A validation study comparing self-reported travel diaries and objective data obtained from in-vehicle monitoring devices in older drivers with bilateral cataract

Seraina Agramunt, MSc, MAS[a,b]

Professor Lynn Meuleners, PhD [a,b]

Dr Kyle Chi Chow, PhD [a,b]

Dr Jonathon Q Ng, MBBS, FRANZCO, PhD [b,c]

Professor Nigel Morlet, MBBS, FRANZCO, FRACS [b,c]

[a] Curtin-Monash Accident Research Centre (C-MARC), Curtin University, Perth, Australia

[b] Eye & Vision Epidemiology Research (EVER) Group, Perth, Australia

[c] School of Population Health, The University of Western Australia, Perth, Australia

Corresponding author:

Professor Lynn Meuleners

Curtin-Monash Accident Research Centre (C-MARC)

GPO BOX U1987, PERTH WA 6845

l.meuleners@curtin.edu.au +61 8 9266 4636

Abstract

Background: Advances in technology have made it possible to examine real-world driving using naturalistic data obtained from in-vehicle monitoring devices. These devices overcome the weaknesses of self-report methods and can provide comprehensive insights into driving exposure, habits and practices of older drivers.

Aim: The aim of this study is to compare self-reported and objectively measured driving exposure, habits and practices using a travel diary and an in-vehicle driver monitoring device in older drivers with bilateral cataract.

Methods: A cross-sectional study was undertaken. Forty seven participants aged 58 to 89 years old (mean=74.1; S.D. = 7.73) were recruited from three eye clinics over a one year period. Data collection consisted of a cognitive test, a researcher-administered questionnaire, a travel diary and an in-vehicle monitoring device. Participants' driving exposure and patterns were recorded for one week using in-vehicle monitoring devices. They also completed a travel diary each time they drove a motor vehicle as the driver. Paired t-tests were used to examine differences/agreement between the two instruments under different driving circumstances.

Results: The data from the older drivers' travel diaries significantly underestimated the number of overall trips ($p<0.001$), weekend trips ($p=0.002$) and trips during peak hour ($p=0.004$). The travel diaries also significantly overestimated overall driving duration ($p<0.001$) and weekend driving duration ($p=0.003$), compared to the data obtained from the in-vehicle monitoring devices. No significant differences were found between instruments for kilometres travelled under any of the driving circumstances.

Conclusions: The results of this study found that relying solely on self-reported travel diaries to assess driving outcomes may not be accurate, particularly for estimates of the number of trips made and duration of trips. The clear advantages of using in-vehicle monitoring devices over travel diaries to monitor driving habits and exposure among an older population are evident.

Keywords: cataract, driving performance, validation, in-vehicle monitoring devices

1. Introduction

The population of the world is ageing and this trend is expected to continue for several decades (United Nations, 2015). It has been estimated that at least a quarter of the population globally, will be aged 60 years or over by 2050 (United Nations, 2015). In Australia, for example, older adults are living longer, healthier lives (Australian Institute of Health and Welfare, 2015). This has led to an increase in the number of older drivers on the road with driving license counts increasing by 44% for the 65+ age group in the decade ending in 2013 (Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2014).

In Australia, driving is the most common form of transport for people aged over 65 years (Australian Bureau of Statistics, 2004). Driving enables an ageing population to maintain their independence, mobility and flexibility (Gwyther & Holland, 2012) and is strongly associated with older adults' social participation (Pristavec, 2016). In contrast, driving cessation has been linked to poorer health, social, cognitive and physical functions and an increased risk of depressive symptomatology (Chihuri, et al., 2016). However, as people age, sensory, motor and cognitive declines as well as medical conditions common in older adults such as cataract, can affect the ability to safely operate a motor vehicle.

Cataract is an opacification of the crystalline lens of the eye (Iroku-Malize and Kirsch, 2016) which causes a gradual decline in visual function and is one of the leading causes of vision impairment globally (Pascolini and Mariotti, 2011). By age 70, almost everyone will have developed some degree of cataract (Taylor et al., 2005). There is evidence to suggest that cataract patients may modify their driving exposure, habits and practices while waiting for surgery (Fraser et al., 2013; Owsley et al., 1999). An early study from the USA found that cataract patients reported reductions in the number of days and destinations driven, driving slower than the general traffic flow and preferring someone else to drive as a result of their visual impairment (Owsley et al., 1999). More recently, Australian cataract patients reported avoiding driving at night, on freeways, in the rain and parallel parking due to their visual impairment (Fraser et al., 2013). However, it should be noted that these studies only used self-report questionnaires to measure the driving exposure, habits and practices of drivers with cataract. These sources however, may be limited in the depth and accuracy of information they can provide about driver behaviour and may be affected by recall and social desirability bias.

