1	(13.6 - 16.6)
Male	61.6	(58.7 - 64.4)	7.4	(5.7 - 9.0)
Both	55.7	(53.9 - 57.5)	11.3	(10.2 - 12.5)
Ages 65-74				
Female	32.6	(28.8 - 36.4)	18.0	(14.4 - 21.6)
Male	45.5	(40.5 - 50.6)	5.7	(3.6 - 7.9)
Both	38.6	(35.4 - 41.8)	12.3	(10.2 - 14.5)
Ages 75+				
Female	18.9	(15.5 - 22.3)	14.5	(12.0 - 17.0)
Male	41.7	(40.5 - 50.6)	8.0	(5.2 - 10.8)
Both	28.4	(24.3 - 32.6)	11.8	(10.0 - 13.6)

[a] POVs, Privately Owned Vehicles; [b] CI, Confidence Interval

To understand the travel patterns among different age groups for weekdays (Monday-Friday) versus weekends (Saturday-Sunday), we analyzed the number of traveling and driving trips and the percentages of POV drivers (Table 5). Adults 25-64 years did slightly more traveling and driving trips during the week than on weekends. Again, for adults 65-74 years, the average number of traveling trips on a weekday was slightly greater than that on weekends. However, the average difference in the number of traveling and driving trips between weekday and weekend were not apparent for adults aged 75+ years. Additionally, the percentages of travelers and POV drivers were also not apparently different between weekday and weekend across all age groups, due to overlapping CIs. The percentage of daily trips per time intervals throughout the day was analyzed for each age group (Figure 1). Adults 65-74 and 75+ years took more trips in the mornings and early afternoons (between 8:00-11:59 AM and 12:00-3:59 PM) than other time periods, while adults 25-64 years took more trips in the late afternoons and early evenings (between 4:00-7:59 PM) (Figure 1).

Table 5. The number of travelling and driving trips and percentage of travelers and POV drivers by age and weekday

	All Traveling Trips		Driving Trips		Travelers		POV[a] Drivers	
	mean	95% CI[b]	mean	95% CI	%	95% CI	%	95% CI
Ages 25-64								
Weekday	4.0	(3.9-4.1)	3.0	(2.9-3.1)	88.4	(87.2-89.5)	74.6	(73.1-76.1)
Weekend	3.4	(3.3-3.6)	2.5	(2.4-2.6)	85.9	(84.2-87.6)	71.4	(69.3-73.4)
Ages 65-74								
Weekday	3.4	(3.1-3.6)	2.3	(2.2-2.5)	76.5	(73.5-79.4)	60.4	(57.1-63.8)
Weekend	2.7	(2.5-3.0)	2.0	(1.8-2.3)	71.1	(65.8-76.3)	57.8	(52.4-63.1)
Ages 75+								
Weekday	2.6	(2.4-2.9)	1.8	(1.6-2.0)	67.4	(63.0-71.7)	46.6	(41.6-51.6)
Weekend	2.4	(2.1-2.7)	1.6	(1.3-1.8)	68.5	(61.6-75.4)	46.1	(39.7-52.5)

[a] POVs, Privately Owned Vehicles; [b] CI, Confidence Interval

<<Figure 1 insert here>>

Figure 1. Distribution of daily trips according to time of day (military time) by age group for the United States in 2015.

4. DISCUSSIONS

Since Ford's Model T, American's have a long standing penchant for privately owned vehicles (POVs).[25] How does age affect the driving habits, daily trips, and modes of travel in our aging society? The 2015 ATUS data show that most trips taken by Americans, regardless of age and gender, were using POVs (Table 1), suggesting most adults still rely heavily on POVs for mobility as the primary mode of transportation in the US. Reporting from the 2009 National Household Transportation Survey (NHTS), Santos, et al. [9] calculated that 83.4% of trips were completed in POVs in 2009. While older adults (65-74 and 75+ years) were less likely to engage in daily travels, this population was less likely to be POV drivers and spent less time driving POVs than younger adults (25-64 years). A similar decline in driving POVs as adults aged was also identified by Collia, et al. [8] and Boschmann and Brady [26] using the 2001 NHTS survey and the 2009 Front Range Travel Counts household survey respectively. Collia, et al. [8] found that although the population of older adults represented 12.6% of U.S. population, their daily trips accounted for only 10% of all trips completed by Americans. Additionally, Boschmann and Brady [26]

found that the average number of trips daily decreased as adults aged. Our study produced the percentage of adults riding in POVs for daily trips (Table 1), the percentage of POV passengers (Table 2), and the time spent riding in POVs (Table 4), but they did not decrease as adults aged. Furthermore, the percentage of riding in POVs for daily trips (Table 1) and the percentage of POV passengers (Table 2) slightly increased as adults aged, indicating that older adults might regard riding in POVs as a possible compensation for reduced driving POVs. Additionally, a lower percentage of older adults walked than younger adults (Table 1), possibly due to retirement, the reduced use of walking for commute to work, or compromised physical abilities.

Our study identified gender as a factor that influenced adults' mobility and daily travel modes (Tables 2,3, and 4). Females, in particular older females (65-74 years and 75+ years) were less likely to drive and had a shorter driving time, , but were more frequently POV passengers and rider as a passenger for longer times . Our results are consistent with previous research [27 28]

Bus transportation accounted for less than 2% of older adults' daily trips (Table 1), suggesting that improvements in public transit may be needed to better meet their mobility needs. As the population ages and their need for riding in POVs for mobility increases, improvements of this population's accessibility to POVs as a passenger are necessary. Friends and family may be the primary resource, but services provided by transportation network companies (e.g., Uber, taxis, etc.) may also be able to assist older adults' mobility. Future studies should evaluate older adults' attitudes or acceptance to services provided by transportation network companies, as older adults may be reluctant to accept services supported by new technologies. [29-31] Another possible and promising solution is the implementation of fully autonomous vehicles. Fully autonomous vehicles are capable of sensing surroundings and complete almost all aspects of the driving task. [32] Thus, fully autonomous vehicles could potentially improve older adults' mobility and travel safety. However, at the current technology stage, only semi-autonomous vehicles are available to the public. Many studies have also suggested semi-autonomous vehicles may induce negative impacts on drivers, such as distraction, fatigue, and poor responses to a take-over request.

[33-35] Future research is needed in this area to examine older adults' acceptance and interactions with autonomous vehicles as they are deployed. [36-38]

Older adults are more likely than younger adults to drive POVs during the day (8:00 to 11:59 AM and noon to 3:59 PM; Figure 1) but less likely to drive POVs in the evening and night (Figure 1).. Older drivers may develop self-regulating driving behaviors, such as avoiding driving in the dark, to compensate for their diminished abilities to operate vehicles and observe traffic hazards.. [39 40]As adults aged, the travel patterns began diminishing according to weekday or weekend. For adults (75+ year), there was no apparent difference of travel patterns between a weekday and a day of weekend in terms of the percentage of travelers and POV drivers. This may be due to more flexibility in post-retirement time.

Limitations: First, since distance traveled per trip was not available in the ATUS, comparing the travel patterns of the different age groups with respect to the trip distance was not possible. Second, our study investigated one-year's data in the ATUS (2015). Future studies are needed to use multiple years of data to evaluate the change of older adults' travel pattern in recent decades. Lastly, while the ATUS survey is nationally representative, it does not reflect differences among individual states.

In conclusion, driving and riding in privately owned vehicles (POVs) were the most popular transit choice among Americans, regardless of age and gender groups. As adults age, their tendency to drive POVs decreases and to ride in POVs as a passenger increases. The decrease in the percentage of POV drivers is more apparent among older females than males. A more complete study of public transit systems should be implemented, to determine if the limited use of city buses across age groups may be supplemented with other public or commercial transportation options such as ride share. A better understanding of older adults' travel patterns will equip transportation system designers, traffic safety engineers, and policy makers to develop strategies to determine transportation needs, provide transit options, and improve transportation safety for older adults and the general public.

KEY MESSAGE

What is already known on this subject

- Older adults (65+ years) spent less time in a vehicle, either as a driver or as a passenger and had fewer annual driving miles, compared to other adult drivers in United States by 2009.
- Identifying older adults travel patterns using more recent data is important due to the shifts in travel behaviors.

What this study adds

- Based on the results of 2015 American Time Use Survey, as adults aged, the percentages of daily trips and daily driving trips decreased. This pattern was more apparent among females than males.
- As adults aged, travel modes began to switch from driving a car to riding as a passenger, particularly for older females.

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Competing Interests: None

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Contributorship: SS and WK had the equal contributions to this paper. SS led the writing and participated in data analysis. WK conducted data analysis and assisted in the manuscript writing. JF and TR critically reviewed and substantial revised the manuscript. MZ mentored for the study design, data analysis, and manuscript writing. MZ had full access to all of the data (including statistical reports and tables) in the study and can take full responsibility for the overall content.

Data sharing Statement: All the data used in this manuscript can be accessed on the website of the Bureau of Labor Statistics at the United States Department of Labor.

