The Effect of Fuel Prices on the Driving Patterns of Older Adults

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Abstract

Examining environmental factors that influence older adults' driving patterns has important implications for understanding factors that can lead to self-regulation and cessation. The current study explored the effect of fuel prices on older adults' driving patterns using objective data from the nationwide Candrive longitudinal study (*N* = 807). Fuel prices were negatively associated with driving distance and positively associated with speeding and acceleration pattern. Specifically, on occasions when fuel prices were high, older adults drove less often but were speeding and accelerating more. However, the magnitudes of the effects were small, suggesting that older adults continue to rely on their vehicles for community mobility, despite variations in fuel prices.

Keywords (6): older adults, driving, gas prices, Candrive

Introduction

Older adults represent the fastest growing segment of the driving population and the number of older drivers is projected to increase at a rapid pace. The majority of older adults use personal vehicles as their primary form of transportation, similar to that of other age groups (Turcotte, 2012). For many older adults, driving provides them with freedom of mobility that promotes their sense of personal identity, control, and belonging to a larger community (Gardezi et al., 2006). These strong emotional ties to driving likely motivate many older adults to continue driving as long as possible (Rudman, Friedland, Chipman, & Sciortino, 2006). Another reason why older adults continue to drive may be that alternative forms of transportation such as public transit services are less available or accessible in their community, particularly for those residing in rural regions. However, declines in physical health and cognitive functioning associated with age-related diseases may put older adults at increased risk of crashes and other unsafe driving behaviors (Anstey, Wood, Lord, & Walker, 2005; Dawson et al., 2010; Green, McGwin, & Owsley, 2013).

Past research has demonstrated that some older adults voluntarily regulate their driving to fit with their functional abilities in order to remain comfortable on the road (Betz & Lowensteing, 2010; Donorfio, D'Ambrosio, Coughlin & Mohyde, 2008; Myers, Paradis, & Blandshard, 2008). Driving self-regulation refers to restrictions while driving which is often a part of the process leading to driving cessation. Much of the existing research on factors that influence older adults' driving practices has mainly focused on individual and interpersonal predictors. Cognitive function and physical health (Marshall & Man-Son-Hing, 2011; Rapoport et al., 2016; Tuokko et al., 2016), as well as psychosocial factors including attitudes (Sukhawathanakul et al., 2015; Wong, Smith, & Sullivan, 2017), comfort level (Molnar et al., 2014; Myers et al., 2008), and confidence (Conlon, Rahaley, & Davis, 2017) have all been shown to predict self-reported driving self-regulation.

However, emerging evidence suggests that environmental factors can also impact older adult's driving patterns. Vivoda and colleagues (2016) found that factors within the transportation environment (e.g., roadway density, increased congestion) increase the odds of self-reported driving reduction and cessation among older adults. Weather conditions can also influence older adults' decisions to drive. While older adults are more likely to make trips for social and/or entertainment purposes on days with good weather (Myers, Trang, & Crizzle, 2011), their driving distance declines over the winter, as snow or other precipitation may discourage driving (Smith et al., 2016).

These relationships are consistent with ecological models of development and health that acknowledge individual behaviors are embedded within the context of broader physical and social environments (Bronfenbrenner, 2009; Schulz & Northridge, 2004). Theoretical models specifically pertaining to driving, such as the Driving as an Everyday Competence model (Lindstrom-Forneri, Tuokko, Garrett, & Molnar, 2010), the Comprehensive Framework for Mobility in Older Adults (Webber, Porter, & Menec, 2010), and the Multilevel Older Persons Transportation and Road Safety model (Wong, Smith, Sullivan, & Allen, 2014) also calls for consideration of environmental factors in relation to older adults' driving competence, performance, and self-regulation. Such macro-level factors can include the availability of community resources, alternative transportation options, infrastructural accessibility, proximity to amenities, and public policy. The current study builds on previous research by examining the impact of fuel prices on changes in driving patterns using objective tracking measures from a national sample of older drivers in Canada. Fuel price is an important environmental factor often expected to play a crucial role in driving decisions.