Recent research has found that self-reported measures of driving exposure (driving distance) among older adults may be inaccurate (Blanchard et al., 2010; Porter et al., 2015). This raises questions concerning the validity of other self-reported driving practices. In addition, recent naturalistic driving studies found that older drivers in general may not restrict their driving as much as they report on questionnaires (Blanchard and Myers, 2010; Myers et al., 2011). For example, older drivers with Parkinson's Disease were found to accurately report their number of days driving in morning/ afternoon driving and residential/ city area driving when compared to data collected from an in-vehicle driver monitoring device (Crizzle et al., 2013). However, they drove more at night, in bad weather, in peak hour traffic and on highways than they self-reported (Crizzle et al., 2013). Similarly, an Australian study of 156 older drivers found that participants tended to underreport their average number of days per week and kilometres per week driven. However, participants accurately reported avoidance of driving at night, in unfamiliar areas and on high speed roads (Molnar et al., 2013). It has also been reported that participants prefer to use in-vehicle monitoring devices over self-reported travel diaries or questionnaires (Blanchard et al., 2010). Indeed, travel diaries may lead to high dropout rates among participants and are seen as an encumbrance when required to be filled in daily (Marshall et al., 2013). However naturalistic driving research overcomes the weaknesses of self-report methods, providing objective measures of real-world driving and allowing comprehensive insights into the driving exposure, habits and practices of older adults. In-vehicle driving monitoring devices are small electronic devices that can be attached to a participant's own car and record electronic, time-tagged GPS data on location and speed which allows naturalistic examination of real life driving patterns.

Older adults with cataract are a unique group of older drivers. Since cataract, unlike other conditions of ageing, can be quite easily corrected by surgery, it is important to determine whether these patients temporarily modify their driving exposure, habits and patterns while waiting for surgery, potentially reducing their crash risk. To date however, the limited investigations of driving patterns among cataract patients have used self-report measures only (Fraser et al. 2013; Owsley et al. 1999). Before further research is undertaken among cataract patients, it is essential to determine the accuracy of self-reported measures (including travel diaries) of driving exposure, habits and patterns, as compared to data obtained from more costly in-vehicle monitoring devices. Current evidence suggests that self-report methods are often inaccurate among general older drivers, however findings are inconsistent on which driving measures older adults are able to accurately report or record, for example, night driving exposure (Crizzle et al. 2013; Molnar et al. 2013). In addition, the majority of these studies sampled from the general older population. Since those awaiting cataract surgery are more likely to be actively and temporarily modifying their driving exposure, habits and patterns than general older drivers, it is essential to determine whether this group are able to accurately report these driving outcomes using a travel diary, as compared to data obtained from in-vehicle monitoring devices.

Therefore, the aim of this study is to compare self-reported information obtained from a travel diary and objectively measured data using in-vehicle driver monitoring device on driving exposure, habits and practices in older drivers with bilateral cataract as they await first eye cataract surgery.

2. Methods

2.1. Research Design and participants

A cross-sectional study was undertaken. Participants with bilateral cataract who were scheduled for first eye cataract surgery within one month were recruited from three eye clinics in Perth, Western Australia (WA). Inclusion criteria stipulated that participants were aged 55 years or older, possessed a current WA driver's licence, drove at least twice a week, had access to a motor vehicle, and lived in the Perth metropolitan area. Participants were excluded from the study if they had a diagnosis of dementia, Alzheimer's disease, Parkinson's disease, were wheelchair bound, colour-blind, did not speak English or had any other ocular conditions that would limit visual outcome. Patients with diagnoses of refractive error or dry eye were acceptable for inclusion in the study.