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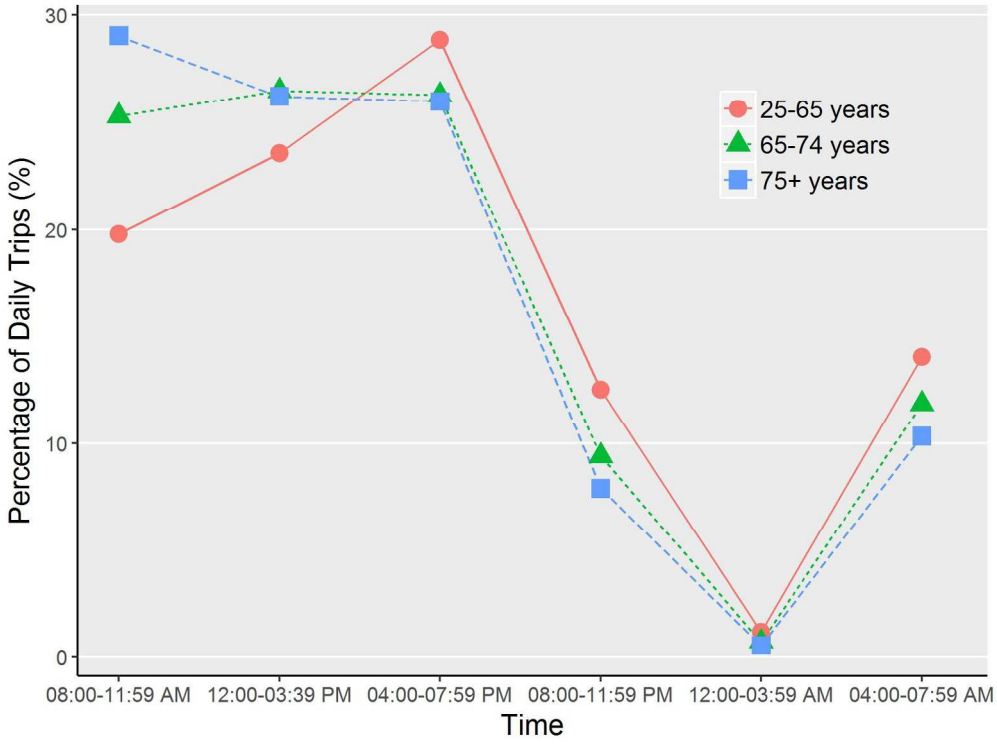


Figure 1. Distribution of daily trips according to time of day (military time) by age group for the United States in 2015.

173x129mm (300 x 300 DPI)

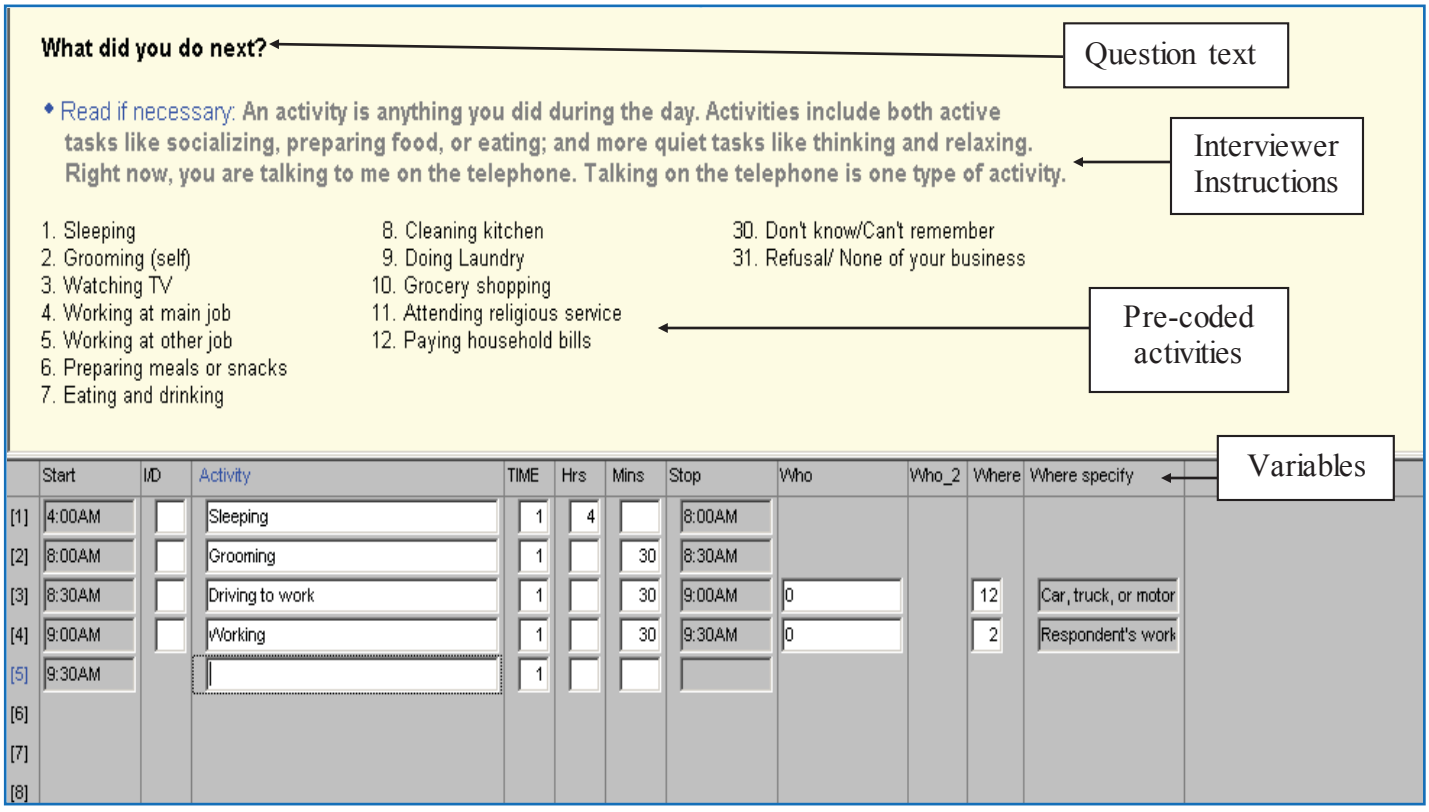
American Time Use Survey Questionnaire

S4: Time-use Diary

Universe: ALL

Next, the interviewer collects a detailed account of the DP's activities from 4 a.m. the previous day to 4 a.m. on the interview day. The interviewer uses pre-codes (1-12 in the diary grid) to quickly record commonly-reported activities, but records the DP's verbatim responses for all other activities. The interviewer then asks how long each reported activity took. This may be recorded either as the duration of the activity or as the start and stop times of the activity. The interviewer continues, asking WHO questions for all activities, except for sleeping, grooming, and personal activities (e.g. cuddling, making out, etc.). He or she then asks the WHERE questions for all activities except for sleeping, grooming, and personal activities. After the DP completely answers all questions about an activity (including duration, with whom, and where), the interviewer prompts for the next activity.

The ATUS does not collect simultaneous activities. If a respondent reports doing more than one activity at a given time, the interviewer first asks her if she can separate the activities into different time intervals. If she is unable to do this, the interviewer asks her which activity was her main activity and records the response.



American Time Use Survey Questionnaire

CORE_LEAD
Universe: **All**

Now I'd like to find out how you spent your time yesterday, [yesterday's day & date], from 4:00 in the morning until 4:00 AM this morning. I'll need to know where you were and who else was with you. If an activity is too personal, there's no need to mention it.

The following variables are included in the diary grid:

ACTIVITY
Universe: **All**

So let's begin. Yesterday, [previous weekday] at 4:00 AM, what were you doing? /What did you do next?
*Use the slash key (/) for recording separate/simultaneous activities.
(If the DP reports an activity with no associated precode, the interviewer can type the activity directly onto the blank activity line.)

1. Sleeping
2. Grooming (self)
3. Watching TV
4. Working at main job
5. Working at other job
6. Preparing meals or snacks
7. Eating and drinking
8. Cleaning kitchen
9. Laundry
10. Grocery shopping
11. Attending religious service
12. Paying household bills
30. Don't know/ Can't remember
31. Refusal/ None of your business [Go to TIME]

TIME
Universe: **ACTIVITY = valid response**

How long did you spend [ACTIVITY]?

1. Enter duration (hours, minutes) [Go to HOURDUR]
2. Enter stop time [Go to STOPTIME]

HOURDUR
Universe: **TIME=1**

Enter Hours [Go to MINDUR]

American Time Use Survey Questionnaire

MINDUR
Universe: **TIME =1 AND HOURDUR=blank or valid entry**

Enter Minutes [Go to STOPTIME]

STOPTIME
Universe: **All**

*Instrument will calculate STOPTIME if HOURDUR and MINDUR have entries other than blank or Don't Know.
*If there is a value for STARTIM, then interviewer should do the following:

Enter Time and AM or PM

WHO
Universe: **Not a personal activity and not an activity with a precode of 1, 2, 30, 31***

Who was with you? / Who accompanied you?
0. Alone
1—39. Household members and nonhousehold children
50. All household members
51. Parents
52. Other non-HH family members <18
53. Other non-HH family members 18 and older (including parents-in-law)
54. Friends
56. Neighbors, acquaintances
57. Other non-HH children < 18
58. Other non-HH adults 18 and older (including parents-in-law)
59. Boss or manager*
60. People whom I supervise*
61. Co-workers*
62. Customers* [Go to WHERE]

*Note: WHO was not asked about work activities (corresponding to precodes 4 and 5) until January 2010. Response options 59-62 were added to the WHO question at this time.

