Characteristics of low and high mileage drivers: Findings from the Ozcandrive older driver cohort study

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Key Findings

- Low mileage group had proportionally more female than male drivers
- Low mileage group drove most trips within 5 km and fewest trips beyond 20 km
- High mileage group drove least trips within 5 km and most trips beyond 20 km
- No significant group differences on all functional outcomes or crash/citation data
- Low mileage group reported lowest scores on Driving Comfort Scale

Abstract

This study used real-world driving data from the Ozcandrive older driver cohort study to examine the relationship between annual mileage driven and a range of demographic and functional factors, self-reported driving comfort, real-world driving patterns and self-reported crashes and citations. Driving data for a subset of Australian participants of the Candrive/ Ozcandrive study (n = 183), aged 75-94 years were included in the analysis. Participants' real-world annual mileage distances were recorded through an in-car recording device (ICRD) installed in participants' own vehicles. Participants' annual mileage distances were grouped into three categories (low: ≤ 5,000 km, middle: > 5,000 - < 13,000 km, and high: ≥ 13,000 km). Preliminary results showed females were more likely to be in the low mileage group compared to male drivers. Additionally, the low mileage group drove significantly more trips 5 km or less compared to the middle and high mileage groups, while the high mileage group drove the greatest percentage of trips beyond 20 km compared to the low and middle mileage groups. On average, the low mileage group reported the lowest total scores on the Driving Comfort Scale compared to the high mileage group which reported the highest total score. However, there were no significant group differences on any tests of cognitive/ functional ability or crash and citation rates. Findings suggest that older adults who drive lower annual mileages may engage in some driving practices that are suggestive of self-regulation. However, a larger-scale study using official crash data is needed to establish whether the low mileage bias is pertinent to older drivers.

Keywords

Older drivers, Low Mileage Bias, Crash risk, Functional ability, Real-world driving

Introduction

Older drivers represent one of the highest risk groups for crash-related deaths and serious injuries per number of drivers and per distance travelled (Koppel, Bohensky, Langford, & Taranto, 2011; Langford & Koppel, 2006). Although there is support for the assertion that older drivers are overrepresented in crashes (OECD., 2001), previous research has found that when annual mileage driven is accounted for, only older drivers with low annual mileages show a heightened crash risk per unit of distance travelled compared to older drivers with higher annual mileages (Janke, 1991). This is consistent with the notion that irrespective of age, drivers who travel shorter distances per trip will have greater crash involvement per unit of distance in comparison to drivers who travel longer driving distances per trip (Alvarez & Fierro, 2008).

The term 'low mileage bias' (LMB) has been used to describe the phenomenon that drivers with lower annual mileages have increased crash rates (Alvarez & Fierro, 2008; Hakamies-Blomqvist, Raitanen, & O'Neill, 2002; Langford, Methorst, & Hakamies-Blomqvist, 2006). The LMB was first demonstrated by Hakamies-Blomqvist et al. (2002)

in a survey of 1,869 drivers within two age groups (26-40 years; 65+ years) who were divided into low, medium and high annual mileage groups (<3,000 km, 3,000 -14,000 km, >14,000 km per year, respectively). The authors found small or no differences in crash rates between the two age groups for those in medium or high mileage groups. However, they found an increase in crash rate per mile driven for older drivers in the low mileage group. Similar studies were later conducted by Langford et al. (2006) and Alvarez and Fierro (2008) among drivers aged 75 years and older who were grouped into the same annual mileage categories as Hakamies-Blomqvist et al. (2002). The authors found further support for the LMB, demonstrating elevated crash rates for drivers with lower annual mileages relative to drivers with higher annual mileages.This effect was evident in both older (i.e., 75+ years) and younger age groups (18 -75 years). Specifically, Langford et al. (2006) found only older drivers travelling less than 3,000 km per year (roughly 10% of older drivers in the survey) had heightened crash rates compared to younger drivers.

A potential explanation for the LMB is that low mileage drivers tend to drive primarily in urban areas with complex traffic situations and intersections which increase their crash risk, or number of crashes per mile of driving (Janke, 1991; Langford & Koppel, 2005). Janke (1991) found that the crash risk on non-freeways was 2.75 times higher than on freeways, likely due to difficulties in negotiating intersections. Conversely, middle and high mileage drivers may conduct more of their driving trips on controlled-access highways and multi-lane divided roadways which are associated with a lower crash risk (Langford et al., 2005).