2.2. Data Collection

Participants were recruited and data collected over a one year period in 2015. They were provided with a Participant Information Sheet and informed consent was obtained before any information was collected by a trained researcher. Data collection consisted of three visual tests (under the guidance of an ophthalmologist), a cognitive test, a researcher-administered questionnaire, travel diary and use of an in-vehicle monitoring device. It took approximately 50 minutes to complete the questionnaire, cognitive and visual tests for each participant. The travel diary and in-vehicle driver monitoring device were provided to each participant at the assessment. The results of the visual tests are not presented as part of this paper. Medical records were also accessed to validate information on co-morbid medical conditions, and current and previous treatments and medication(s). Ethics approval was obtained from Curtin University as well as the three public hospital eye clinics.

2.2.1. Questionnaires/instruments

Socio-demographic data, such as age, gender, level of education, marital and employment status, country of birth, living situation, medications, co-morbid conditions and years of driving experience was collected using a researcher administered questionnaire. Each participant was also asked about their driving experience and confidence when driving. All participants were also assessed to determine their cognitive status using the Mini-Mental Status Examination (MMSE) (Folstein et al., 1975).

2.2.2. In-vehicle monitoring device

The in-vehicle driving monitoring device provides information on real-time driving exposure, patterns and speed. The device also includes GPS tracking which allows for recording of the routes that the vehicle has taken. The system transmits time stamped second-by-second data on speed and location for all trips. It is small (8.5 x 11 x 3.2cm), operates from the cigarette lighter for cars manufactured before 2006 and the On Board Diagnostic II (OBD II) port for more recent vehicles. The data collected, regardless of the year of the motor vehicle, was exactly the same. Data were transmitted to a secure service provider which was then uploaded by the researcher to a secure server at the University for each participant.

Participants were instructed on the use of the in-vehicle monitoring device at the assessment and also provided with an information sheet on how to use the device. The device can be easily inserted and removed from the vehicle within seconds and this was demonstrated and participants given the opportunity to practice in the presence of the researcher. Participants were instructed to use the in-vehicle device for seven days and drive as they normally would with the equipment installed in their vehicle. They were told they should disconnect the device if someone else drove the vehicle. If they were unable to or forgot to disconnect the device when someone else drove the vehicle, they were asked to note this in their travel diary. Participants were also instructed to move the device from one vehicle to another if they drove multiple vehicles during the seven day period and record this in their travel diary. Participants were asked to return the in-vehicle monitoring device and travel diary by post in a pre-paid envelope at the end of the seven day period. After receiving the device, the researcher interviewed each participant to clarify any data issues that may have arisen during the seven day period, check their use of multiple vehicles and confirm whether there had been any other drivers of the vehicle while the device was connected.

Figure 1: In-vehicle driver monitoring device

2.2.3. Travel Diary

Each participant was also required to complete a travel diary each time they drove as the driver of a motor vehicle (not including motorbike or scooter) during the seven day collection period. They were instructed to fill out the diary as soon as possible after the completion of the trip so that their recall was accurate. Information collected included the type of vehicle driven (make, model and year), the number, age and position of passengers driven, purpose of the trip, date, start and finish time of the trip, start and finish kilometres recorded on the odometer, duration of trip and distance travelled. The diary also allowed participants to note if anyone else drove the vehicle while the device was connected.

2.3. Statistical analysis

Descriptive statistics were used to describe the demographic characteristics of the cohort. The data from the in-vehicle monitoring devices and the travel diaries were cleaned and entered into a SPSS database. Each trip in the participant's travel diary was manually checked by the researcher against the data recorded from the in-vehicle monitoring device by date and time of day. Any trips that were reported in the travel diary as being made by another driver were removed. No participants reported driving more than one vehicle during the seven day period, either in the travel diary or interview. Self-reported driving outcomes from the travel diary were compared to data from the in-vehicle monitoring devices over the seven day monitoring period. Pairwise deletion was used in the analysis to deal with missing data. Outcomes of interest from the in-vehicle monitoring device included driving exposure (kilometres driven), number of trips, duration of travel, weekend driving, night-time driving and driving in peak hour traffic. Peak hour driving was defined as driving between the hours of 6 and 9 a.m. or from 4 to 7 p.m. Day time was defined as the period between sunrise and sunset and night time was defined as the period from sunset to sunrise, with the sunset and sunrise times of the study period obtained from the Australian Government's Bureau of Meteorology website (www.bom.gov.au). Paired t-tests were used to examine differences between the two instruments.