American Time Use Survey Questionnaire

WHERE
Universe: Personal activity reported OR ACTIVITY ≠ Precodes 1, 2, 30, 31

Where were you while you were [ACTIVITY]?

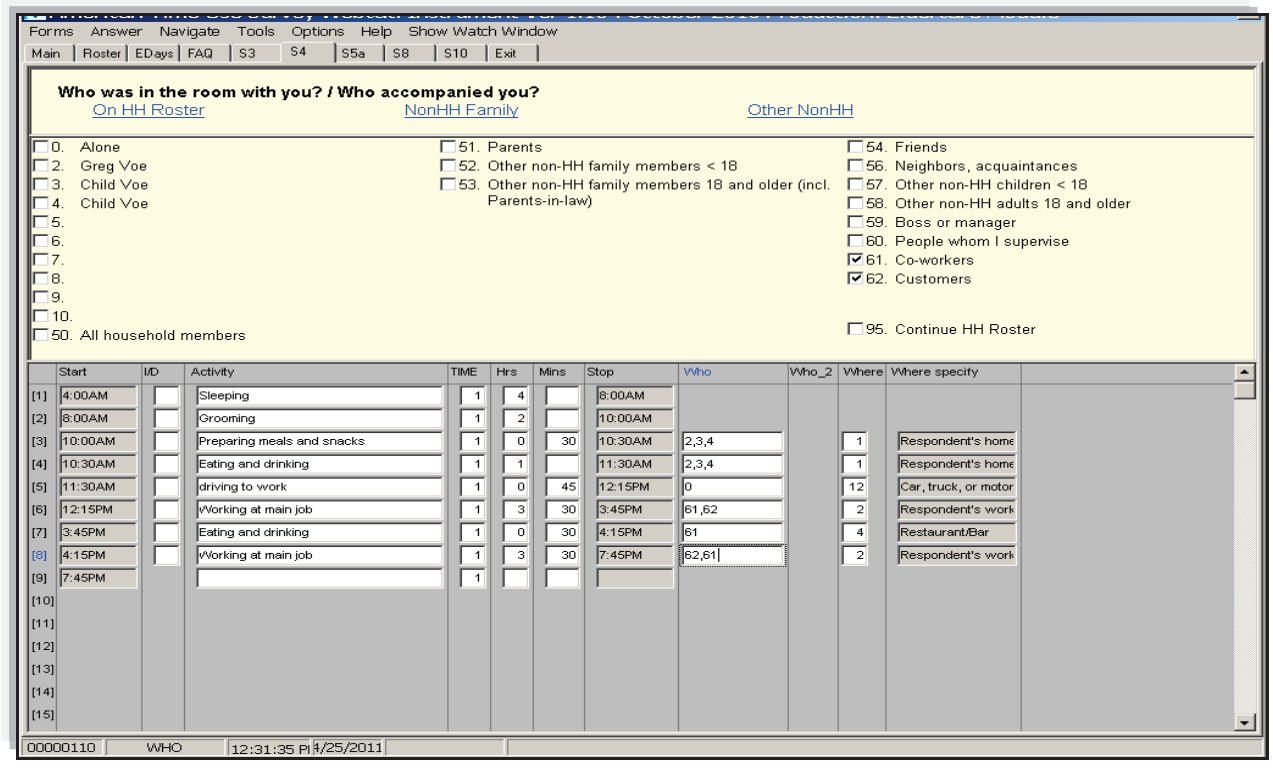
PLACE		MODE OF TRANSPORTATION
1. DP's home or yard	30. Bank*	12. Car, truck, or motorcycle (driver)
2. DP's workplace	31. Gym/ Health Club*	13. Car, truck, or motorcycle (passenger)
3. Someone else's home	32. Post Office*	14. Walking
4. Restaurant/Bar		15. Bus
5. Place of worship		16. Subway/Train
6. Grocery store		17. Bicycle
7. Other store/Mall		18. Boat/Ferry
8. School		19. Taxi/Limousine Service
9. Outdoors away from home		20. Airplane
10. Library		21. Other (specify)
11. Other place (specify)		

[If STOPTIME> 4 AM, go to S5: (Summary questions)]
[Else continue to next row]

*Note: Response options 30-32 were added to WHERE in mid-2004.

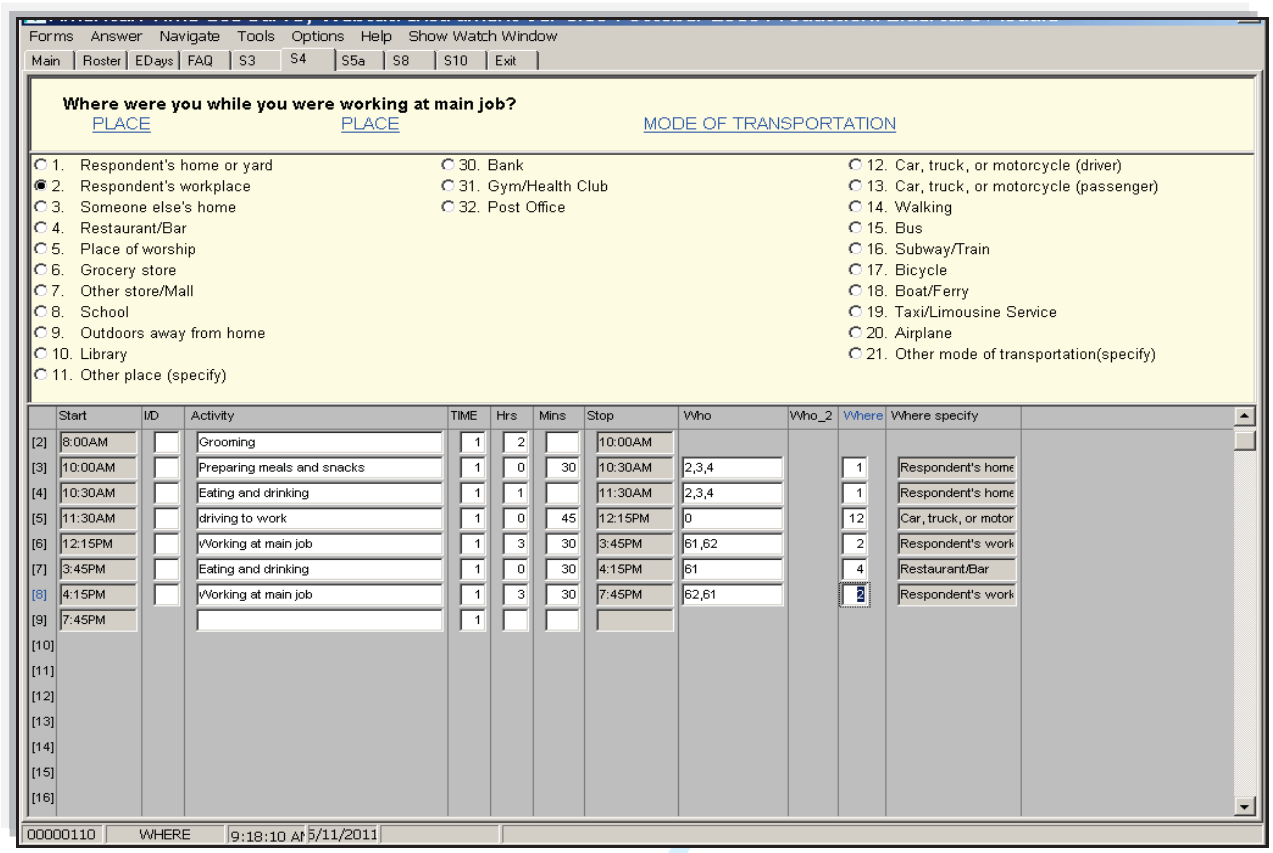
The following screenshots demonstrate how the WHO and WHERE questions are collected in the instrument:

WHO Screenshot



American Time Use Survey Questionnaire

WHERE Screenshot



The following variable is not included in the diary grid. This question is asked only if the respondent did not report any eating or drinking as a main activity for the 24-hour reporting day.

