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Older driver estimates of driving exposure compared to in-vehicle data in the Candrive II study

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ABSTRACT

Most studies on older adults' driving practices have relied on self-reported information. With technological advances it is now possible to objectively measure the everyday driving of older adults in their own vehicles over time. **Objective**. The purpose of this study was to examine the ability of older drivers to accurately estimate their kilometers driven over one year relative to objectively measured driving exposure. **Methods**. A sub-sample (n=159 of 928; 50.9% male) of Candrive II participants (age ≥ 70 years of age) was used in these analyses based on strict criteria for data collected from questionnaires as well as an OttoView-CD Autonomous Data Logging Device installed in their vehicle, over the first year of the prospective cohort study. **Results**. Although, there was no significant difference overall between the self-reported and objectively measured distance categories, only moderate agreement was found (weighted kappa = 0.57; 95% CI 0.47 to 0.67). Almost half (45.3%) chose the wrong distance category, and some people mis-estimated their distance driven by up to 20,000 km. Those who misjudged in the low mileage group (≤ 5,000 km) consistently under-estimated, while the reverse was found for those in the high distance categories (≥ 20,000), i.e., they always over-estimated their driving distance. **Conclusions**. Although self-reported driving distance categories may be adequate for studies entailing broad group comparisons, caution should be used in interpreting results. Use of self-reported estimates for individual assessments should be discouraged.

Key words: mobility; ageing; automobile driving; naturalistic driving

INTRODUCTION

Although research regarding older drivers has expanded greatly in recent years, many questions remain concerning: the ability of older drivers to effectively self-regulate/restrict their own driving, the association between low mileage, other driving practices and crash risk, as well as how best to regulate at-risk drivers. To address many of these important issues, measures of driving exposure are required. However, most studies of older adults' driving practices rely on what the older drivers self-report. The use of this approach has potential limitations. Staplin et al. (2003) found that driver responses to questions concerning weekly versus annual miles driven yielded discrepant results (by 50%) for over 40% of the sample, precluding the use of this variable to examine association with crash risk in the MaryPOD study. Staplin et al. (2008) provided a cautionary note related to the low mileage bias issue, because older drivers tend to misclassify when self-reporting very low (<3,000) or very high (>14,000) mileage estimates, as compared to odometer readings. Other studies using electronic in-vehicle devices have also found that older drivers had problems accurately estimating how far they drove (Blanchard et al. 2010, Crizzle et al. 2013, Huebner et al. 2006). Limitations of those prior studies include: relatively small sample sizes (n< 60), short measurement periods (one to two weeks), and the use of devices with limited memory capacity (about 300 hours). Over a longer time frame (4 months), a recent study found that older Australian drivers (n=156) tended to underreport driving exposure (Molnar et al. 2013). However, they compared how far participants said they drove in a "normal week" to four months of driving data (averaged to a week), without examining the details of those weeks. Hence they did not account for potential anomalies in driving patterns (e.g., long-distance vacation trips).

The purpose of this study was to provide a detailed determination of the validity of self-estimates of yearly driving exposure in a large group of older adults, by comparing their self-reported data to actual distance driven over a full year, as measured by in-vehicle monitoring devices.

METHODS

Participants

All participants were from Candrive II, a Canadian multi-centre, prospective, longitudinal, cohort study examining many issues about older drivers. The main focus of Candrive is to identify screening tools that can be used by physicians to identify potentially unsafe older drivers (Marshall et al. In Press). Full details on sample recruitment, inclusion/exclusion criteria, and annual assessment protocols for the Candrive II study are presented elsewhere (Marshall et al. In Press). Briefly, volunteers were eligible if they were 70 years or older, regularly drove (at least four times per week), and primarily drove one vehicle (at least 70% of the time) which was 1996 or newer (in order to accommodate the monitoring device).

Annual assessments

On a yearly basis, study participants completed a number of questionnaires and functional assessments. The pertinent question for the present analyses was: "Please estimate the number of kilometers you have driven in the past year." There were eight possible categorical response options:

< 1000; 1001-3000; 3001-5000; 5001-10,000; 10,001-15,000; 15,001-20,000; 20,001-25,000; and > 25,000 kilometers.