3. Results

3.1. Demographic characteristics

The demographic characteristics of the 47 participants (57.4% male and 42.6% female) are summarised in Table 1. The participants were aged 58 to 89 years with a mean age of 74.1 (SD= 7.73) years. More than half of the participants (57.4%) were born in Australia. For the majority (55.3%), an apprenticeship or University degree was the highest level of education. More than half of the sample (53.2%) were married/ de facto and the majority of participants lived with another person (57.4%). Retired participants accounted for 89.3% of the sample, whereas 10.7% were still employed. The majority of participants (97.9%) had at least one co-morbid health condition in addition to cataract and were taking prescribed medications (91.5%). The mean Mini-Mental Status Examination (MMSE) score for participants was 27.78 (SD= 1.90) which is consistent with normal cognitive functioning.

Table 1: Descriptive characteristics

Variable	N=47	%
Gender		
Male	27	57.4
Female	20	42.6
Age Group		
55-64	6	12.8
65-74	20	42.6
75-84	15	31.9
>=85	6	12.8
Marital Status		
Single/separated/divorced/widowed	22	46.8
De facto/married	25	53.2
Highest level of education completed		
Primary or secondary school	21	44.6
Tertiary education/training	26	55.3
Country of birth		
Australia	27	57.4
Other countries	20	42.5
Employment status		

Retired on pension	33	70.2
Retired self-funded	9	19.1
Employed	3	6.4
Self-employed	2	4.3
Living arrangements		
Live alone	20	42.6
Lives with spouse/family members/others	27	57.4
Prescription medication		
No	4	8.5
Yes	43	91.5
Presence of comorbidities		
No	1	2.1
Yes	46	97.9

The mean number of years of driving for the cohort was 52 (S.D. =10.92) years. Despite participants having bilateral cataract, the majority of participants (85.1%) reported having no difficulty when driving during the daytime in familiar places. All drivers owned their own car and always wore a seatbelt when driving. The majority of participants considered themselves to be either good drivers (44.7%) or excellent drivers (31.9%). However 10.6% of the drivers reported that in the past year it was suggested to them by family, friends or other people that they should stop or limit their driving.

3.2. In-vehicle monitoring devices and self-reported travel diaries

3.2.1. Overall driving

The results of paired t-tests for driving exposure are summarised in Table 2.

Table 2: Results of paired t-tests for driving outcomes from the in-vehicle monitoring devices and the self-reported travel diaries during a one week observation period

	Self-report travel diaries		In-vehicle monitoring devices						
Driving Outcome	**M**	**SD**	**M**	**SD**	**n**	**95% CI for Mean Difference**	**t**	**df**	**p-value**
Overall									
Kilometres driven	166.17	125.61	143.49	111.47	17[a]	-0.72 , 46.10	2.05	16	0.057
Number of trips	12.60	7.85	19.38	10.49	47	-9.16 , -4.41	-5.75	46	< 0.001
Driving duration per week (minutes)	347.96	254.16	181.96	136.38	24[b]	84.16 , 247.84	4.20	23	< 0.001
Number of days driving	4.74	1.66	4.85	1.59	47	-0.41 , 0.20	-0.70	46	0.490
Weekend driving									
Kilometres driven during weekend	51.97	56.98	45.46	54.48	17[a]	-2.03 , 15.04	1.62	16	0.126
Number of trips during weekend	3.34	2.68	4.91	4.10	47	-2.53 , -0.62	-3.33	46	0.002
Driving duration during weekend (minutes)	109.83	103.49	56.54	57.48	24[b]	20.22 , 86.36	3.33	23	0.003