EATCK
Universe: **ACTIVITY ≠ Precode 7**

You did not report any eating or drinking yesterday. Did you do any eating or drinking yesterday as your main activity?
1. Yes [Edit diary, go to S5: (Summary questions)]
2. No [Go to S5: (Summary questions)]

STROBE 2016 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	P1 and P2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	P2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	P4, line 2-19
Objectives	3	State specific objectives, including any pre-specified hypotheses	P4, line 15-26 P6, line 1-5
Methods			
Study design	4	Present key elements of study design early in the paper	P5, line 8-14 P6, line 1-10
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5, line 9-26 P6, line 1-20
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	P5, line 9-14
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P6, line 12-24
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	P5, line 8-21
Bias	9	Describe any efforts to address potential sources of bias	P6, line 18-20
Study size	10	Explain how the study size was arrived at	P5, line 8-14 P6, line 12-13
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	P6, line 4-10 P6, line 12-13
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	P6, line 12-24

		(*b*) Describe any methods used to examine subgroups and interactions	P6, line 12-24
		(*c*) Explain how missing data were addressed	P5, line 19-21
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	P7, line 2-4
		(b) Give reasons for non-participation at each stage	Not avaialble
		(c) Consider use of a flow diagram	Not available
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	P7, Table 1 P9, Table 2 P10, Table 4 P11, Table 5
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Not applicable
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	P7, Table 1 P9, Table 2 P9, Table 3 P10, Table 4 P11, Table 5 Figure 1
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	P7, Table 1 P9, Table 2 P9, Table 3 P10, Table 4 P11, Table 5 Figure 1
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable

		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicatble
Discussion			
Key results	18	Summarise key results with reference to study objectives	P11, line 10-15 P12, line 13-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	P13, line 10-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P 12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	P13, line 15-23
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P15, line 8-11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A Cross-sectional Study of Travel Patterns of Older Adults in the United States during 2015: Implications for Mobility and Traffic Safety

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A Cross-sectional Study of Travel Patterns of Older Adults in the United States during 2015: Implications for Mobility and Traffic Safety

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ABSTRACT

Background*:* With an ever increasing population of older adults (65+ years) in the United States, a better understanding of this population's travel patterns is needed to improve travel mobility and transportation safety.

Objective: In this study, we described the travel patterns of older adults in the United States during 2015.

Methods: Travel patterns of older adults (65-74 and 75+ years) were compared with younger adults (25-64 years) by frequency and proportion of daily trips. The daily trips of various age groups were estimated using the 2015 American Time Use Survey.

Results: The percentage of daily travelers was 88% for adults (25-64 years), 75% for adults (65-74 years), and to 68% for adults (75+ years). While the percentage of privately owned vehicle (POV) drivers and average time of driving POVs decreased, the percentage of POV passengers increased as adults aged. Females were less likely to drive POVs and had decreased average daily driving time, but they were more likely to ride in POVs as passengers and had longer average daily riding times than their male counterparts across all age groups. Older adults were more likely to travel in the mornings and early afternoons (8:00 AM to 3:59 PM) while younger adults were more likely to travel in the late afternoons and early evenings (4:00 PM-7:59 PM).

Conclusions*:* Privately owned vehicle use is the predominant mode of transit in the United States. As adults age, the percentages of daily travelers and POV drivers decrease. This pattern is more apparent among females than males. This study delineated travel patterns of older adults using a 2015 national survey, and the findings facilitate traffic systems designers and policy makers to develop and implement initiatives to accommodate older adults' mobility needs and improve traffic safety.

Keywords: travel activities, privately owned vehicles, mobility, older adults

ARTICLE SUMMARY

Strengths and limitations of this study

- This study used the most recent 2015 American Time Use Survey (ATUS) dataset to identify travel patterns of older adults.
- Older adults' travel patterns were evaluated using multiple measures including the percentage of each mode of transit for daily trips (e.g., privately owned vehicles [POVs] and bus) and the average times of driving POVs and riding in POVs as passengers.
- Some information of older adults' daily trips is not available in the ATUS, such as the distance travelled per trip, limiting the ability of this study to evaluate the distance per trip for older adults.
- As adults age, their tendency to drive POVs decreases and to ride as a passenger increases. The limited use of busses may require more complete studies and designs of public transit systems to meet the older adults' mobility needs.

1 BACKGROUND

Older adults (65 years or over) are more likely to be severely injured in motor vehicle collisions compared to younger adults. [1-3] Older adults also have one of the highest crash rates per unit of exposure (e.g., vehicle miles of travel). [4 5] Additionally, both the absolute and proportional growth of the older population has increased continuously from 2010 to 2014. [6] The population of older adults in the United States (U.S.) is expected to exceed 86 million by 2050. [7] Thus, the vulnerability of older adults in traffic crashes and their increased population have posed significant concerns regarding their transportation safety and mobility. To improve transportation safety and mobility for older adults, comparisons of travel patterns with younger counterparts may reveal important insights. Several studies have investigated the travel patterns of older Americans using the National Household Transportation Survey (NHTS). [8-13] They have found that mobility patterns are characterized by a major reliance on privately owned vehicles (POVs) across gender and age groups with lower proportions of cyclists and pedestrians. A detailed summary of travel trends was produced by Santos, et al. [9] using the 2009 NHTS which identified older adults (65+ years) as spending the least amount of time in a vehicle, either as a driver or as a passenger. Additionally, older drivers have the least average annual miles per licensed driver compared to other adult drivers.[9] However, those studies used the NHTS data up to 2009 (the most recent NHTS data was in 2009). Compared to previous generations, the current generation of older adults maintains driver licenses longer, postpones retirement, and is more mobile. [14-17] Therefore, identifying older adults travel patterns using more recent U.S. nationwide data is important due to potential shifts in travel behaviors. To our knowledge, no study has evaluated older adults' travel patterns in the U.S. on national scale, using data more recent than 2009.

This study aimed to identify travel patterns of the older adult population using the most recent 2015 American Time Use Survey (ATUS) dataset, which has not been widely used to estimate travel exposures. Specifically, this study described the mobility patterns of the older adult population compared with the younger adult population via frequencies and proportions of daily trips. Compared to the NHTS, the ATUS data provided the duration of each respondent's trips, a potentially new measure to older

adults' travel patterns. While using these different measures of travel exposure, this study's findings highlighted some similarities to previous studies (e.g., Santos, et al. [9] using the 2009 NHTS), and identified new mobility patterns of older adults. Understanding these mobility patterns will add to the existing knowledge of older adult travel behaviors and may be useful in policymaking, transportation planning, and road design to accommodate the aging U.S. population.

2 METHODS

2.1 Data Source

The 2015 American Time Use Survey (ATUS), an annual and nationally representative survey by the U.S. Census Bureau, was the primary data source for this cross-sectional analysis. The ATUS can be accessed on the website of the Bureau of Labor Statistics at the United States Department of Labor [18] and this study was approved by the Research Institute of Nationwide Children's Hospital's Institute Research Board (IRB). One function of the ATUS is to discern how U.S. residents 15 years or older spend time on daily activities. The respondents of the 2015 ATUS were assigned a weight based on their selection probability, the day of the week they responded (i.e., weekday or weekend), and their response rates. All ATUS survey data were collected through computer-assisted phone interviews. The ATUS methodology has been described in detail elsewhere. [18]

One section of the ATUS was a time-use diary (the template of the time-use diary questionnaire is located in Appendix 1 [19]), which was used to record respondents' daily activities, starting at 4:00 AM on the previous day and ending at 4:00 AM on the interview day. For each activity, the respondents were asked to provide information regarding the duration of the activity, who accompanied the respondent, whether the activity was travel related, and where the activity took place. For our study, if the place of an activity was coded as "blank", "do not know", and "refused to answer", the whole record of that activity was removed from the analysis. Trips were the activities coded as travel related and defined as a movement from one point to another using any given mode of transportation. For example, if an individual stated that they left their house and drove to the grocery store, this was counted as one trip. Later, after the individual finished grocery shopping, the return trip was counted as another trip. For

multimodal trips with one destination, each trip was coded separately in the ATUS dataset. For example, if an individual walked to bus station and took the bus to his/her destination, this sequence of travel-related activities was coded as two trips: one by walking and one by bus. Modes of transportation initially included privately owned vehicles (as both a driver and passenger), walking, biking, riding in a bus, train, boat, taxi, plane, or other modes. Other modes of transportation in the survey referred to unspecified modes of transportation. Privately owned vehicles referred to cars, trucks, or motorcycles. Finally, the dataset included each respondent's demographic information (e.g., age and gender) and their activity records during the dairy day. Each respondent had one or multiple activities in their dairy date. Each activity had information regarding the starting time, ending time, duration, whether the activity was travel-related (i.e., trips), and where the activity took place (which referred to the mode of transportation if the activity was travel-related). Additionally, each respondent was associated with an individual final weight and 160 replicate weights which were used to compute estimates and their standard errors respectively.

2.2 Statistical Analysis

Older adults' travel patterns and behaviors were compared with those 25-64 years, who were the majority of road users and often considered as the reference group. [20-22] Ages were categorized into the following groups: 25-64 years, 65-74 years, and 75+ years. Travel patterns were evaluated after stratification by age and gender using percentage of each mode of transit for daily trips, the percentage of users of each transit mode, the average times of driving POVs and riding in POVs (which refers to taking POVs as passengers in this and following sections), and the percentages of driving POVs in different time periods during a day. The travel behaviors of weekdays and weekends were also compared. Due to the multistage survey design of the ATUS, the balanced repeated replication method was used to estimate the variance and the 95% confidence interval (CI). The detailed information of balanced repeated replication variance has been described elsewhere [23 24]. Additionally, weighted logistic regressions for complex surveys were used to estimate whether an individual drove POVs or rode in POVs in on their diary day

based on his/her age, gender, and residency (i.e., urban or rural area). All the analyses were conducted in SAS Enterprise Guide 9.4.

