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A cross-sectional study of travel patterns of older adults in the USA 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 USA, 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 USA 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 travellers was 88% for adults (25–64 years), 75% for adults (65–74 years) and 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 (from 8:00 to 15:59) while younger adults were more likely to travel in the late afternoons and early evenings (from 16:00 to 19:59).

Conclusions POV use is the predominant mode of transit in the USA. As adults age, the percentages of daily travellers 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.

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 (eg, 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 buses may require more complete studies and designs of public transit systems to meet the older adults' mobility needs.

BACKGROUND

Older adults (65 years or over) are more likely to be severely injured in motor vehicle collisions compared with younger adults.[1–3] Older adults also have one of the highest crash rates per unit of exposure (eg, vehicle miles of travel).[4 5] Additionally, 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 USA 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 characterised 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 with other adult drivers.[9] However,

those studies used the NHTS data up to 2009 (the most recent NHTS data were in 2009). Compared with 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 US nationwide data is important due to potential shifts in travel behaviours. To our knowledge, no study has evaluated older adults' travel patterns in the USA 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 with 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 (eg, 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 behaviours and may be useful in policy-making, transportation planning and road design to accommodate the ageing US population.

METHODS

Data source

The 2015 ATUS, an annual and nationally representative survey by the US 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 US Department of Labor,[18] and this study was approved by the Research Institute of Nationwide Children's Hospital's Institutional Review Board. One function of the ATUS is to discern how US 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 (ie, 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 online supplementary appendix 1),[19] which was used to record respondents' daily activities, starting at 04:00 am on the previous day and ending at 03:59 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 POVs (as both a driver and passenger); walking; biking; riding in a bus, train, boat, taxi or plane; or other modes. Other modes of transportation in the survey referred to unspecified modes of transportation. POVs referred to cars, trucks or motorcycles. Finally, the dataset included each respondent's demographic information (eg, 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 (ie, 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.

Statistical analysis

Older adults' travel patterns and behaviours 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 categorised 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 behaviours 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% 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 (ie, urban or rural area). All the analyses were conducted in SAS Enterprise Guide 9.4.

RESULTS

The 2015 ATUS study sample included 5634 females and 4297 males (25 years or older). The sample age group

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

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

*Unspecified mode of transportation.
POV, privately owned vehicle.

distribution was as follows: 7519 (25–64 years), 1484 (65–74 years) and 928 (75+ years). Normalised to the US population, survey results showed that 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.

Daily US travellers per transportation mode were produced by age and gender (table 2). For adults aged 25–64 years, 87.7% (95% CI: 86.7% to 88.7%) of them travelled in their dairy day, while this percentage decreased to 74.9% (95% CI: 72.6% to 77.2%) as adults aged to 65–74 years and finally to 67.7% (95% CI: 63.9% to 71.4%) for adults 75+ years. While the percentages of all travellers 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

Table 2 Daily travel of US population (2015): per cent of all travellers and per cent travellers per mode of transit by age and gender

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

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%.
POV, privately owned vehicle.

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

	POV drivers		POV passengers	
	OR	95% CI	OR	95% CI
Ages				
65–74	0.53	0.47 to 0.60	1.21	1.01 to 1.44
75+	0.32	0.27 to 0.38	1.49	1.18 to 1.87
Male	1.58	1.40 to 1.78	0.42	0.36 to 0.48
Rural	1.02	0.87 to 1.20	1.06	0.88 to 1.27

The ORs 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.
POV, privately owned vehicle.

males). This divide continued to widen with age to where males 75+ years accounted for 73.1% versus 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% to 64.7%) for males, which was one and one-half times more their female counterparts (37.9% (95% CI: 32.8% to 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 and 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 and they presented 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 with those 25–64 years (7.0% (95% CI: 5.3% to 8.6%) and 5.5% (95% CI: 3.6% to 7.3%) compared with 10.4% (95% CI: 9.6% to 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 with adults 25–64 years, adults 65–74 (OR: 0.53 (95% CI: 0.47 to 0.60)) and 75+ (OR: 0.32 (95% CI: 0.27 to 0.38)) years had lower odds of daily driving POVs. However, adults 65–74 (OR: 1.21 (95% CI: 1.01 to 1.44)) and 75+ (OR: 1.49 (95% CI: 1.18 to 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 to 1.78)) but lower odds of riding in POVs than their female counterparts (OR: 0.42 (95% CI: 0.36 to 0.48)).

Differences in the average daily driving and riding time in POVs were analysed 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).

To understand the travel patterns among different age groups for weekdays (from Monday to Friday) versus weekends (Saturday and Sunday), we analysed the number of travelling and driving trips and the percentages of POV drivers (table 5). Adults 25–64 years did slightly more travelling and driving trips during weekdays than weekends. Again, for adults 65–74 years, the average number of daily travelling trips on weekday was slightly greater than that on weekend. However, the average difference in the number of travelling and driving trips between weekday and weekend were not apparent for adults aged 75+ years. Additionally, the percentages of travellers and

Table 4 Distribution of daily driving and riding times in POVs by gender and age group, US population, 2015

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

POV, privately owned vehicle.