Another possible explanation for the LMB is that low mileage drivers may have a higher crash risk due to poorer perceived or actual declines in driving ability compared to high mileage drivers. This is consistent with findings that an increased number of medical conditions, known to impair driving ability, tend to be associated with advanced age and lower mileages (Alvarez et al., 2008). Indeed, several studies have reported that low mileage drivers perform significantly worse on functional assessments and across a range of physical/sensory and cognitive tests, as well as relicensing driving examinations compared to high mileage drivers (Koppel et al., 2005; Langford et al., 2013). Similarly, low mileage older drivers have reported lower levels of comfort in challenging road situations, including at night and on freeways, had poorer perceptions of their driving abilities and reported more restrictions to their driving compared to high mileage drivers (Blanchard & Myers, 2010; Langford et al., 2013; Myers, Trang, & Crizzle, 2011). It may be that cognitive and/or physical health status is the mediating factor that both reduces annual mileages and increases crash risk (Ball et al., 1998; Owsley et al., 1998).

Although there is considerable evidence to support the LMB, most studies have examined per-mileage crash rates among older drivers using self-reported driving data and crash frequencies (Hakamies-Blomqvist et al., 2002; Langford et al., 2006; Alvarez & Fierro, 2008). However, several authors have suggested that the subjective methods used to validate the LMB may not be reliable particularly

as older drivers' self-estimates of annual driving distance may be inaccurate (Langford et al., 2013; Langford, Koppel, Charlton, Fildes, & Newstead, 2006; Staplin, Gish, & Joyce, 2008). A preferred approach is to use objective data sources to measure both annual mileages and crash rates to further validate the LMB and guide improvements to roadway safety and mobility for older drivers (Langford et al., 2008).

The current study aimed to use real-world driving data from the Ozcandrive prospective study of older drivers (Marshall et al., 2013) to investigate associations between annual mileages and:

- Demographic and functional factors;
- Self-reported day-time and night-time driving comfort;
- Annual naturalistic driving patterns, and
- Self-reported crashes and driving citations.

Methods

Candrive/Ozcandrive Project

The Candrive/Ozcandrive study is a multicentre, prospective cohort study which involves a total of 1,230 older drivers from Canada, Australia and New Zealand. In addition to the naturalistic driving data collected, participants completed annual assessments, which included demographic and driving-history questions, measures of functional performance, medications and medical conditions, and self-reported information on driving-related comfort, abilities and practices. Full details on sample recruitment and annual assessment protocols can be found elsewhere (Marshall et al., 2013). All data used in the current study were from the Year 1 assessment protocols (Marshall et al., 2013).

Participants

The Australian subset of the Candrive/Ozcandrive study comprised 257 participants living in the greater Melbourne area in Victoria, Australia. Participants, ranging in age from 75 to 94 years, were recruited into the study on a rolling basis between June 2010 and June 2011. Drivers' first year of data, collected during the period June 2010 - June 2012 was included in the current study. All participants were required to meet the following inclusion criteria: (a) aged 75 years or older; (b) held a valid driver's license; (c) drove at least four times per week; (d) drove a 2003 model vehicle or newer, and (e) did not have an absolute contraindication to driving, as defined by the Austroads Fitness to Drive Guidelines (Austroads, 2013).

Measures

Naturalistic driving data

Monitoring of participants' driving patterns occurred throughout the study using a custom-designed in-car recording device (ICRD; OttoView-CD autonomous data logging device) and software suite that was developed for Candrive II/Ozcandrive by Persen Technologies Inc. (Winnipeg, Manitoba). The ICRD was powered through

the on-board diagnostic port of the participants' primary vehicle. The ICRD collected information from the vehicle (e.g., time/date of trip, speed, distance travelled and vehicle parameters) and vehicle location was registered using the Global Positioning System (GPS). Data were saved at a rate of 1 Hz onto a Secure Digital (SD) card that was changed approximately every 4 months to ensure adequate storage space. For participants who shared their vehicle with another driver, a radio frequency identifier system (RFID) was attached to the study participants' car keys. The RFID signals marked the study participants' driving data, thus allowing other driver data to be disregarded. A log book was also provided for shared vehicles for the purpose of recording details for all non-participant driving trips. Additionally, in the event that participants changed their primary vehicle, every effort was made to transfer the ICRD device into the new vehicles on the same day the vehicles were acquired.