3 RESULTS

The 2015 ATUS study sample included 5,634 females and 4,297 males (25 years or older). The sample age group distribution was as follows: 7,519 (25-64 years), 1,484 (65-74 years), and 928 (75+ years). Normalized to the US population, survey results showed adults 25-64 years took 23.95 billion daily trips, adults aged 65-74 years took 3.22 billion daily trips, and those 75+ years took 1.81 billion daily trips. Among those trips, the percentage of daily driving trips in POVs decreased as adults aged, while the percentage of daily riding trips in POVs increased with age (Table 1). Specifically, the percentages of daily driving trips in POVs for adults 25-64, 65-74, and 75+ years were 77.6%, 72.9%, and 68.9%, respectively. The percentages of daily riding trips in POVs were 12.4% for ages 25-64, 18.6% for ages 65-74, and 24.5% for ages 75+ years, respectively. The percentages of daily walking trips among all trips across the three age groups ranged from 5.2% to 7.0%. The percentages for all other modes of daily transportation including bus, bicycle, train, boat, taxi, plane, and other were ≤ 1% to negligible.

Table 1. Distribution of daily trips by mode of transit using the 2015 American Time Use Survey, United States population

Transit Mode	Age: 25-64		Age: 65-74		Age: 75+	
	%	95% CI[a]	%	95% CI	%	95% CI
POVs[b] (Drivers)	77.6	(76.5 - 78.8)	72.9	(69.3 - 76.5)	68.9	(64.8 - 73.1)
POVs (Passengers)	12.4	(11.6 - 13.3)	18.6	(16.1 - 21.2)	24.5	(20.8 - 28.2)
Walk	7.0	(6.4 - 7.7)	5.8	(3.9 - 7.8)	5.2	(3.7 - 6.8)
Bus	0.9	(0.7 - 1.2)	1.1	(0.6 - 1.6)	0.4	(0.0 - 0.9)
Bicycle	0.4	(0.2 - 0.6)	0.1	(0.0 - 0.3)	0.2	(0.0 - 0.4)
Train	1.0	(0.7 - 1.3)	1.1	(0.0 - 2.3)	0.0	(0.0 - 1.2)
Boat	0.0	(0.0 - 0.0)	0.1	(0.0 - 0.2)	0.2	(0.0 - 0.5)
Taxi	0.3	(0.2 - 0.4)	0.1	(0.0 - 0.2)	0.2	(0.0 - 0.5)
Plane	0.0	(0.0 - 0.1)	0.1	(0.0 - 0.2)	0.1	(0.0 - 0.3)
Others[c]	0.1	(0.0 - 0.2)	0.1	(0.0 - 0.3)	0.1	(0.0 - 0.4)
Total	100.0		100.0		100.0	

[a] CI, confidence interval; [b] POV, privately owned vehicles; [c] unspecified mode of transportation

Daily US travelers per transportation mode were produced by age and gender (Table 2). For adults aged 25-64 years, 87.7% (95% CI: 86.7-88.7%) of them travelled in their dairy day, while this

percentage decreased to 74.9% (95% CI: 72.6-77.2%) as adults aged to 65-74 years and finally to 67.7% (95% CI: 63.9-71.4%) for adults 75+ years. While the percentages of all travelers by male (88.0%) and female (87.3%) were similar for adults 25-64 years, the divide began to widen for adults 65-74 years (73.5% for females; 76.5% for males). This divide continued to widen with age to where males 75+ years accounted for 73.1% vs. 63.8% for females. The percentage of daily POV drivers decreased as adults aged. The percentage of males driving POVs was higher than for females per each age group. By 75+ years the percentage of adults driving POVs was 58.4% (95% CI: 52.1-64.7%) for males, which was one and one-half times more their female counterparts [37.9% (95% CI: 32.8-43.1%)] (Table 2). With the decrease in the percentage of daily driving among older adults, the percentage of older POV passengers increased. The percentage of POV passengers for all adults between 25-64 years was 16.7%, increasing to 19.8%, and 23.9% for adults 65-74 years and 75+ years, respectively. Males were more likely to drive POVs but also represented a lower percentage of POV passengers than females per age group. Additionally, older adults (65-74 and 75+ years) had lower percentages of walkers compared to those 25-64 years [7.0% (95% CI: 5.3-8.6%) and 5.5% (95% CI: 3.6-7.3%) compared to 10.4% (95% CI: 9.6-11.2%), respectively] (Table 2). Weighted logistic regression models were used to estimate the associations of the age (25-64, 65-74, or 75+ years), gender (male or female), and residency (urban or rural area) with the odds of daily driving and riding in POVs (Table 3). The results showed that compared to adults 25-64 years, adults 65-74 [odds ratio (OR): 0.53 (95% CI: 0.47 - 0.60)] and 75+ [OR: 0.32 (95% CI: 0.27 - 0.38)] years had lower odds of daily driving POVs. However, adults 65-74 [OR: 1.21 (95% CI: 1.01 - 1.44)] and 75+ [OR: 1.49 (95% CI: 1.18 - 1.87)] years had higher odds of riding in POVs than those 25-64 years. Males had higher odds of driving POVs than females [OR: 1.58 (95% CI: 1.40 – 1.78)] but lower odds of riding in POVs than their female counterparts [OR: 0.42 (95% CI: 0.36 – 0.48)].

Table 2.– Daily travel of United States population (2015): percent of all travelers and percent travelers per mode of transit by age and gender

	All Travelers		POV[a] Drivers		POV Passengers		Walkers	
	%	95% CI[b]	%	95% CI	%	95% CI	%	95% CI
Ages 25-64								
Female	87.3	(86.0 - 88.7)	70.1	(68.3 - 71. 9)	22.2	(20.7 - 23.7)	11.2	(9.9 - 12.5)
Male	88.0	(86.5 - 89.6)	77.4	(75.5 - 79.3)	10.9	(9.6 - 12.2)	9.6	(8.5 - 10.7)
Both	87.7	(86.7 - 88.7)	73.7	(72.4 - 74.9)	16.7	(15.7 - 17.7)	10.4	(9.6 - 11.2)
Ages 65-74								
Female	73.5	(70.6 - 76.5)	53.4	(49.8 - 57.0)	27.9	(24.4 - 31.4)	5.7	(4.0 - 7.3)
Male	76.5	(72.6 - 80.4)	67.0	(62.3 - 71.7)	10.3	(6.8 - 13.9)	8.5	(5.4 - 11.5)
Both	74.9	(72.6 - 77.2)	59.7	(57.0 - 62.4)	19.8	(17.3 - 22.2)	7.0	(5.3 - 8.6)
Ages 75+								
Female	63.8	(58.9 - 68.8)	37.9	(32.8 - 43.1)	28.9	(23.9 - 33.8)	5.1	(2.8 - 7.4)
Male	73.1	(67.5 - 78.7)	58.4	(52.1 - 64.7)	16.8	(11.2 - 22.4)	6.0	(2.9 - 9.0)
Both	67.7	(63.9 - 71.4)	46.5	(42.4 - 50.5)	23.9	(20.2 - 27.5)	5.5	(3.6 - 7.3)

[a] POV, Privately Owned Vehicles; [b] CI, Confidence Interval

* As one adult might use multiple modes of transportation per day, the summation of the percentages of POV drivers, POV passengers, and walkers per row was not necessary to be equal to 100.0%.

Table 3. The odds of daily travel as drivers or passengers according to age, gender, rural residence, United States population (2015)

	POV[a] Drivers		POV Passengers	
	Odds ratio	95% CI[b]	Odds ratio[c]	95% CI
Ages				
65-74	0.53	(0.47 - 0.60)	1.21	(1.01 - 1.44)
75+	0.32	(0.27 - 0.38)	1.49	(1.18 - 1.87)
Male	1.58	(1.40 - 1.78)	0.42	(0.36 - 0.48)
Rural	1.02	(0.87 - 1.20)	1.06	(0.88 – 1.27)

a POV, Privately Owned Vehicles; b CI, Confidence Interval

*The odds ratios were calculated using weighted logistic regression models for complex surveys; the adults 25-64 years were used as a reference group for the three age groups.

Differences in the average daily driving and riding time in POVs were analyzed by gender and age group and shown in Table 4. The average daily driving time in POVs decreased as adults aged [55.7 min, 38.6 min, and 28.4 min for adults in groups 25-64, 65-74, and 75+ years, respectively]. Additionally, female adults drove less but rode longer times in POVs than their male counterparts per age group. However, differences between age groups in average riding times in POVs were negligible (Table 4).

Table 4. Distribution of daily driving and riding times in POVs by gender and age group, United States population, 2105.

	POV[a] Drivers		POV Passengers	
	mean (min)	95% CI[b]	mean (min)	95% CI
Ages 25-64				
Female	50.1	(47.8 - 52.3)	15.1	(13.6 - 16.6)
Male	61.6	(58.7 - 64.4)	7.4	(5.7 - 9.0)
Both	55.7	(53.9 - 57.5)	11.3	(10.2 - 12.5)
Ages 65-74				
Female	32.6	(28.8 - 36.4)	18.0	(14.4 - 21.6)
Male	45.5	(40.5 - 50.6)	5.7	(3.6 - 7.9)
Both	38.6	(35.4 - 41.8)	12.3	(10.2 - 14.5)
Ages 75+				
Female	18.9	(15.5 - 22.3)	14.5	(12.0 - 17.0)
Male	41.7	(40.5 - 50.6)	8.0	(5.2 - 10.8)
Both	28.4	(24.3 - 32.6)	11.8	(10.0 - 13.6)

[a] POVs, Privately Owned Vehicles; [b] CI, Confidence Interval

To understand the travel patterns among different age groups for weekdays (Monday-Friday) versus weekends (Saturday-Sunday), we analyzed the number of traveling and driving trips and the percentages of POV drivers (Table 5). Adults 25-64 years did slightly more traveling and driving trips during weekdays than weekends. Again, for adults 65-74 years, the average number of daily traveling trips on weekday was slightly greater than that on weekend. However, the average difference in the number of traveling and driving trips between weekday and weekend were not apparent for adults aged 75+ years. Additionally, the percentages of travelers and POV drivers were also not apparently different between weekday and weekend across all age groups, due to overlapping CIs. The percentage of daily trips per time intervals throughout the day was analyzed for each age group (Figure 1). Adults 65-74 and 75+ years took more trips in the mornings and early afternoons (between 8:00-11:59 AM and 12:00-3:59 PM) than other time periods, while adults 25-64 years took more trips in the late afternoons and early evenings (between 4:00-7:59 PM) (Figure 1).