Number of days with driving during weekend	1.36	0.74	1.34	0.70	47	-0.11	,	0.15	0.33	46	0.743
Peak hour driving											
Kilometres driven during peak hours	41.27	37.35	36.52	35.51	15[c]	-4.01	,	13.51	1.16	14	0.264
Number of trips during peak hours	3.29	3.26	4.75	4.21	24[b]	-2.40	,	-0.52	-3.21	23	0.004
Driving duration during peak hours (minutes)	152.00	262.84	49.75	48.24	24[b]	-2.12	,	206.62	2.03	23	0.054
Number of days with driving during peak hours	1.92	1.44	2.38	1.47	24[b]	-0.74	,	-0.18	-3.41	23	0.002
Night time driving											
Kilometres driven during night time	17.05	27.44	13.91	19.68	15[c]	-5.11	,	11.37	0.82	14	0.428
Number of trips during night time	1.46	2.92	1.58	2.41	24[b]	-0.73	,	0.48	-0.43	23	0.671
Driving duration during night time (minutes)	26.71	44.07	16.58	26.01	24[b]	-1.55	,	21.80	1.80	23	0.086

Number of days with night time driving	0.71	0.91	0.83	1.05	24[b]	-0.31 , 0.06	-1.37	23	0.185

[a]*30 of the 47 participants had missing information in the time entries of their travel diaries.*

[b]*23 of the 47 participants had missing information in the odometer entries of their travel diaries.*

[c]*32 of the 47 participants had missing information in both the time and odometer entries of their travel diaries*

Compared to the self-reported travel diaries, the in-vehicle monitoring devices recorded less (not significant) kilometres driven ($p=0.057$), significantly more trips undertaken ($p<0.001$) and less driving time per week ($p<0.001$). According to the in-vehicle monitoring devices, an average of 143.49 kilometres (S.D. = 111.47) were driven during the study period, whereas participants self-reported that they drove 166.17 (S.D. = 125.61) kilometres.

An average of 19.38 (S.D. = 10.49) trips were captured by the in-vehicle monitoring devices, while the participants' self-reported diary reported that they undertook an average of 12.60 (S.D. = 7.85) trips. Participants also significantly overestimated the duration of their driving, with the information from the travel diaries reporting that participants drove an average of 348 minutes per week (S.D. = 254 minutes), compared to 182 minutes (S.D. = 136 minutes) recorded by the in-vehicle monitoring devices ($p<0.001$). However, in terms of the mean number of days driven during the seven day period, the results from the in-vehicle monitoring device and travel diaries were very similar with no significant difference observed ($p = 0.490$).

3.2.2. Weekend driving

Similar patterns were also observed in regards to weekend driving. Compared to the self-reported travel diaries, the in-vehicle monitoring devices recorded less (but not significant) kilometres driven on the weekend than the self-reported travel diaries ($p=0.126$). According to the in-vehicle monitoring devices, an average of 45.46 kilometres (S.D. = 54.48) were driven on the weekend, whereas participants self-reported that they drove an average of 51.97 kilometres (S.D. = 56.98) on the weekend.

A significant difference ($p=0.002$) was observed in terms of the number of trips taken during the weekend with an average of 4.91 (S.D. = 4.1) trips recorded using the in-vehicle monitoring devices compared to 3.34 (S.D. = 2.68) trips recorded in the self-reported travel diaries. Again, participants significantly overestimated the duration of their driving during the weekend, with 110 minutes (S.D. = 103 minutes) recorded on the travel diaries, while a shorter duration (57 minutes; S.D. = 57 minutes) was actually recorded by the devices (p=0.003). There was no significant difference (p=0.743) between the data obtained by the in-vehicle monitoring devices and the travel diaries in regard to the number of days driven during the weekend (1.34 and 1.36 days respectively).

3.2.3. Peak hour driving

The information obtained from the in-vehicle monitoring devices reported less km driven though not significant (p=0.264), significantly more trips taken (p=0.004), less time driving though not significant (p=0.054) and significantly greater number of days driving (p=0.002) during peak hours, compared to the self-reported travel diaries.

Participants drove 36.52 kilometres (S.D. = 35.51) during peak hours according to the in-vehicle monitoring device, compared to 41.27 kilometres (S.D. = 37.35) recorded in the travel diaries. The self-reported driving duration during peak hours was again overestimated in the travel diaries (though not significant) with an average of 152 minutes (S.D. = 263 minutes) reported compared to 50 minutes (S.D. = 48 minutes) by the in-vehicle monitoring devices. There was a greater number of trips made during peak hours per week according to the in-vehicle monitoring devices, compared to the travel diaries, with 4.75 trips (S.D. = 4.21) and 3.29 trips (S.D. = 3.26) made respectively. In addition, a significantly higher average number of days driving during peak hour were recorded by the in-vehicle monitoring devices (2.38 days; S.D. = 1.47), compared to the self-reported diaries (1.92 days; S.D. = 1.44).