Demographic and functional performance measures

Relevant demographic characteristics (age and gender), as well as scores on a range of functional performance measures were selected for analysis. These functional performance measures are described in more detail below.

Functional Performance measures

The MoCA (Nasreddine et al., 2005) and MMSE (Folstein, Folstein & McHugh, 1975) are brief cognitive assessments with total scores ranging from 0 to 30. Scores below 26 on the MoCA and 24 on the MMSE indicate cognitive impairment.

Trail Making Test –Trails B (Moses, 2004) is a timed measure of general cognitive function and executive functioning which involves connecting 25 numbers and letters in alternating order (i.e., 1 to A to 2 to B, etc.). The score is the overall time in seconds required to complete the connections, where a time in excess of 180 seconds may indicate increased risk of crash (Staplin, Gish & Wagner, 2003).

Rapid Pace Walk is a timed measure of motor speed, balance and coordination (Carr, Schwartzberg, Manning & Sempek, 2010). A time in excess of 10 seconds may indicate increased crash risk (Staplin et al., 2003).

The Snellen eye chart provides a measure of visual acuity. Visual acuity scores obtained from the Snellen eye chart were converted to the logarithm of the minimum angle of resolution (LogMAR) (McGwin & Brown, 1999). A LogMAR score of 0.0 is considered normal vision, whereas a score of +0.3 is considered reduced vision and is the Australian legal driving limit (Austroads, 2013).

The Older Americans Resources and Services (OARS) activities of daily living scale (McCusker et al., 1999) includes 14 items; seven items assess biological functions (BADL) including eating, dressing, undressing, grooming, walking, getting in and out of bed, bathing and continence and the other seven items assess instrumental functions (IADL) including using the telephone, travel, shopping, meal preparation, housework, taking medicine and management of finances. The total score is the sum of all 14 items and ranges from 0 to 28 with higher scores indicating greater independence.

Driving Comfort

Self-reported driving comfort was measured using two scales that assess comfort of driving in various situations during the day and at night. The 13-item daytime and 16-item night-time Driving Comfort Scales (DCS-D, and DCS-N, respectively) ask participants to rate their comfort while driving in a range of driving situations. Possible scores range from 0 to 100 per cent, with higher scores indicating greater driving comfort (Blanchard & Myers, 2010; MacDonald, Myers & Blanchard, 2008).

Real-world driving patterns

The real-world driving patterns, as measured by the ICRD, that were selected for analysis are described in Table 1.

Self-reported crashes and citations

The number of self-reported crashes and citations across Year 1 for each participant was collected including overall crashes and at-fault crashes only. A crash was identified as 'at-fault' if the participant was responsible for the damage, including both single-vehicle and two-vehicle collisions.

As per Langford et al. (2013), the crash risk for each driving distance group was defined as the number of crashes per

Table 1. Description of Real-world Driving Variables

Driving Patterns	Outcome Variable	Definition
Annual Mileage	Annual distance (km)	Total annual kilometers driven
Number of Trips	Total trips	Total number of annual trips driven
Night-Time Driving	% Night	Percentage of total annual trips driven at night (i.e., between 1800 to 0600 hours)
Peak Hour Driving	% Peak hour	Percentage of total annual trips driven during peak traffic hours (i.e., weekday periods between 0700 to 0930 hours or between 1600 to 1800 hours)
Shorter/ Longer Trips	% ≤ 5 km / > 20 km	Percentage of trips falling into the following trip length categories: ≤ 5 km and > 20 km

million kilometres driven. The crash risk for each driving distance group was calculated by expressing the number of crash-involved drivers in each group as a ratio of the total distance for all drivers in each group, with the rate then standardised to represent one million kilometres of driving.