Equipment

The OttoView-CD Autonomous Data Logging Device (Otto) (Persen Technologies, Winnipeg, MB, Canada) can be viewed in Figure 1. The device comprises six components: an on-board diagnostic system (OBDII) connector, a GPS antenna, a 2 GB SD memory card, a key fob (FOB), a radio frequency antenna (RFID), and the main unit which has inputs for all of the above. The OBDII connector enables the device to be powered by the vehicle and provides the vehicle's data. The GPS antenna is fixed on the dash to allow for a good view of satellites. The RFID and FOB were used in cases where there were multiple users of the vehicle, where the keys linked to the FOB are to be solely used by the study participant. The first record is considered the start of the trip, although it technically occurs 7 to 12 seconds after the ignition starts, when the device with all its components (e.g., GPS antenna, RFID antenna, main unit) powers on. Data are collected every second while the ignition is on. The end of a trip occurs when the ignition is turned off.

Data and Statistical Analyses

The data collected and stored on the SD memory card were read by the Candrive Driver Tracking System (DTS) software application (Persen Technologies, Winnipeg, MB, Canada). This software was also used to filter the file if someone else drove the vehicle based on recognition of the FOB by the RFID antenna, and occasional trips made by other drivers as noted by the participant (on driving logs or when queried every four months). Other filtering included removing trips that were 100 m or less, or 5 seconds or less. Although this device includes GPS capabilities and can be used to examine driving locations, due to time delays (locking into satellites at the beginning of a trip), GPS data cannot be reliably used to measure the distance of an entire trip and would result in systematic underestimation of trip distance. Thus, trip distance was calculated based on the aggregation of speed, as measured by the vehicle speed sensor, multiplied by time for each record (in seconds) of a trip. All year one driving data files for a participant were combined and summed to provide the total distance driven. Distances were categorized to correspond with one of the eight self-report response options.

Several criteria were used to determine which data were included in these analyses. To be included, participants had to have: 1) answered the question regarding distance driven in the past year at the 2nd assessment; 2) driven only one vehicle over the year (as a device was only installed in one vehicle even if they drove multiple vehicles); and 3) at least 51weeks (358 days) of useable driving. Figure 2 presents a flowchart showing the loss of participants based on these criteria. The primary reason people were excluded was due to driving more than one vehicle (n=409; 44.1%) as all of their driving would not have been captured.

In order to determine if there was a systematic difference (over- or under-estimation) in self-reported compared to objectively measured driving distance, a Wilcoxon signed rank test was performed (as data were not normally distributed). Tests of significant differences are not suitable for determining whether two values are the same (Altman and Bland 1983), therefore actual versus self-reported distance for each individual were graphically examined and frequencies calculated for errors in estimation. Furthermore, because underestimation and over-estimation can effectively cancel each other out when using a measure of central tendency, we followed this analysis with a measure of agreement. The weighted Kappa statistic was used to assess the level of agreement (Landis and Koch 1977).

RESULTS

The 159 participants included in these analyses ranged in age from 70 to 92 (mean 77 ± 5 years); 50.9% were male. This group, on average, had 363 ± 1.6 days of useable driving data. On average, they made 1,400 ± 532 trips (range = 476 to 3,579) and drove 10,145 ± 5,889 km (range = 1,137 to 33,514) over the year, resulting in an average distance per trip of 7.2 km. The median driving distance was 10,001 to 15,000 km according to both the self-reported and the objective data. There was no significant difference, suggesting that there was no systematic under- or over-estimation. The weighted kappa statistic was 0.57 (95% CI 0.47 to 0.67), indicating moderate agreement (Landis and Koch 1977).

As can be seen in Figure 3, participants were not always accurate in their estimations. In fact, for the two lowest mileage categories, those who estimated inaccurately, underestimated their driving distance, while for the two highest distance categories, the opposite was true, they over-estimated. Overall, 45.3% of the sample incorrectly estimated their driving distance over the year (see Figure 4). This figure also shows that 34% of incorrect estimates were within one adjacent category (i.e., ± 1), and 7.6% were within two categories (i.e., ± 2). The remaining participants had errors of 3, 4 or even 5 categories, which resulted in a difference of up to 20,000 km.