3.2.4. Night time driving

No significant differences were found for night driving between the information provided by the in-vehicle monitoring devices and the travel diaries. Information obtained by the travel diaries reported an average of 17.05 kilometres of night time driving amongst the participants (S.D. = 27.44), while the in-vehicle monitoring devices reported an average of 13.91 kilometres per week (S.D. = 19.68). This difference was not significant (p=0.428).

In regards to the number of night time trips, there was also no significant difference (p=0.671) between the travel diaries which reported an average of 1.46 (S.D. = 2.92) trips during the night, compared to the in-vehicle monitoring devices which reported an average of 1.58 trips (S.D. = 2.41). No significant difference (p=0.086) was evident in relation to driving duration at night with the travel diaries recording an average of 27 minutes (S.D. = 44 minutes), and the in-vehicle monitoring devices recording an average of 17 minutes (S.D. = 26 minutes). The average number of days participants drove during the night was also not significantly different (p=0.185) between the travel diaries and the in-vehicle monitoring devices with an average of 0.62 (S.D=0.99) days and 0.83 (S.D. = 1.09) days recorded respectively.

4. Discussion

This is the first study to compare the driving exposure and practices of bilateral cataract patients awaiting surgery as obtained by self-reported travel diaries and in-vehicle monitoring devices. The study found that there were significant differences between self-reported driving outcomes and those obtained from the in-vehicle monitoring devices. Overall, the data from the older drivers' travel diaries significantly underestimated the number of trips made in certain conditions and frequently overestimated their driving duration, as compared to the objective data obtained from the in-vehicle monitoring devices.

It should be noted that a high proportion of participants had missing information in their travel diaries, in terms of either the time entries (64% of the participants), odometer entries (49% of the participants), or both time and odometer entries (68% of the participants). This indicates that a high proportion of older drivers were unable to accurately or completely fill in the travel diary for a period of a week. In general, those participants who were able to complete the travel diary quite accurately recorded their kilometres travelled and days driven, but did not accurately record their number of trips or driving duration. Together, these findings demonstrate that travel diaries might not be an optimal tool for collecting driving patterns of older drivers. More reliable sources of driving data such as in-vehicle monitoring devices should be encouraged when collecting information about naturalistic driving behaviours.

A growing body of evidence has assessed driving behaviours using naturalistic in-vehicle monitoring devices (Blanchard and Myers, 2010; Blanchard et al., 2010; Huebner et al., 2006; Molnar et al., 2014; Porter et al., 2015). It has been shown that in-vehicle monitoring devices connected through the OBD-II port, as well as GPS devices provide accurate and valid measures of driving outcomes (Huebner et al., 2006). Travel data obtained by GPS devices have been found to equal or surpass the quality of data obtained by travel diaries (Wolf et al., 2001). Research has also found that these devices are preferred by study participants over travel diaries, particularly among older drivers (Blanchard et al., 2010; Marshall et al., 2007).

In the current study, the participants' travel diaries significantly under-reported the number of trips taken overall, on the weekend and in peak hours and significantly over-estimated the duration spent driving in the overall study period and on the weekend. These results are consistent with other studies which showed that drivers tend to underestimate the number of trips recorded in their travel diaries compared to the trips recorded by electronic devices (Blanchard et al., 2010). Similarly, another study showed that drivers overestimated the travel duration of their trips (Stopher et al., 2007). There are several possible reasons for these observed discrepancies between the self-reported travel diaries and the in-vehicle monitoring devices. Although participants were requested by the researcher to fill out the travel diary immediately after completion of their trip, it is possible that some participants may not have done this and completed the diary at a later date. There is also the possibility of a lack of accuracy due to memory impairment or fatigue after a long trip (Marshall et al., 2007). It is also possible that some participants may have included the duration of their whole trip even when they were not driving thus overestimating the duration of their trips.