Data Analyses

Driving data were cleaned and filtered against trip criteria, yielding a total of 183 participants included for analysis. Participants' data were excluded from the analysis if any of the following criteria were met: a) withdrawn from the study before Year 1 was completed and therefore had missing data; b) unexplained interruptions in their driving (i.e., defined as breaks in driving of one month, or greater, that did not coincide with interruptions recorded in the participant's secondary driver's log book); c) data that was affected by RFID fob detection issues (i.e., defined as periods of one month, or greater, during which no RFID fob was detected); d) driven a secondary vehicle for more than 30 percent of their total distance (i.e., calculated based on participant's annual estimates of primary and secondary vehicle usage); e) entries in their secondary driver's log book that differed significantly from driving data (i.e., mismatch between dates/times recorded in log book and ICRD recording on at least 28 days in total), or f) recorded secondary driver trip times as 'unknown' on at least 28 days in total. In addition to these criteria, driving trips were excluded from analysis if the ICRD data indicated that no RFID fob was detected for that trip, or if trip times overlapped by at least 50 percent with an entry in the secondary driver's log book. Altogether, there were 74 participants whose data were not included in the current analyses.

Statistical Analyses

Included participants were allocated to one of three groups according to their annual milage. Annual driving distances were categorised as $\leq 5{,}000$ km, $> 5{,}000$ and $< 13{,}000$ km and $\geq 13{,}000$ km, corresponding to the 20-60-20 percentiles of the older driver cohort. Similar parameters have been used in previous studies (see Hakamies-Blomqvist et al.,

2002; Langford et al., 2006a; Alvarez & Fierro, 2008). The group sizes are shown in Table 2. The low mileage group represented 18 percent of the total sample.

To test the association between the annual mileage categories and demographic variables, Chi Square Tests of Independence were conducted using SPSS version 23 (IBM Corp., 2015).

To examine the association between the annual mileage groups and functional performance variables, self-reported driving comfort scores, real-world driving behaviour and crash/citation rates, separate non-parametric Kruskal-Wallis H tests were performed. Given that numerous tests were conducted, a Bonferroni correction was applied to reduce the rate of Type I error (Field, 2013). The threshold of statistical significance was set, conservatively, to $p < 0.01$.

Results

Demographic characteristics and annual mileage groups

Table 2 shows the demographic characteristics for each of the annual mileage groups.

There was no significant association between the annual mileage groups and age group, $\chi^2(2) = 4.5$, $p = 0.1$. There was a significant association between annual mileage groups and gender, $\chi^2(2) = 11.0$, $p = 0.004$, Cramer's V = 0.2, representing a small association. Female drivers were more likely to be in the low mileage group compared to male drivers, whereas male drivers were more likely to be in the high mileage group compared to female drivers.

Functional performance and annual mileage groups

Table 3 summarises participants' performance on the functional measures across the annual mileage groups.

Table 2. Demographic Characteristics across Annual Mileage Groups

			Low annual mileage (≤ 5000 km)	Middle annual mileage (> 5000 - < 13,000 km)	High annual mileage (≥ 13000 km)
Total		*N*	33	113	37
		%	18	61.7	20.2
Gender	**Male**	*N*	19	78	34
		%	57.6	69.0	91.9
	Female	*N*	14	35	3
		%	42.4	31.0	8.1
Age	**< 80 years**	*N*	14	62	25
		%	42.4	54.9	67.6
	≥ 80 years	*N*	19	51	12
		%	57.6	45.1	32.4

Table 3. Functional Performance across Annual Mileage Groups

Functional Measure (Criterion for Impairment)	% (N) Unimpaired	Low annual mileage (≤ 5,000 km) Mean (SD) Median (IQR)	Middle annual mileage (> 5,000 - < 13,000 km) Mean (SD) Median (IQR)	High annual mileage (≥ 13,000 km) Mean (SD) Median (IQR)
Rapid Pace Walk (≤ 10s)	97.3 (178)	7.2 (1.7) 7.0 (6.0-8.0)	7.0 (1.4) 7.0 (6.0-8.0)	6.7 (1.2) 7.0 (6.0-7.0)
LogMAR Visual Acuity Test (≤ + 0.30)	(178)	0.1 (0.1) 0.1 (0-0.2)	0.1 (0.2) 0.1 (0-0.2)	0.1 (0.1) 0.1 (0-0.2)
MMSE (≥ 30)	100.0 (183)	28.9 (1.2) 29.0 (28.0-30.0)	29.0 (1.1) 29.0 (28.0-30.0)	29.2 (1.1) 30.0 (28.5-30.0)
MoCA (≥ 26)	72.7 (133)	25.9 (2.6) 26.0 (23.8-28.0)	26.7 (2.2) 27.0 (25.0-28.0)	26.9 (1.6) 27.0 (26.0-28.0)
Trail Making Test- Trails B (≤ 180s)	93.4 (171)	114.2 (38.6) 104.0 (90.5-140.5)	115.2 (48.1) 108.0 (82.3-137.0)	96.4 (34.8) 86.0 (72.0-124.5)
OARS Activities of Daily Living (Min/Max: 0 – 28)	N/A	27.6 (0.9) 28.0 (27.0-28.0)	27.9 (0.4) 28.0 (28.0-28.0)	27.9 (0.2) 28.0 (28.0-28.0)