DISCUSSION

This study used stringent data inclusion criteria to examine the accuracy of self-reported driving distance estimations using a full year of driving monitoring. Overall there was moderate agreement with objectively measured distance. About half the participants were able to select the correct distance category, and another 34% were within one category. Consistent with prior studies on older drivers (Blanchard et al. 2010, Crizzle et al. 2013, Huebner et al. 2006), we did not find systematic over- or under-estimation of self-reported distance across the sample as a whole. In contrast, the four month study on Australian drivers (Molnar et al. 2013) found that their sample of older drivers underreported exposure. However, they did not examine if this was consistent across the range of estimates and used correlational rather than concordance statistics.

We found interesting trends in those who self-reported extremely low or high distances. Those who were incorrect according to the objective measure for the low exposure categories (≤ 5,000 km) always under-estimated their distance. Conversely, those who were incorrect in the high distance categories (≥ 20,000 km) always over-estimated. Crizzle et al. (2013) found that 82% of their older drivers with Parkinson's disease, who drove substantially less than age- and gender-matched controls, significantly underestimated their driving distance over two weeks. Staplin et al. (2008) also found instances of under-estimation in those with low mileages, and over-estimation in those with high mileages. As these researchers (Staplin et al. 2008) point out, this calls into question the conclusions of prior studies that relied on self-reported measures of exposure, and suggests that such information cannot be used in a valid fashion by licensing authorities to identify individual older drivers that require increased scrutiny (e.g., those who drive the least).

In conclusion, these results suggest that self-reported measures of driving exposure (distances) might suffice for some research studies looking at broad group comparisons. However, given that some individuals were incorrect by up to 20,000 km, self-reported data should not be used for individual level decisions (by clinicians or licensing authorities), and would not be appropriate for research studies looking at detailed driving patterns of older drivers.

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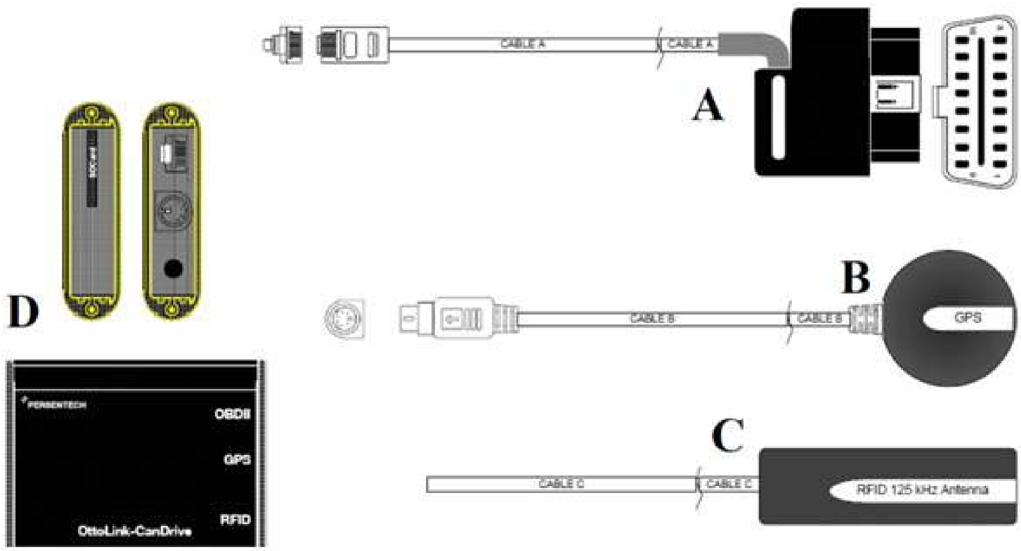

Figure 1. A diagram of the in-vehicle recording device components, A is the plug for the on-board diagnostics (OBDII) port, B is the global positioning system (GPS) receiver, C is for the radio frequency identification (RFID) antenna, and D shows the main device where all inputs and memory card reside.