Table 5. The number of travelling and driving trips and percentage of travelers and POV drivers by age and weekday

	All Traveling Trips		Driving Trips		Travelers		POV[a] Drivers	
	mean	95% CI[b]	mean	95% CI	%	95% CI	%	95% CI
Ages 25-64								
Weekday	4.0	(3.9-4.1)	3.0	(2.9-3.1)	88.4	(87.2-89.5)	74.6	(73.1-76.1)
Weekend	3.4	(3.3-3.6)	2.5	(2.4-2.6)	85.9	(84.2-87.6)	71.4	(69.3-73.4)
Ages 65-74								
Weekday	3.4	(3.1-3.6)	2.3	(2.2-2.5)	76.5	(73.5-79.4)	60.4	(57.1-63.8)
Weekend	2.7	(2.5-3.0)	2.0	(1.8-2.3)	71.1	(65.8-76.3)	57.8	(52.4-63.1)
Ages 75+								
Weekday	2.6	(2.4-2.9)	1.8	(1.6-2.0)	67.4	(63.0-71.7)	46.6	(41.6-51.6)
Weekend	2.4	(2.1-2.7)	1.6	(1.3-1.8)	68.5	(61.6-75.4)	46.1	(39.7-52.5)

[a] POVs, Privately Owned Vehicles; [b] CI, Confidence Interval

<<Figure 1 insert here>>

Figure 1. Distribution of daily trips according to time of day by age group for the United States in 2015.

4. DISCUSSIONS

Since Ford's Model T, American's have a long standing penchant for privately owned vehicles (POVs).[25] How does age affect the driving habits, daily trips, and modes of travel in our aging society? Many studies have investigated the travel patterns of older Americans using the 2001 or 2009 National Household Transportation Survey (NHTS).[8-13] Our study used more recent data than previous studies to identify travel patterns of older adults in the current generation. Additionally, the 2015 ATUS data enable us to identify new travel patterns of older adults by providing new measures, such as the time of driving and riding in POVs. Our results showed that more than 90% trips taken by Americans, regardless of age and gender, were using POVs, suggesting most adults still rely heavily on POVs for mobility as the primary mode of transportation in the US. Reporting from the 2009 National Household Transportation Survey (NHTS), Santos, et al. [9] calculated that 83.4% of trips were completed in POVs in 2009. Older adults (65-74 and 75+ years) were less likely to engage in daily travels and this population was also less likely to be POV drivers and spent less time driving POVs than younger adults (25-64 years). A similar decline in driving POVs as adults aged was also identified by Collia, et al. [8] and Boschmann and Brady [26]

using the 2001 NHTS survey and the 2009 Front Range Travel Counts household survey, respectively. Collia, et al. [8] found that although the population of older adults represented 12.6% of U.S. population, their daily trips accounted for only 10% of all trips completed by Americans. Additionally, Boschmann and Brady [26] found that the average number of trips daily decreased as adults aged. Our study produced the percentage of adults riding in POVs for daily trips, the percentage of POV passengers, and the average time of riding in POVs, but they did not decrease as adults aged. Furthermore, the percentage of riding in POVs for daily trips and the percentage of POV passengers slightly increased as adults aged, indicating that older adults might regard riding in POVs as a possible compensation for reduced driving POVs. Additionally, a lower percentage of older adults walked than younger adults, possibly due to retirement, the reduced use of walking for commute to work, or compromised physical abilities.

Our study identified gender as a factor that influenced adults' mobility and daily travel modes. Females, in particular older females (65-74 years and 75+ years) were less likely to drive and had a shorter driving time, but were more frequent POV passengers and rider as a passenger for longer times. Our results are consistent with previous research [27 28]

Bus transportation accounted for less than 2% of older adults' daily trips, suggesting that improvements in public transit may be needed to better meet their mobility needs. As adults aged and their need for riding in POVs for mobility increases, improvements of this population's accessibility to POVs as a passenger are necessary. Friends and family may be the primary resource, but services provided by transportation network companies (e.g., Uber, taxis, etc.) may also be able to assist older adults' mobility. Future studies should evaluate older adults' attitudes or acceptance to services provided by transportation network companies, as older adults may be reluctant to accept services supported by new technologies. [29-31] Another possible and promising solution is the implementation of fully autonomous vehicles. Fully autonomous vehicles are capable of sensing surroundings and complete almost all aspects of the driving task. [32] Thus, fully autonomous vehicles could potentially improve older adults' mobility and travel safety. However, at the current technology stage, only semi-autonomous vehicles are available to the public. Many studies have also suggested semi-autonomous vehicles may

induce negative impacts on drivers, such as distraction, fatigue, and poor responses to a take-over request. [33-35] Future research is needed in this area to examine older adults' acceptance and interactions with autonomous vehicles as they are deployed. [36-38]

Older adults are more likely than younger adults to drive POVs during the day (8:00 to 11:59 AM and noon to 3:59 PM) but less likely to drive POVs in the evening and night. Older drivers may develop self-regulating driving behaviors, such as avoiding driving in the dark, to compensate for their diminished abilities to operate vehicles and observe traffic hazards. [39 40] As adults aged, the travel patterns begin diminishing according to weekday or weekend. For adults (75+ year), there was no apparent difference of travel patterns between a weekday and a day of weekend with respect to the percentage of travelers and POV drivers. This may be due to more flexibility in post-retirement time.

Limitations: First, since distance traveled per trip was not available in the ATUS, comparing the travel patterns of the different age groups with respect to the trip distance was not possible. Second, our study investigated one-year's data in the ATUS (the 2015 ATUS data). Future studies are needed to use multiple years of data to evaluate the change of older adults' travel pattern in recent decades. Lastly, as the ATUS data is nationally representative, it does not reflect differences among individual states.

In conclusion, driving and riding in privately owned vehicles (POVs) were the most popular transit choice among Americans, regardless of age and gender groups. As adults age, their likelihoods and average time of driving POVs decrease but the likelihoods of riding in POVs increase. The decrease in the percentage of POV drivers is more apparent among older females than males. A more complete study of public transit systems should be implemented, to determine if the limited use of city buses across age groups is supplemented with other public or commercial transportation options such as ride share. A better understanding of older adults' travel patterns will equip transportation system designers, traffic safety engineers, and policy makers to develop strategies to determine transportation needs, provide transit options, and improve transportation safety for older adults and the general public.

KEY MESSAGE

What is already known on this subject

- Older adults (65+ years) spent less time in a vehicle, either as a driver or as a passenger and had fewer annual driving miles, compared to other adult drivers in United States by 2009.
- Identifying older adults travel patterns using more recent data is important due to the shifts in travel behaviors.

What this study adds

- Based on the results of 2015 American Time Use Survey, as adults aged, the percentages of daily trips and daily driving trips decreased. This pattern was more apparent among females than males.
- As adults aged, travel modes began to switch from driving a car to riding as a passenger, particularly for older females.

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Contributorship: SS and WK had the equal contributions to this paper. SS led the writing and participated in data analysis. WK conducted data analysis and assisted in the manuscript writing. JF and TR critically reviewed and substantial revised the manuscript. MZ mentored for the study design, data analysis, and manuscript writing. MZ had full access to all of the data (including statistical reports and tables) in the study and can take full responsibility for the overall content.

Data sharing Statement: All the data used in this manuscript can be accessed on the website of the Bureau of Labor Statistics at the United States Department of Labor.