Note. Rapid Pace Walk score ≤ 10s indicates unimpairment. LogMAR Visual Acuity test score ≤ + 0.30 indicates unimpairment. MMSE = Mini-Mental State Examination. MMSE score ≥ 30 indicates no cognitive impairment (score of 24 or above indicates mild cognitive impairment); MoCA = Montreal Cognitive Assessment. MoCA score ≥ 26 indicates unimpairment; Trail Making Test-Trails B score ≤ 180s indicates unimpairment. OARS = Older Americans Resources and Services. Range of scores on OARS Activities of Daily Living = 0-28.

There were no significant differences across annual mileage groups in terms of participants' scores on the Rapid Pace Walk, $H(2) = 1.9$, $p = 0.4$, LogMAR Visual Acuity Test, $H(2) = 1.6$, $p = 0.4$, MMSE, $H(2) = 1.4$, $p = 0.5$, MoCA, $H(2) = 2.5$, $p = 0.3$, TMT-B, $H(2) = 6.6$, $p = 0.04$ or OARS activities of daily living scale $H(2) = 8.7$, $p = 0.01$.

Driving comfort and annual mileage group

Table 4 summarises participants' performance on the Driving Comfort Scale across the annual mileage groups.

The results of analyses for the Driving Comfort Scale showed significant differences across annual mileage groups for both day-time driving, $H(2) = 12.6$, $p = 0.002$ and night-time driving, $H(2) = 10.6$, $p = 0.005$. Pairwise comparisons with adjusted p-values showed that the low mileage group scored significantly lower than the middle mileage group ($p = .004$., $r = 0.2$) and high mileage group ($p = .001$, $r = 0.3$) on the DCS-Daytime scale.

Real-world driving patterns and annual mileage group

Table 5 summarises the real-world driving patterns across annual mileage groups.

A Kruskal Wallis test showed a significant difference in the total number of trips driven, $H(2) = 51.2$, $p < 0.001$. Pairwise comparisons with adjusted p-values showed that the high mileage group had a significantly greater number of trips per year compared to the middle mileage ($p < .001$, $r = 0.3$) and low mileage group ($p < .001$, $r = 0.6$). The middle mileage

group also had a greater number of trips per year compared to the low mileage group, ($p < .001$, $r = 0.4$).

There was a statistically significant difference in the proportion of driving trips that were 5 km or less across annual mileage groups, $H(2) = 20.4$, $p < .001$. Pairwise comparisons with adjusted p-values showed that the low mileage group drove a significantly higher proportion of trips that were 5 km or less compared to the high mileage group ($p < .001$., $r = 0.3$) and middle mileage group ($p = .002$, $r = 0.3$).

The groups also differed in terms of the proportion of driving trips that were greater than 20 km, $H(2) = 73.6$, $p < 0.001$. Pairwise comparisons with adjusted p-values showed that the high mileage group drove a significant greater proportion of trips beyond 20km compared to the middle mileage group ($p < .001$., $r = 0.4$) and low mileage group ($p < .001$., $r = 0.6$). The middle mileage group also drove a significantly greater proportion of trips beyond 20km compared to the low mileage group ($p < .001$., $r = 0.3$).

There were no significant differences across the annual mileage groups in terms of their proportion of driving trips at night, $H(2) = 3.7$, $p = 0.2$ or their proportion of driving trips during peak hour, $H(2) = 3.9$, $p = 0.1$.