Most of the evidence about the impact of the financial burden of fuel prices on discouraging driving comes from large-scale nationally representative datasets. For example, in a nationally representative German sample, Frondel and Vance (2010) found that higher fuel prices led to less car usage in general (e.g., number of trips, distance). There is evidence to suggest fuel prices can impact the behaviors among younger samples. In a study involving young adults (18-30 year olds), Hou and colleagues (2011) found that higher gasoline prices were associated with an increase in leisure physical activity. The authors argued that high gas prices may influence an individual's decisions to drive to a particular location for physical activity, and instead they may choose to use other forms of transportation that can have an indirect impact on physical activity (e.g., walking or cycling to their destination). However, we know very little about the direct impact of fluctuating fuel prices specifically on older adult driving behaviors. High fuel prices may be a particular deterrent among older drivers who may already be increasingly uncomfortable with driving and who may be on fixed incomes. They may opt to avoid driving for recreational or social purposes but still have to drive out of necessity, such as attending medical appointments. However, since driving is the main form of transportation for older adults in Canada (Statistics Canada, 2011), they might be less likely to change their driving patterns in response to gas prices in order to maintain their mobility.

Much of the research on older adult driving has relied on self-report data. As well, to our knowledge, there have yet been studies that have examined the effect of fuel prices in a group of older drivers whose driving distances have been objectively measured longitudinally using an in-vehicle global positioning system (GPS). Objective measures of driving provide an advantage over self-report measures, as older drivers tend to inaccurately estimate driving distance compared to objectively measured mileage (Blanchard, Myers & Porter, 2010; Huebner et al., 2006; Porter et al., 2015).

The purpose of this study was to model the fluctuations in fuel prices and to determine whether changes in fuel prices had any effect on the longitudinal driving patterns of older adults. Driving patterns were derived from monthly records of driving distance, speeding, and acceleration patterns captured by in-vehicle GPS devices. It was hypothesized that higher fuel prices would lead to shorter distances travelled and more fuel-efficient driving (e.g., less speeding and lower acceleration profiles).

Methods

Participants

Participants were part of the Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive), a longitudinal study of older drivers in seven Canadian cities (Victoria, Winnipeg, Thunder Bay, Hamilton, Toronto, Ottawa and Montreal; Marshall et al., 2013). Participants had to drive regularly (4 times per week or more) and be 70 years of age or older in order to be eligible for the study. At baseline, participants ranged in age from 70 to 94 years ($M = 76.21$, $SD = 4.85$); 62% ($n = 577$) were male. Most participants completed some post-secondary education (45%), 19% had obtained a diploma or a trade/technical certificate beyond high school, 26% completed high school, and 10% did not continue beyond grade school. The Candrive sample has been shown to be comparable to a representative sample of Canadian older drivers on a range sociodemographic and health variables (Gagnon et al., 2016).

At baseline the initial sample yielded 928 participants. However, 121 participants were excluded from the analyses of the current study due to ineligible data. Specifically, among the 121 participants with ineligible data, 12 had recording devices that were incompatible with their vehicle, 1 quit or restricted driving within the first 6 months, and 108 had unusable data (e.g., due to device/user error, they always drove an alternate vehicle that resulted in a large portion of unmeasured data, or participants indicated being away for an extended period of time on a trip). Excluding these participants resulted in a final sample of 807 individuals with eligible data.

Procedure

All participants had an autonomous recording device installed in their primary vehicle to monitor their driving patterns while they were enrolled in the study. The device records data from the vehicle through the on-board diagnostic system as well as global positioning system (GPS) signals at 1 Hz. For each time point the location and vehicle speed are recorded. From this data trip distance and instantaneous acceleration can be calculated. For these data a trip is defined as beginning when the ignition is turned on and ending when the ignition is turned off. The device software also allows for the obtaining of geographic information system (GIS) data. This includes speed limits for roadways within the city of each site. The in-vehicle device also contains a radio frequency identifier system (antenna plus key chain fob) that can identify the participant as the vehicle driver, so that data on driving done by people other than the participant can be removed. For more details on the device and data processing see Porter et al. (2015).

Measures

Fuel prices. Monthly average fuel prices (cents per litre) for each research site, for the time period of interest (June 2009 to September 2013), were obtained from Statistics Canada. Data for all sites were available except Hamilton. Given the proximity of Toronto to Hamilton, Toronto prices were used for participants from Hamilton.

Driving patterns. For these analyses, monthly driving distance was the primary focus, where speeding as well as acceleration were considered secondary outcomes. Driving distance was assessed separately by summer (April to October) and winter (November to March) months. Speeding was examined within speed limit zones of: 40, 50, 60, 70, 80, 90, and 100 km/hr. It was calculated as the proportion of total driving time that was spent in excess of the speed limit of the respective zone. Number of hard accelerations were determined relative to both distance travelled and number of stops made. That is, hard accelerations refer to the number of hard accelerations per km and stops. A value of ≥ 0.27369795918 g was considered to be a hard acceleration event (Jun et al., 2007). Both hard accelerations relative to distance travelled and number of stops were skewed so the data was log transformed.