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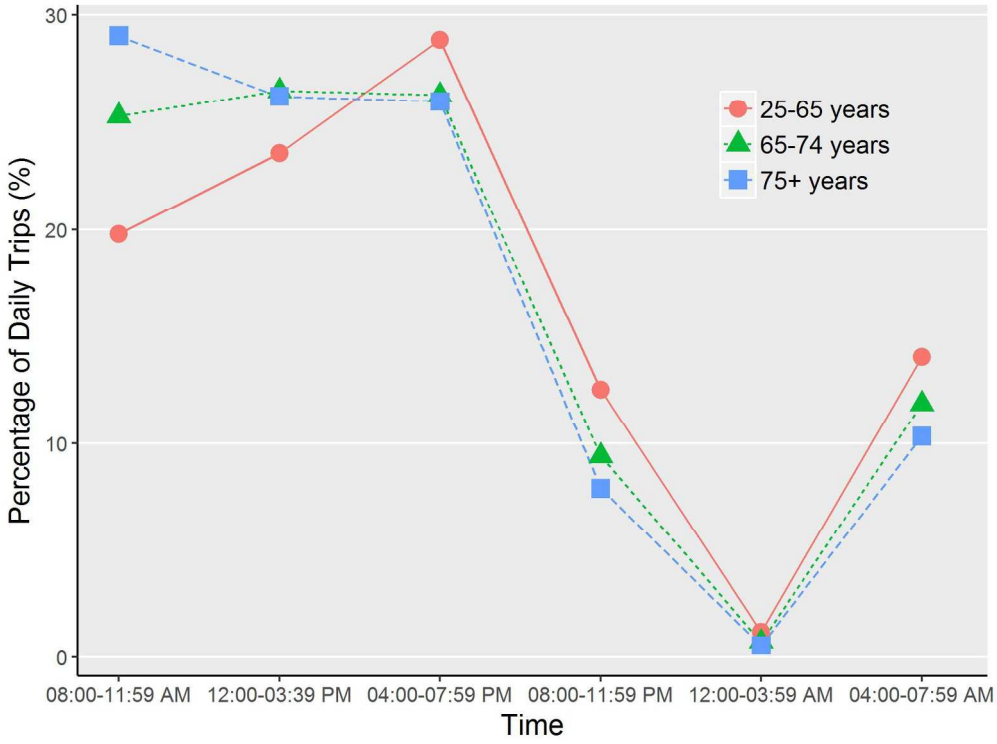


Figure 1. Distribution of daily trips according to time of day (military time) by age group for the United States in 2015.

173x129mm (300 x 300 DPI)

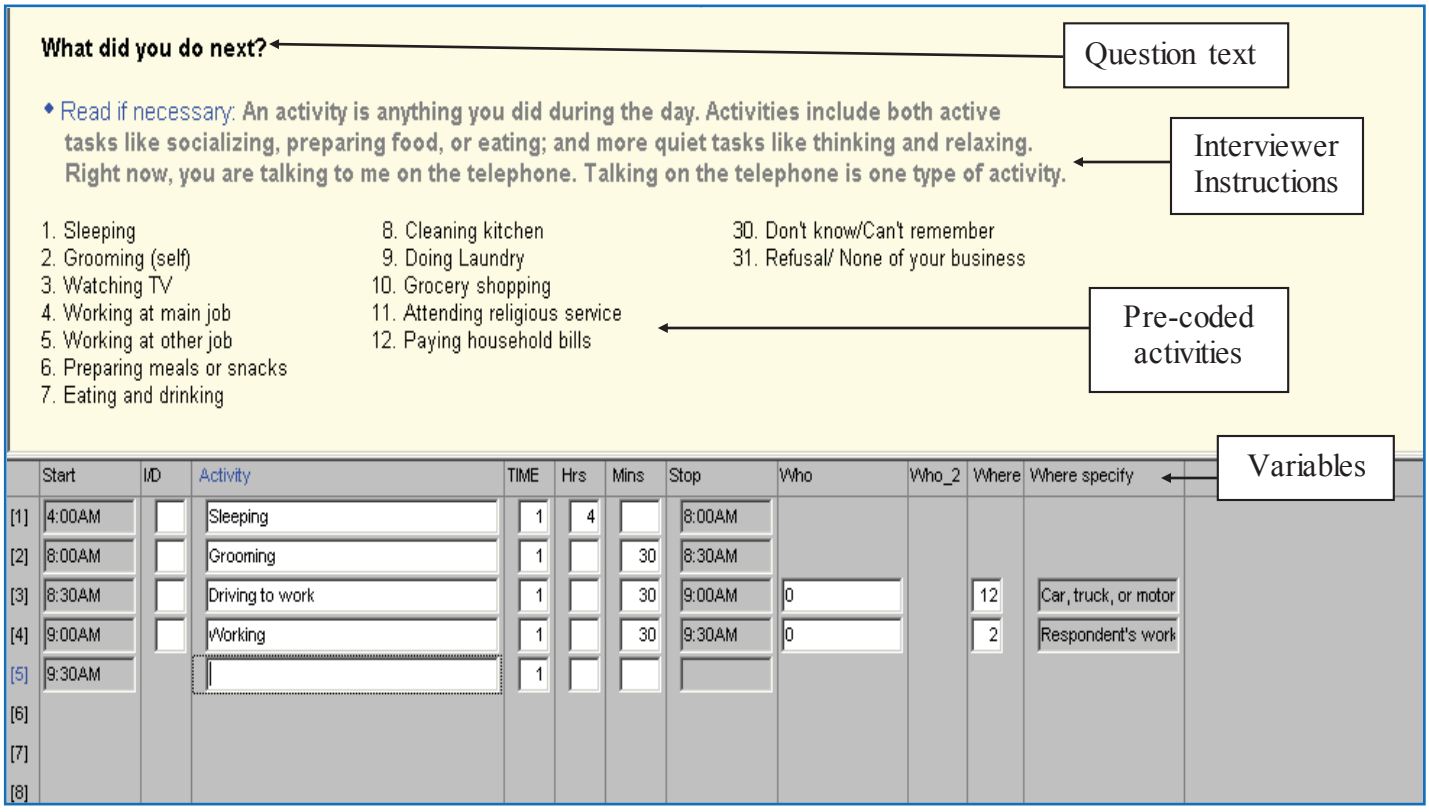
American Time Use Survey Questionnaire

S4: Time-use Diary

Universe: ALL

Next, the interviewer collects a detailed account of the DP's activities from 4 a.m. the previous day to 4 a.m. on the interview day. The interviewer uses pre-codes (1-12 in the diary grid) to quickly record commonly-reported activities, but records the DP's verbatim responses for all other activities. The interviewer then asks how long each reported activity took. This may be recorded either as the duration of the activity or as the start and stop times of the activity. The interviewer continues, asking WHO questions for all activities, except for sleeping, grooming, and personal activities (e.g. cuddling, making out, etc.). He or she then asks the WHERE questions for all activities except for sleeping, grooming, and personal activities. After the DP completely answers all questions about an activity (including duration, with whom, and where), the interviewer prompts for the next activity.

The ATUS does not collect simultaneous activities. If a respondent reports doing more than one activity at a given time, the interviewer first asks her if she can separate the activities into different time intervals. If she is unable to do this, the interviewer asks her which activity was her main activity and records the response.



American Time Use Survey Questionnaire

CORE_LEAD
Universe: **All**

Now I'd like to find out how you spent your time yesterday, [yesterday's day & date], from 4:00 in the morning until 4:00 AM this morning. I'll need to know where you were and who else was with you. If an activity is too personal, there's no need to mention it.

The following variables are included in the diary grid:

ACTIVITY
Universe: **All**

So let's begin. Yesterday, [previous weekday] at 4:00 AM, what were you doing? /What did you do next?
*Use the slash key (/) for recording separate/simultaneous activities.
(If the DP reports an activity with no associated precode, the interviewer can type the activity directly onto the blank activity line.)

1. Sleeping
2. Grooming (self)
3. Watching TV
4. Working at main job
5. Working at other job
6. Preparing meals or snacks
7. Eating and drinking
8. Cleaning kitchen
9. Laundry
10. Grocery shopping
11. Attending religious service
12. Paying household bills
30. Don't know/ Can't remember
31. Refusal/ None of your business [Go to TIME]

TIME
Universe: **ACTIVITY = valid response**

How long did you spend [ACTIVITY]?

1. Enter duration (hours, minutes) [Go to HOURDUR]
2. Enter stop time [Go to STOPTIME]

HOURDUR
Universe: **TIME=1**

Enter Hours [Go to MINDUR]

American Time Use Survey Questionnaire

MINDUR
Universe: **TIME =1 AND HOURDUR=blank or valid entry**

Enter Minutes [Go to STOPTIME]

STOPTIME
Universe: **All**

*Instrument will calculate STOPTIME if HOURDUR and MINDUR have entries other than blank or Don't Know.
*If there is a value for STARTIM, then interviewer should do the following:

Enter Time and AM or PM

WHO
Universe: **Not a personal activity and not an activity with a precode of 1, 2, 30, 31***

Who was with you? / Who accompanied you?
0. Alone
1—39. Household members and nonhousehold children
50. All household members
51. Parents
52. Other non-HH family members <18
53. Other non-HH family members 18 and older (including parents-in-law)
54. Friends
56. Neighbors, acquaintances
57. Other non-HH children < 18
58. Other non-HH adults 18 and older (including parents-in-law)
59. Boss or manager*
60. People whom I supervise*
61. Co-workers*
62. Customers* [Go to WHERE]

*Note: WHO was not asked about work activities (corresponding to precodes 4 and 5) until January 2010. Response options 59-62 were added to the WHO question at this time.

American Time Use Survey Questionnaire

WHERE
Universe: Personal activity reported OR ACTIVITY ≠ Precodes 1, 2, 30, 31

Where were you while you were [ACTIVITY]?