Annual driving distance groups and annual crash and citation rates

Table 6 summarises the participants' Year 1 self-reported crashes, at-fault crashes and driving citations across the annual mileage groups. Participants self-reported 41 Year

Table 4. Scores on Driving Comfort Scale across Annual Mileage Groups

	Low annual mileage (≤ 5,000 km)	Middle annual mileage (> 5,000 - < 13,000 km)	High annual mileage (≥ 13,000 km)
	Mean (SD) Range Median (IQR)	Mean (SD) Range Median (IQR)	Mean (SD) Range Median (IQR)
Driving Comfort Scale – Daytime	68.6 (19.0) 76.9 (61.1-84.6)	77.1 (12.8) 78.8 (68.8-86.5)	82.6 (11.9) 85.6 (75.0-89.9)
Driving Comfort Scale – Nighttime	59.6 (22.6) 59.4 (51.2-85.9)	70.0 (18.3) 73.4 (57.8-82.8)	75.8 (14.9) 78.1 (62.9-88.7)

Table 5. Real-world Driving Patterns across Annual Mileage Groups

Real-world driving behaviour	Low mileage group (≤ 5,000 km)	Middle mileage group (> 5000 - < 13,000 km)	High mileage group (≥ 13,000 km)
	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)
Total Trips	849.1 (329.3) 806.0 (480.3-1027.0)	1252.8 (386.8) 1163.0 (960.3-1492.8)	1627.1 (551.7) 1548.0 (1304.0-1791.0)
% Night Time Driving	7.3 (7.0) 6.0 (2.1-9.9)	8.7 (5.8) 8.0 (3.8-11.7)	9.6 (6.5) 7.9 (4.5-13.6)
% Peak Hour Driving	15.4 (7.4) 15.2 (10.8-18.2)	17.5 (5.7) 17.3 (13.4-21.6)	16.1 (5.8) 16.3 (11.8-18.3)
% Trips ≤ 5 km	71.2 (13.2) 73.7 (61.0-83.3)	62.7 (12.4) 63.8 (55.5-71.7)	59.1 (7.9) 57.0 (53.2-64.7)
% Trips > 20 km	2.5 (2.4) 1.5 (0.9-3.6)	5.8 (5.0) 4.5 (2.2-7.4)	12.8 (5.3) 11.1 (9.4-16.0)

Table 6. Self-reported Crash and Citation involvement across Annual Driving Distance groups

		Low annual mileage (≤ 5,000 km)	Middle annual mileage (> 5 000 - <13,000 km)	High annual mileage (≥ 13,000 km)
		N (%)	*N (%)*	*N (%)*
Crash involvement during Year 1	No crashes	26 (78.8)	90 (79.6)	30 (81.1)
	1 or more crashes	7 (21.2)	23 (20.4)	7 (18.9)
At-fault crash involvement during Year 1	No at-fault crashes	27 (81.8)	97 (85.8)	33 (89.2)
	1 or more at-fault crashes	6 (18.2)	16 (14.2)	4 (10.8)
Citation involvement during Year 1	No citations	28 (75.7)	94 (83.2)	28 (75.7)
	1 or more citations	5 (24.3)	19 (16.8)	9 (24.3)

1 crashes - 28 of which were reported as at-fault crashes. In addition, participants self-reported 41 driving citations during Year 1. Four participants had been involved in more than one crash (i.e., 2 crashes in Year 1) and six participants had received more than one driving citation (i.e., 4 participants with 2 citations, 2 participants with 3 citations).

Participants drove a total of 1,690,696 km during Year 1. The annual crash and citation rates per million kilometres driven for each annual mileage group are displayed in

Table 7. Most participants did not report any crashes, at-fault crashes or citations: 31 participants, 93 participants and 30 participants for the low, middle and high mileage groups respectively. Likewise, 32 participants, 100 and 33 participants from the low, middle and high mileage groups respectively did not report any at-fault crashes. Finally, 32 participants, 97 participants and 28 participants from the low, middle and high mileage groups respectively did not report any citations.