Interestingly, no significant differences were found between the travel diaries and in vehicle monitoring devices in terms of kilometres driven overall, on the weekend, during peak hour or a night. However, a higher average number of kilometres were consistently reported in the travel diaries, compared to the in-vehicle monitoring devices. It is possible that the lack of significant results for kilometres driven could be due to the small sample size available for this outcome and this should be investigated in further research

The travel diaries also accurately reported the number of days of the week driven overall, on the weekend and at night compared to the in-vehicle monitoring devices, but significantly under-reported the number of days driving in peak hour. This is similar to previous research which found significant variation between self-reported and actual driving during challenging situations such as peak hour traffic (Crizzle et al., 2013).

Interestingly, the results for night time driving exposure differed from the other driving situations examined in the study. There was no significant differences between the number of kilometres travelled, night time trips taken, the duration of night time driving or number of days with night time driving between the travel diaries and in-vehicle monitoring devices. The more accurate recording of night driving outcomes may be due to the fact that drivers with cataract in this study drove less at night than they did in the other driving situations examined. Previous research has found that older drivers with cataract report difficulty with and self-restrict their night driving (Fraser et al., 2013; Owsley et al., 1999). Therefore, the infrequency of night driving and difficulty experienced may have made the details of night driving exposure easier for participants to recall and record accurately. These findings are similar to those from a large Australian study that older drivers accurately report avoidance of night driving (Molnar et al., 2013).

The results of this study in relation to actual driving exposure are consistent with previous research using objective measures. In particular, the results of the in-vehicle monitoring device reported that participants drove an average of 143 km per week compared to 164 km reported by Blanchard et al. (2010) and 186 by Marshall et al. (2007). The lower mileage travelled may be due to the fact that the cohort was waiting for their first eye cataract surgery and may not have been driving as they would under normal circumstances.

There were several strengths of the study. The in-vehicle monitoring devices used in this study were able to be easily installed in all cars. Some devices that have been examined previously were restricted to use in cars manufactured from 1996 onwards due to the vehicle interface. The data from the in-vehicle monitoring devices were also linked to the Australian Government's Bureau of Meteorology website to determine light conditions which provided an accurate representation of day and night time driving patterns for participants. Furthermore, participants recruited did not have any other major eye conditions besides cataract, such as glaucoma or macular degeneration, as those conditions could have had an impact on their driving behaviour.

However, the study has limitations. The use of a convenience sample, small sample size and the large amount of missing data may affect the generalisability of the results. Recall bias may also be present. Additionally, driving was monitored for one week only and it is possible, given the age-group of participants, that illness may have curtailed driving exposure during the week of the assessment. Generally driving fluctuates from week to week and a longer monitoring time is optimal to identify driving outcomes. Furthermore one week may limit the type of environmental conditions participants may experience such as avoiding driving in the rain. While no participants reported driving multiple vehicles during the seven day period, either in their travel diary or interview, it is possible that they did so without reporting it, affecting the accuracy of the data. It is also possible that a person other than the participant drove the vehicle while the in-vehicle monitoring device was connected. However, the ease of removal and installation of the device, short collection period of seven days and the opportunity for participants to record other drivers in the travel diary or report them in the interview would have reduced the likelihood of this occurring.

In conclusion, the results of this study found that relying solely on self-reported travel diaries to assess driving outcomes for cataract patients awaiting surgery may not be accurate, particularly for estimates of number and duration of trips. The accuracy of estimates of kilometres driven requires further research. Also the potential for attrition of participants using a travel diary is high due to subject fatigue and continuously updating the travel diary. The clear advantages of the in-vehicle monitoring devices over the travel diaries are evident particularly for an older driving population.

Acknowledgements

Funding was provided by Curtin University, through an International Postgraduate Research Scholarship (#52423).

5. References

Australian Bureau of Statistics, 2004. 3222.0. Population Projections, 2004 to 2011. Canberra, ACT: Author

Australian Institute of Health and Welfare (AIHW). Australia's Welfare 2015. Australian Government, Canberra, 2015.

Blanchard, R. A., & Myers, A. M., 2010. Examination of driving comfort and self-regulatory practices in older adults using in-vehicle devices to assess natural driving patterns. Accid Anal Prev 42(4), 1213-1219.

Blanchard, R. A., Myers, A. M., & Porter, M. M., 2010. Correspondence between self-reported and objective measures of driving exposure and patterns in older drivers. Accid Anal Prev 42(2), 523-529.Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2014. Road Safety of Older Australians: Recent Statistics, Information Sheet 50, BITRE, Canberra.