Data analyses

Joinpoint regression analyses were used to depict how gas prices changed over time across sites (Joinpoint Trend Analysis Software version 4.5.0.1, National Cancer Institute; http://surveillance.cancer.gov/joinpoint/). This approach allows for detection of trends and identifies the number of times the linear trend changes over a given period of time. That is, this allows for detection of the number of significant shifts in gas price trends from 2009 to 2013. The analytic approach uses the Monte Carlo Permutation method to determine whether each change in trend or 'joinpoint' is statistically significant (Kim et al., 2000).

The relationships between monthly driving patterns and gas prices were analyzed using univariate linear mixed-models. For each model, a particular driving behavior (distance, speeding, acceleration patterns) was the independent variable and regressed upon fuel price. Subjects were considered a random effect to account for within subject correlation (i.e., driving behaviors were assumed to be alike within an individual). For all of these analyses, data were included when there were complete months of driving patterns data available. Maximum likelihood procedures were used to produce estimates for all models.

Results

Descriptives

Means and standard deviations of driving variables are presented in Table 1. The average trip distance in the year was 853 km. Participants spent over 20% of the time speeding in the 80, 90, and 100 zones.

Table 1. Means and Standard Deviations of Monthly Driving Variables

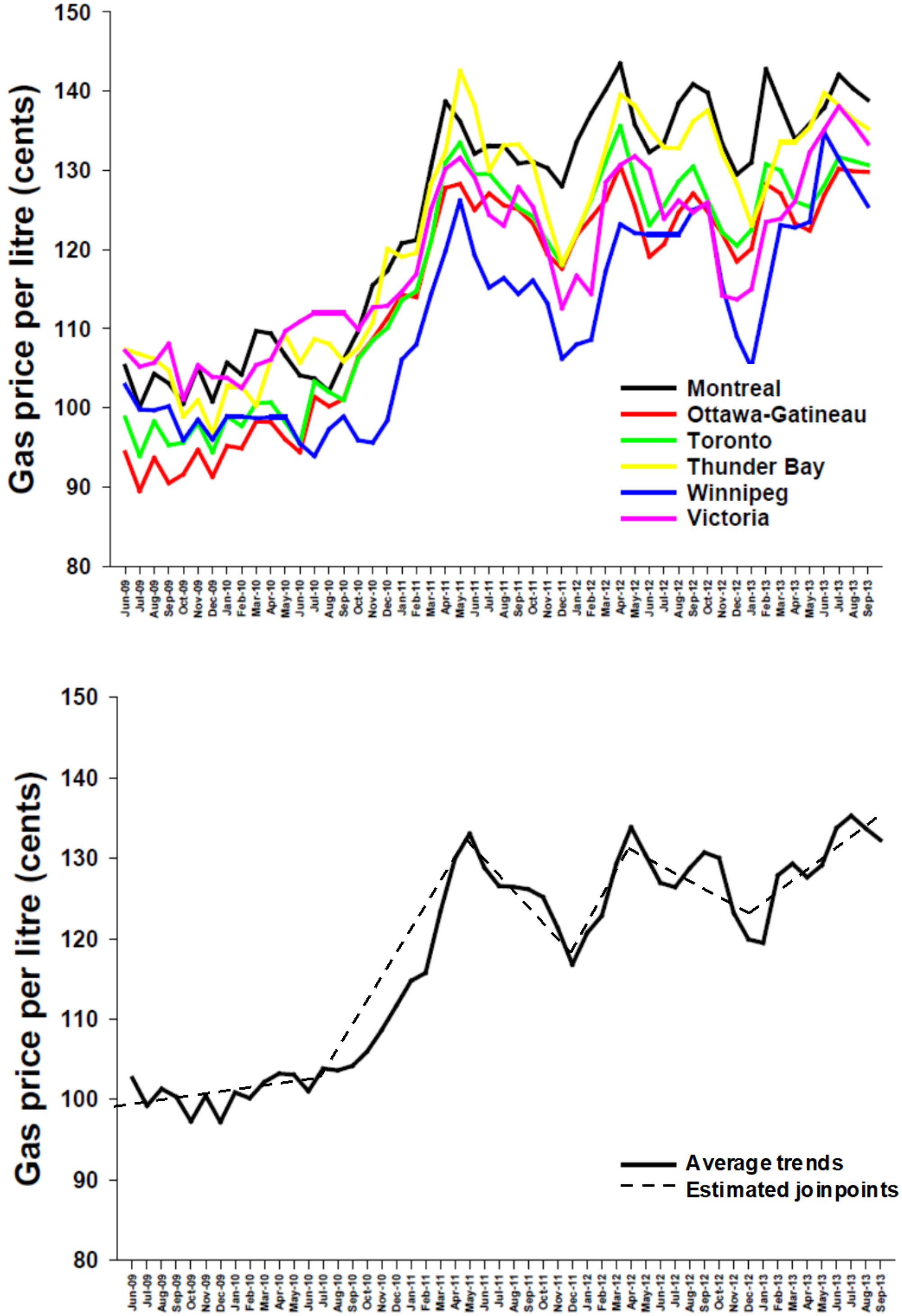
	Mean	SD	Minimum	Maximum
Distance (km)	853.14	734.88	0.01	11737.87
Speeding (%)				
80	22.70	21.76	0	100
90	29.74	26.41	0	100
100	30.26	26.51	0	100
Acceleration Patterns				
Per Km	0.03	0.04	0	0.52
Per Stops	0.02	0.02	0	0.28