Table 7. Annual Crash and Citation Rates per Million Kilometres Driven across Annual Mileage Groups

	Low annual mileage (≤ 5,000 km)	Middle annual mileage (> 5 000 - <13,000 km)	High annual mileage (≥ 13,000 km)
	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)
Crash rate per million km driven	54.0 (121.2) 0.0 (0.0-0.0)	27.7 (59.0) 0.0 (0.0-0.0)	11.2 (24.1) 0.0 (0.0-0.0)
At-fault crash rate per million km driven	48.5 (118.8) 0.0 (0.0-0.0)	18.5 (48.3) 0.0 (0.0-0.0)	6.2 (18.8) 0.0 (0.0-0.0)
Citation rate per million km driven	0.2 (0.6) 0.0 (0.0-0.0)	0.2 (0.5) 0.0 (0.0-0.0)	0.3 (0.7) 0.0 (0.0-0.5)

There was no significant association between the annual mileage groups and annual rates for crashes, $H(2) = 0.8$, $p = 0.7$, at-fault crashes $H(2) = 1.6$, $p = 0.4$, or driving citations $H(2) = 0.5$, $p = 0.8$.

Discussion

The aim of the current study was to examine the relationship between objective measures of annual mileage and a range of functional performance factors, self-reported driving comfort, as well as real-world driving patterns and self-reported crashes and driving citations. The findings showed that there were no significant differences across annual mileage groups in terms of their functional performance or independence in performing everyday activities, suggesting the cohort were relatively healthy in the first year of the longitudinal study presented here. However, it was interesting to note that self-reported day-time and night-time driving comfort levels were lowest in the low mileage group suggests that these drivers may have made restrictions to their driving distance in response to poorer perceived driver comfort and confidence in certain driving situations compared to the higher mileage groups. This is consistent with previous research by Alvarez and colleagues (2008) and Blanchard and Myers (2010).

Annual mileage groups also differed with respect to their real-world driving patterns. Specifically, low mileage drivers drove significantly more short trips (i.e., < 5km) and fewer long distance trips (i., > 20 km). It is possible that these differences reflect differences in life choices and/ or employment circumstances (Molnar et al., 2013). For instance, work commitments, proximity of recreation clubs, and availability of alternative transportation options for participants in the low mileage group may be such that they do not need to travel greater distances or more than 20 km from home (Charlton et al., 2006).

Interestingly, while the groups differed with respect to total trips driven and relative numbers of short (and long) distance trips, there were no differences evident in other driving patterns indicative of self-regulation. Across all groups, driving in peak traffic was recorded for only 15-17 percent of all trips and night-time driving represented less than 10 percent of all trips. This is in contrast to findings reported by Langford et al. (2013) which showed that low mileage drivers were more likely to report that they restricted their driving at night and in heavy traffic comapred with high mileage drivers. Notwithstanding the differences observed in drivers' perceived comfort in night-time driving in the current study, the absence of evidence from the objective driving data for differences in challenging driving situations may reflect the relatively homogeneous and healthy level of drivers' functional abilities.

Another potential explanation for the discrepant findings in the current study is that slightly different distance parameters were used to define middle and high mileage groups. Several previous studies (Hakamies-Blomqvist et al., 2002; Langford et al., 2006; Alvarez & Fierro, 2008) used the following distance parameters: low mileage = < 3,000 km, middle mileage = 3,000 - 14,000 km and high mileage = > 14,000 km. Langford et al. (2013) applied slightly higher parameters (low mileage = < 5,001 km, middle mileage = > 5,001 - < 15,000km, and high mileage = ≥ 15,000 km for high mileage). Furthermore, in the current study, driving patterns were measured using naturalistic methods and in-vehicle devices while the majority of previous studies have relied on self-reported annual mileage which the authors acknowledged may be inaccurate (Langford et al., 2013; Langford et al., 2006; Alvarez & Fierro, 2008; Hakamies-Blomqvist et al., 2002).

A key finding of this study was that crash rates did not differ across the annual mileage groups. This is in spite of the finding that drivers with low annual mileage drove proportionally more short distance trips than high annual mileage drivers which are likely to have been in high-risk urban areas. It is acknowledged that crashes are infrequent events as reflected by the low number of at-fault crashes in the current study (n = 28). This may explain the absence of a significant LMB effect. This finding is in contrast to recent findings reported by Antin et al. (2017) using real-world driving data, as well as several previous findings from self-report studies which have shown increased crash rates among low annual mileage drivers (Langford et al., 2006; Alvarez & Fierro, 2008; Hakamies-Blomqvist et al., 2002). Furthermore, the discrepancy between the current findings