Chihuri, S., Mielenz, T. J., Dimaggio, C. J., Betz, M. E., DiGuiseppi, C., Jones, V. C., & Li, G. (2016). Driving cessation and health outcomes in older adults. Journal of the American Geriatrics Society, 64(2), 332-341.

Crizzle, A. M., Myers, A. M., & Almeida, Q. J., 2013. Self-regulatory practices of drivers with Parkinson's disease: Accuracy of patient reports. Parkinsonism Relat. Disord. 19(2), 176-180.

Folstein M.F., Folstein S.E., McHugh P.R., 1975. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiat Res 12:189-198.

Fraser, M. L., Meuleners, L. B., Ng, J. Q., & Morlet, N., 2013. Driver self-regulation and depressive symptoms in cataract patients awaiting surgery: a cross-sectional study. BMC Ophthalmol 13(1), 45.

Gwyther, H., & Holland, C. (2012). The effect of age, gender and attitudes on self-regulation in driving. Accident Analysis & Prevention, 45, 19-28.

Huebner, K. D., Porter, M. M., & Marshall, S. C., 2006. Validation of an electronic device for measuring driving exposure. Traffic Inj Prev 7(1), 76-80.

Iroku-Malize, T., & Kirsch, S. (2016). Eye Conditions in Older Adults: Cataracts. FP essentials, 445, 17-23.

Marshall, S. C., Wilson, K. G., Man-Son-Hing, M., Stiell, I., Smith, A., Weegar, K., . . . Molnar, F. J. (2013). The Canadian Safe Driving Study—Phase I pilot: Examining potential logistical barriers to the full cohort study. Accident Analysis & Prevention, 61, 236-244.

Marshall, S. C., Wilson, K. G., Molnar, F. J., Man-Son-Hing, M., Stiell, I., & Porter, M. M., 2007. Measurement of driving patterns of older adults using data logging devices with and without global positioning system capability. Traffic Inj Prev 8(3), 260-266.

Molnar, L. J., Charlton, J. L., Eby, D. W., Langford, J., Koppel, S., Kolenic, G. E., & Marshall, S., 2014. Factors affecting self-regulatory driving practices among older adults. Traffic Inj Prev 15(3), 262-272.

Molnar, L. J., Eby, D. W., Charlton, J. L., Langford, J., Koppel, S., Marshall, S., & Man-Son-Hing, M., 2013. Driving avoidance by older adults: Is it always self-regulation?. Accid Anal Prev 57, 96-104.

Myers, A. M., Trang, A., & Crizzle, A. M., 2011. Naturalistic study of winter driving practices by older men and women: examination of weather, road conditions, trip purposes and comfort. Can J Aging 30(4), 577-589.Owsley, C., Stalvey, B., Wells, J., & Sloane, M. E., 1999. Older drivers and cataract: driving habits and crash risk. J Gerontol A Biol Sci Med Sci. 54(4), M203-M211.

Pascolini, D., & Mariotti, S. P. (2011). Global estimates of visual impairment: 2010. British Journal of Ophthalmology, bjophthalmol-2011-300539.

Porter, M. M., Smith, G. A., Cull, A. W., Myers, A. M., Bédard, M., Gélinas, I., . . . Rapoport, M. J. (2015). Older driver estimates of driving exposure compared to in-vehicle data in the Candrive II study. Traffic injury prevention, 16(1), 24-27.

Pristavec, T. (2016). Social participation in later years: the role of driving mobility. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, gbw057.

Stopher, P., FitzGerald, C., & Xu, M., 2007. Assessing the accuracy of the Sydney Household Travel Survey with GPS. Transportation 34(6), 723-741.

Taylor, H. R., Keeffe, J. E., Vu, H. T., Wang, J. J., Rochtchina, E., Pezzullo, M. L., & Mitchell, P., 2005. Vision loss in Australia. Med J Aust 182(11), 565-568.

United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: The 2015 Revision, Volume I: Comprehensive Tables (ST/ESA/SER.A/379).

Wolf, J., Guensler, R., & Bachman, W., 2001. Elimination of the travel diary: Experiment to derive trip purpose from global positioning system travel data. Transport Res Rec (1768), 125.