Fuel prices

Monthly fuel prices for each city separately, as well as combined across sites, are illustrated in Figure 1. While individual cities have differing fuel prices across time, the pattern of change is similar. When examining fuel prices by each city or when combined across sites, the same pattern is observed, with regard to large fluctuations in fuel prices, particularly between the spring of 2010 and the fall of 2011. During this time, fuel prices increased by almost 40%. Over the total time period, the minimum average gas price, across all sites, was $0.972 (per litre CAD), and the maximum was $1.353. However, this increase was not linear across the entire time frame, as several trends were noted in the joinpoint analyses. Findings from the joinpoint analyses showed that a 5-joinpoints model was the best fitting model. That is, on average, there were 5 significant shifts in gas price trends that occurred during the course of the study.

Specifically, gas prices on average rose a total of four times and declined twice across the duration of the study.

a.



b.

Figure 1. A. Monthly fuel prices for each site. B. Average monthly gas prices and estimated joinpoints (i.e., significant shifts in price) with all sites combined.

Driving patterns

Table 2. The Effects of Fuel Price on Monthly Driving Patterns

	Driving Distance				Speeding						Acceleration Patterns			
	Summer		Winter		80km		90km		100km		Hard Accelerations per Km		Hard Accelerations per Stop	
	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
Intercept	964.590**	20.781	766.874**	19.014	20.949**	1.521	21.993**	2.166	29.324**	1.803	-4.461**	0.059	-4.520**	0.050
Gas price	-3.329**	0.526	-1.699**	0.653	0.024*	0.012	0.072**	0.017	0.009	0.014	0.005**	0.0004	0.005**	0.0004

*Note. Est=Estimate; SE=Standard Error; *p<.05 **p<.001; Estimates for acceleration patterns are log transformed*

Driving distance. There was a significant relationship between fuel price and driving distance for both the summer months (April to October; $\beta = -3.329$, $p < .001$) and winter months (November to March; $\beta = -1.699$, $p = .009$). Specifically, a 20 cent increase would indicate a 7% decrease in monthly driving distance during the summer months and a 4% decrease in monthly driving distance during the winter months.

Speeding. Fuel price did not have a significant association with speeding within the lower speed limit zones of 40, 50, 60, and 70 km/hr. However, fuel price was positively associated with speeding in the higher speed limit zones of 80 and 90 km/hr (βs = .0239 and .0724, $p = .04$ and $p < .001$ respectively), but not 100 ($\beta = .0086$, $p = .54$) but not in the 100 km/hr zone. Specifically, when driving in 80 km/hr zones, participants spent 23% of the time exceeding the speed limit and 30% of the time speeding in 90 km/hr zones. A 10 cent increase in gas prices resulted in participants exceeding the speed limit 0.2% more of the time in 80km/hr zones and 0.7% more of the time in 90 km/hr zones.

Acceleration patterns. There was a positive relationship between fuel prices and hard accelerations per km and stops (βs = .0054 and .0045 respectively, $p < .001$). However, the magnitude of the effect was small. Specifically, for every 10-cent increase in gas price, there was a 5.5% increase in hard accelerations per km and a 4.6% increase in hard accelerations per stops.

Discussion

This study examined the effects of gas prices on the driving patterns of older adults. Findings from the joinpoint analyses revealed that gas prices fluctuated over the course of the study. Findings from the regression models demonstrated that driving behaviors covaried with fluctuations in gas prices. Specifically, on occasions when gas prices were high, there was a reduction in driving distance. In contrast, increased speeding (at higher speed limits) and hard accelerations were associated with higher gas prices. However, the magnitudes of the effects of gas prices on all the driving outcomes were small such that a relatively large cent change in fuel price would result in a substantial change. This finding is consistent with analyses of gas prices and freeway speeds, which demonstrate that drivers respond minimally to increased fuel costs (Burger & Kaffine, 2009). This result is surprising given that higher fuel prices should motivate individuals to conserve fuel consumption by reducing to more fuel-efficient speeds.