and the findings from Antin et al. (2017) may be explained by differences in the way crashes were measured. The current study relied on self-reported crashes and citations, while Antin et al. (2017) used crash data from the Strategic Highway Research Program NDS study. Furthermore, several authors (Janke et al., 1991; Antin et al., 2017) have suggested that functional impairment profiles may mediate the association between annual mileage and crash rate. Therefore, it is likely that the older driver cohort, including the low mileage group, in the current study had relatively good functional abilities and any age-related declines in their functional performance were either not sufficient to have impaired their driving ability, or they were able to adapt their driving to compensate. Antin and colleagues (2017) have also made the point that older adults who voluntarily participate in a naturalistic driving study may have higher levels of driving fitness and confidence which could explain the lack of significant group differences on crash risk. Indeed, participants's average scores (for all annual mileage groups) on the MMSE and TMT-B test indicate unimpaired cognitive status.

An important finding shown in the current study was that the low mileage group drove the fewest number of total trips, as well as the greatest proportion of short trips (i.e., within 5 km) and the lowest proportion of trips beyond 20 km compared to the higher mileage groups. Conversely, the high mileage group drove the greatest number of trips over one year, with the lowest percentage of those trips being within 5 km and the greatest proportion of trips beyond 20 km. This is a new finding and provides some useful insights into real-world driving patterns of those drivers who typically drive less in terms of annual mileage. It is reasonable to expect that the predominantly short distance trips driven by the low mileage group are more likely to have been in high-risk urban areas, rather than on highways or divided roads which carry a lower crash risk and tend to be associated with greater travel distances (Janke et al., 1991). This hypothesis remains to be explored in future analyses of road types used. There was also evidence of a gender effect, specifically that the low mileage group had proportionally more female drivers than male drivers. This is in alignment with findings from self report studies (Charlton et al., 2006; Kostyniuk & Molnar, 2008) which showed that female drivers drove shorter trip distances and had a smaller number of total trips compared to male drivers.

Despite the advantages of using real-world driving data in the current study, crash and citation rates, as well as at-fault status of crashes, were self-reported and there is a possibility that some drivers may over- or under-report their crash involvement (McGwin Jr, Owsley, & Ball, 1998). Although several authors have suggested that self-report and authority records can provide complementary information (McGwin et al., 1998), many studies have shown low agreement between the two data sources (Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Owsley, Ball, Sloane, Roenker, & Bruni, 1991). This includes the observation that self-reports tend to identify more crashes than state records particularly given that participants tend to report even minor crashes (Owsley et al., 1991). This is consistent with findings from a recent study among participants at the University of Manitoba site of the Candrive study (Porter et al., 2018) which compared self-reported crashes with official insurance claims or driver records. The authors found a higher frequency of crashes reported to study staff compared to those recorded in official jurisdictional record. On the other hand, crashes may be under-reported if participants fail to recall when the crash occurred or choose not to disclose this information due to social desirability bias (Blanchard & Myers, 2010; McGwin et al., 1998).

Future studies may benefit from analysing official crash data from licensing authorities.

Another limitation of the current study is that the cohort of older drivers was relatively small for the conclusions drawn and only one year of data for crashes and citations was collected. Therefore, the results may not be generalisable to all older drivers, particularly given their relatively high functional performance and voluntary participation in a longitudinal study. However it is likely that their functional performance and real-world driving patterns will decline with age, potentially affecting crash involvement. One of the strengths of the longitudinal design is that as the cohort of Ozcandrive participants ages, follow-up analyses will be conducted to monitor potential changes in the relationship between older drivers' annual mileage and functional performance or crash rates across the eight-year study period. An additional limitation is that data in the current study were analysed using simple bivariate analyses. In order to examine complex interactions between the relevant demographic, functional and driving-related variables, more advanced statistical modeling will be conducted using Ozcandrive data across the entire study period.

Conclusions

Using real-world driving data, the current study has provided preliminary evidence of a relationship between annual mileage and select real-world driving patterns. Larger-scale follow-up research with official crash data are required to further examine the relationships between annual mileage, functional abilities and crash and citation rates. Such findings can be used to inform stakeholders involved in research, policy-making and services for older drivers, particularly regarding the issue of safe mobility and licensing options.

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