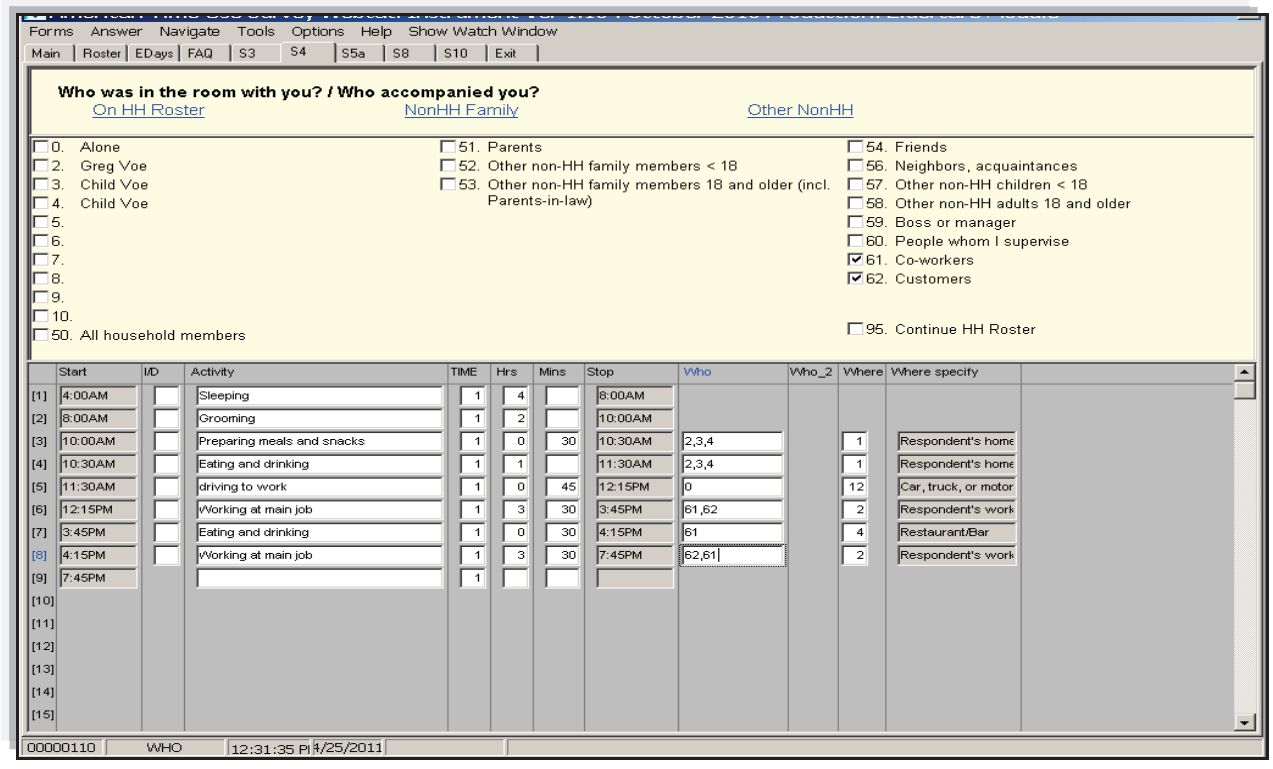
PLACE		MODE OF TRANSPORTATION
1. DP's home or yard	30. Bank*	12. Car, truck, or motorcycle (driver)
2. DP's workplace	31. Gym/ Health Club*	13. Car, truck, or motorcycle (passenger)
3. Someone else's home	32. Post Office*	14. Walking
4. Restaurant/Bar		15. Bus
5. Place of worship		16. Subway/Train
6. Grocery store		17. Bicycle
7. Other store/Mall		18. Boat/Ferry
8. School		19. Taxi/Limousine Service
9. Outdoors away from home		20. Airplane
10. Library		21. Other (specify)
11. Other place (specify)		

[If STOPTIME> 4 AM, go to S5: (Summary questions)]
[Else continue to next row]

*Note: Response options 30-32 were added to WHERE in mid-2004.

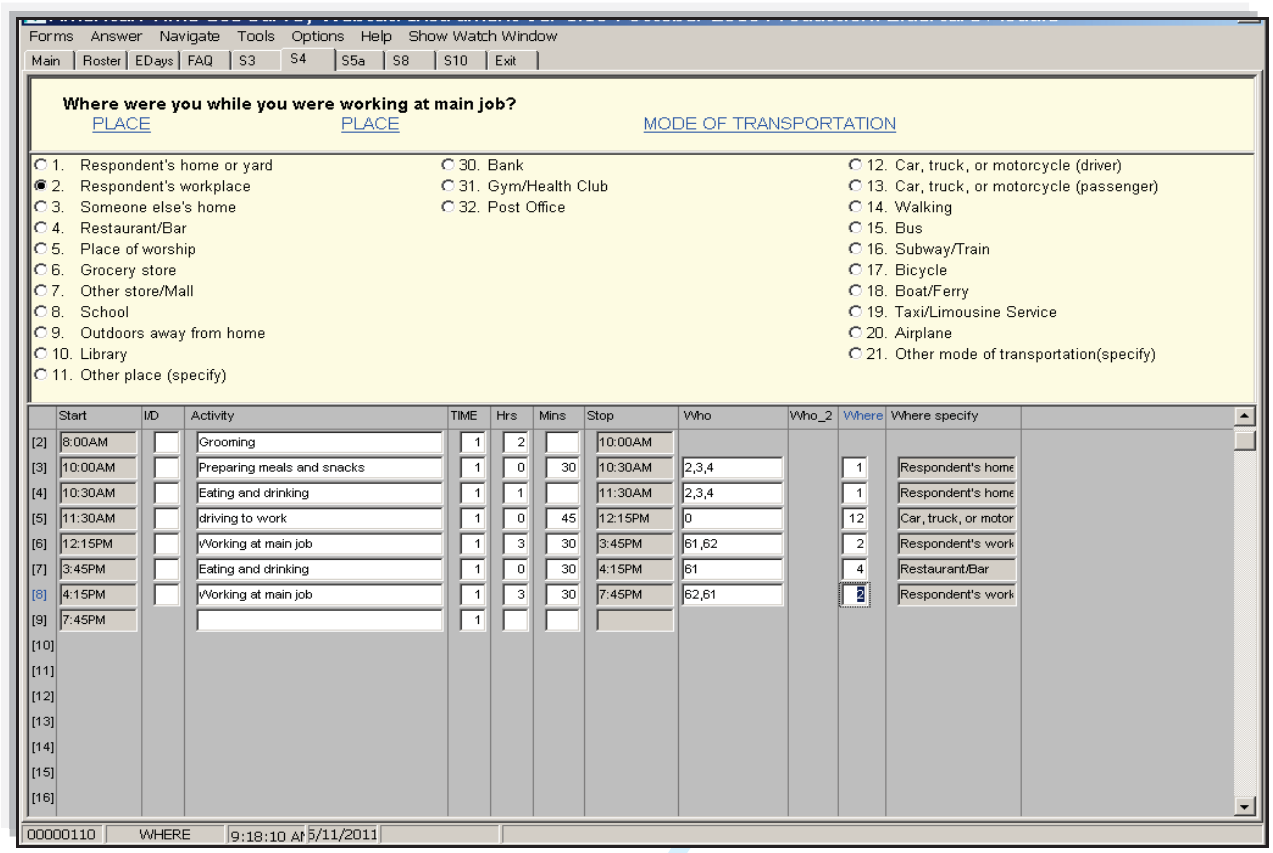
The following screenshots demonstrate how the WHO and WHERE questions are collected in the instrument:

WHO Screenshot



American Time Use Survey Questionnaire

WHERE Screenshot



The following variable is not included in the diary grid. This question is asked only if the respondent did not report any eating or drinking as a main activity for the 24-hour reporting day.

EATCK
Universe: **ACTIVITY ≠ Precode 7**

You did not report any eating or drinking yesterday. Did you do any eating or drinking yesterday as your main activity?
1. Yes [Edit diary, go to S5: (Summary questions)]
2. No [Go to S5: (Summary questions)]

STROBE 2016 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	P1 and P2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	P2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	P4, line 2-19
Objectives	3	State specific objectives, including any pre-specified hypotheses	P4, line 15-26 P6, line 1-5
Methods			
Study design	4	Present key elements of study design early in the paper	P5, line 8-14 P6, line 1-10
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5, line 9-26 P6, line 1-20
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	P5, line 9-14
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P6, line 12-24
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	P5, line 8-21
Bias	9	Describe any efforts to address potential sources of bias	P6, line 18-20
Study size	10	Explain how the study size was arrived at	P5, line 8-14 P6, line 12-13
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	P6, line 4-10 P6, line 12-13
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	P6, line 12-24

		(*b*) Describe any methods used to examine subgroups and interactions	P6, line 12-24
		(*c*) Explain how missing data were addressed	P5, line 19-21
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	P7, line 2-4
		(b) Give reasons for non-participation at each stage	Not avaialble
		(c) Consider use of a flow diagram	Not available
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	P7, Table 1 P9, Table 2 P10, Table 4 P11, Table 5
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Not applicable
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	P7, Table 1 P9, Table 2 P9, Table 3 P10, Table 4 P11, Table 5 Figure 1
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	P7, Table 1 P9, Table 2 P9, Table 3 P10, Table 4 P11, Table 5 Figure 1
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable

		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicatble
Discussion			
Key results	18	Summarise key results with reference to study objectives	P11, line 10-15 P12, line 13-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	P13, line 10-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P 12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	P13, line 15-23
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P15, line 8-11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.