These findings suggest that older adults continue to rely on their vehicles as their main mode of transportation even when gas prices are high, which is in contrast to what has been reported in other studies involving younger samples who resort to alternative forms of transportation when fuel prices are high (e.g., Hou et al., 2011). It may be that older adults' desire to maintain their independence outweighs the environmental barrier of higher gas prices when it comes to driving. This finding is consistent with previous studies that highlight the loss of independence as one of the main reasons older adults remain behind-the-wheel (Adler & Rottunda, 2006; Gardezi et al., 2006). Lack of access to or the acceptability of other forms of transportation may also contribute to older adults' decisions to continue drive. For example, older adults residing in rural communities report driving more than their urban counterparts (e.g., Coxon et al., 2015) perhaps relying more on their personal vehicles due to limited access to alternative transportation.

It is possible that the driving habits and routines of older adults are well established such that gas prices have a relatively small impact on their driving distance, speeding, and acceleration. Engrained driving habits may be difficult to modify in the face of changing environmental or individual changes. For example, studies involving "driving signatures" are able to identify older drivers based on their unique acceleration and deceleration patterns (e.g., Wallace et al., 2016). Although gas prices did not substantially impact the driving behaviors of older adults in this sample, it is possible that other environmental factors could have a more salient influence. Notable changes in the transportation environment, such as high traffic density, likely pose greater challenges to older adults' driving abilities than do economic constraints of gas prices (Vivoda et al., 2016). Changes in more macro-level environmental factors, such as public policies, regarding relicensing may have a larger impact on older drivers' decisions reduce or cease driving (Kulikov, 2010).

Limitations and Future Directions

There are limitations in this study that merit consideration. First, findings from this study are limited to this Canadian sample, which may not be representative of older drivers from other nations. Moreover, in order to participate in the study, individuals must not have medical conditions that would impair their driving at baseline. Thus the sample consisted mainly of relatively healthy, active drivers aged 70 years and older, at baseline. Differences in health and functional status may influence decisions to drive in the face of varying gas prices. Future research into whether functional abilities moderate the association between gas prices and driving behaviours is needed as functional abilities may contribute to variability in driving behaviours among older adults. It is possible that the presence of functional deficits can increase driving by limiting alternative forms of transportation. On the other hand, functional deficits could also serve to limit driving. Another limitation of the study is that our analytic models did not account for individual level predictors, such as income, as this information was not collected in the study. Gas prices may be more taxing on individuals with lower income as they have fewer resources than individuals with higher income. For example, older adults with lower income are more likely to cite physical limitations such as problems with their eyesight as a common reason for limiting driving (Ragland, Satariano, & MacLeod, 2004). On the other hand, older adults with higher income may be able to afford the cost of alternative modes of transportation for ease of travel (e.g., taking a taxi) that may encourage them to reduce their driving over time. For example, Unsowrth, Wells, Browning, Thomas, and Kendig (2007) found that older adults who rated their incomes as ‘comfortable’ are more likely to relinquish driving than those with lower incomes. In addition to income, older adults who have others available to drive them or other forms of social support may be more willing to reduce their own driving. More research is needed to discern the effects of gas prices on different groups of older drivers with varying levels of income, functional abilities and forms of social support.

Despite these limitations, our study demonstrated that objective measures of driving can be useful in determining driving patterns of older adults and may be used to examine these patterns in relation to environmental changes such as gas prices. The negative association between gas price and driving distance may have implications on motor vehicle crashes. The effect of fuel price on motor vehicle crash fatalities among older adults has been examined cross-sectionally (Bell et al., 2015). However, a longitudinal investigation of this relationship can more accurately determine whether gas prices can exert a protective effect over time. Examining factors that mediate the effect of gas prices on driving patterns may also be useful in determining psychological processes that promote or dampen its effect. For example, psychosocial variables, such as driving confidence and attitudes, have been shown to influence driving self-regulation by mediating the association with physical health and driving outcomes (Conlon et al., 2017; Tuokko et al., 2016). It is possible that holding positive or negative attitudes towards driving may interact with an individual’s decisions to restrict their driving on occasions when gas prices are high. Lastly, interventions that target driving cessation may benefit from including discussions or program components that address environmental barriers, such as fuel prices.

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