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 analysed for each age group (figure 1). Adults 65–74 and 75+ years took more trips in the mornings and early afternoons (between 08:00 and 11:59 and between 12:00 and 15:59) than other time periods, while adults 25–64 years took more trips in the late afternoons and early evenings (between 16:00 and 19:59) (figure 1).

DISCUSSION

Since Ford's Model T, Americans have a long-standing penchant for POVs.[25] How does age affect the driving habits, daily trips and modes of travel in our ageing society? Many studies have investigated the travel patterns of older Americans using the 2001 or 2009 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 that most adults still rely heavily on POVs for mobility as the primary mode of transportation in the USA. Reporting from the 2009 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

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

	All travelling trips		Driving trips		Travellers		POV drivers	
	Mean	95% CI	Mean	95% CI	%	95% CI	%	95% CI
Ages 25–64 years								
Weekday	4.0	3.9 to 4.1	3.0	2.9 to 3.1	88.4	87.2 to 89.5	74.6	73.1 to 76.1
Weekend	3.4	3.3 to 3.6	2.5	2.4 to 2.6	85.9	84.2 to 87.6	71.4	69.3 to 73.4
Ages 65–74 years								
Weekday	3.4	3.1 to 3.6	2.3	2.2 to 2.5	76.5	73.5 to 79.4	60.4	57.1 to 63.8
Weekend	2.7	2.5 to 3.0	2.0	1.8 to 2.3	71.1	65.8 to 76.3	57.8	52.4 to 63.1
Ages 75+ years								
Weekday	2.6	2.4 to 2.9	1.8	1.6 to 2.0	67.4	63.0 to 71.7	46.6	41.6 to 51.6
Weekend	2.4	2.1 to 2.7	1.6	1.3 to 1.8	68.5	61.6 to 75.4	46.1	39.7 to 52.5

POV, privately owned vehicle.

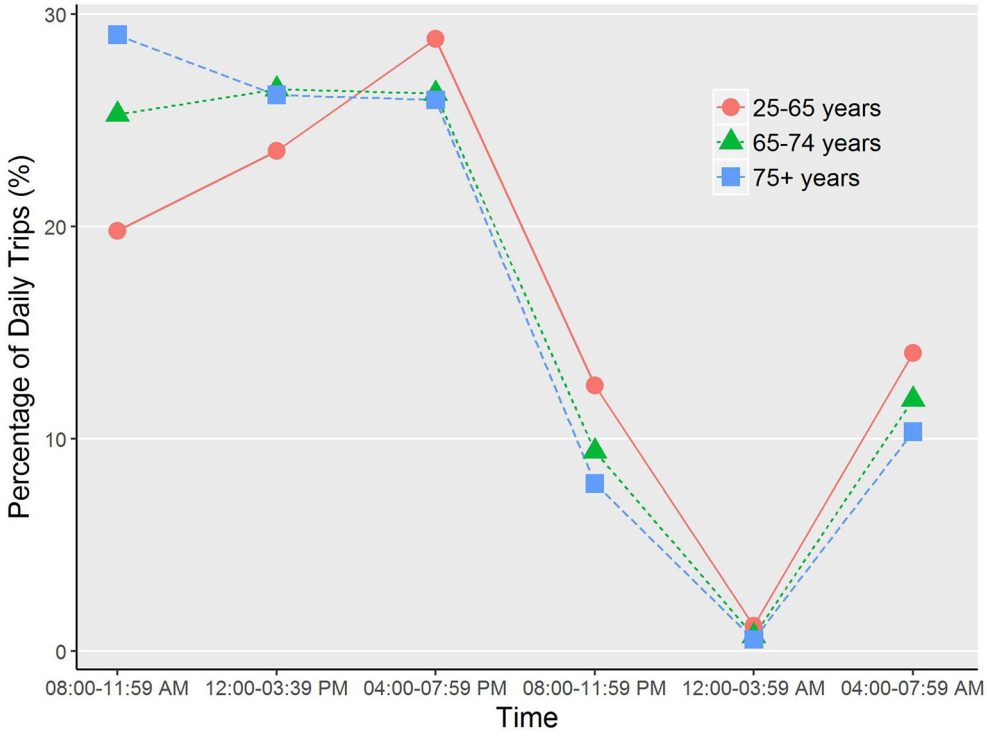

Figure 1 Distribution of daily trips according to time of day by age group for the US population in 2015.

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 US 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 (eg, 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 semiautonomous vehicles are available to the public. Many studies have also suggested that semiautonomous vehicles may induce negative impacts on drivers, such as distraction, fatigue and poor responses to a takeover 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 (from 8:00 to 11:59 and from noon to 15:59) but less likely to drive POVs in the evening and night. Older drivers may develop self-regulating driving behaviours, 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+ years), there was no apparent difference of travel patterns between a weekday and a day of weekend with respect to the percentage of travellers and POV drivers. This may be due to more flexibility in postretirement time.

Limitations

First, since distance travelled 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 1 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. Last, as the ATUS data are nationally representative, they do not reflect differences among individual states.

CONCLUSIONS

Overall, driving and riding in 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.

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