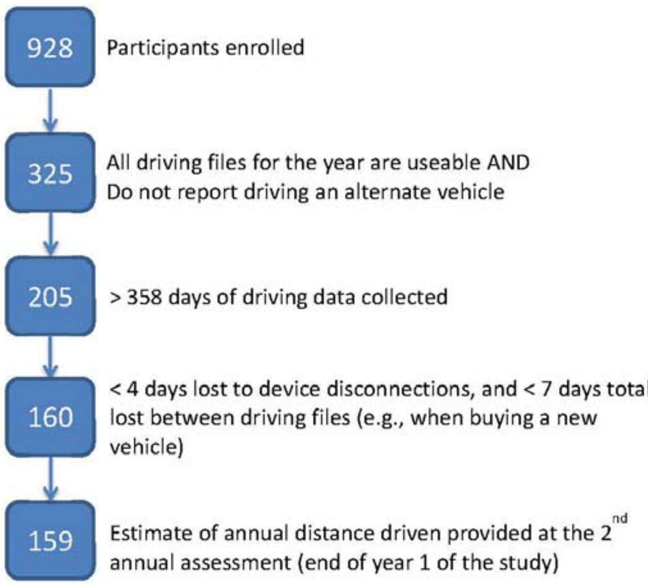

Figure 2. Flowchart of participant selection for the analyses of this study.

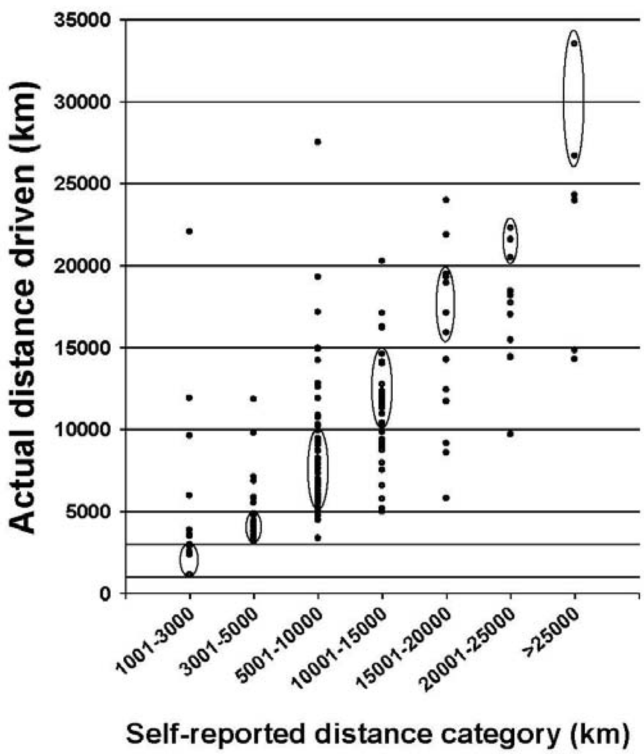

Figure 3. This scatterplot shows the relationship between self-reported and actually measured driving distances over the first year of the study for 159 participants. The ellipses indicate concordance between their self-reported distance category and the distance measured by the in-vehicle device.

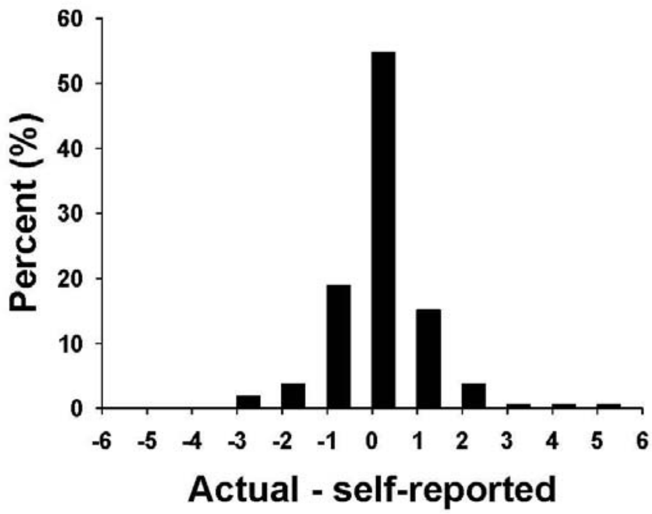

Figure 4. Percentage of participants according to the difference between the self-reported category and the "actual" category, where 0 indicates concordance.