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Prospective study of healthy older drivers: No increase in crash involvement or traffic citations at 24 months following a failed on-road assessment

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ABSTRACT

There is a general belief that requesting driving assessments for older drivers without evidence of cognitive impairment is a poor use of resources. There is, however, limited empirical evidence to support this view. We prospectively followed 56 neurologically-healthy drivers aged 70–84 years for 24 months to determine whether a non-enforced pass or fail outcome on an on-road driving assessment was related to the subsequent incidence of self- and officially-reported crashes and traffic offences. There was no significant relationship found between pass or fail outcome and either later crashes, or crashes combined with the more common occurrence of traffic offences. However, drivers who drove more km at the initial assessment were more likely to have a crash or traffic offence in the following 2 years. This prospective study suggests that an on-road driving assessment provides little indication of crash and traffic offence likelihood in the subsequent 2 years in the context of older drivers who do not have cognitive impairment.

1. Introduction

The increasing number of older people in society and the higher rates of traffic-related injury and death for older adults compared to middle-aged drivers (Langford & Koppel, 2006; Organisation for Economic Co-operation and Development, 2001; Tefft, 2008) leave policy-makers understandably concerned about detection of at-risk older drivers. Several researchers have stated that assessment for drivers based on age alone is not justified and that assessment resources should instead be focused on those with demonstrable risk factors for unsafe driving, such as stroke and cognitive impairment (De Raedt & Ponjaert-Kristoffersen, 2000; Langford & Koppel, 2006; Langford, Methorst, & Hakamies-Blomqvist, 2006; Organisation for Economic Co-operation and Development, 2001). Support for this perspective requires prospective studies to follow the driving behaviour of older people following an on-road assessment to indicate whether the outcome is indeed related to subsequent driving behaviour. Ethical difficulties in allowing a group of drivers who have failed an on-road assessment to continue driving usually preclude comparison of their future driving with that of drivers who passed. Only two studies have thus far addressed this question.

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A New Zealand study (Keall & Frith, 2004) prospectively followed the incidence of police-reported injury crashes in a large population sample of over 39,300 drivers aged 80 and above following an on-road driving test. The test was administered under driver licensing laws (now rescinded) that required adults aged 80 and over to pass a biennial on-road driving test. There was no limit to the number of times drivers could sit the test to secure a passing grade, thus providing a rare opportunity to determine whether drivers who failed one or more on-road tests, but who eventually passed, were more likely to experience a police-reported crash in the following 2 years than drivers who passed on their first attempt. Seventeen percent of the sample failed the on-road test at least once before receiving a pass grade, and the risk of involvement in a crash in the following 2 years rose 33% for each time the test was repeated. However, this increase must be considered in the context of the base rate of crashes that lead to injury or death. Only 1.2% of those drivers who failed at least one on-road test went onto have a serious crash in the following 24-months compared to 0.7% of those who passed the test on their first attempt (see Table 1).

Other factors also weaken the impact of this study. First, everyone followed over the 2 year follow-up eventually passed the on-road test, even if it took several attempts (two participants passed on their ninth assessment). Thus, the "fail" group is not equivalent to a fail group seen in most driving literature. A related problem was that those drivers who failed and never passed an assessment (5% of the participants) lost their licence and could not be followed up. Additionally, drivers who received notification of their up-coming compulsory assessment may have decided to cease driving before any assessment. These latter two groups may be at the most risk of subsequent negative driving outcomes and yet could not be followed. Also, the outcome measure of police-reported crashes is a high criterion for determining unsafe driving practice. In New Zealand a police report of a crash is only made if it culminated in injury or death. Thus, minor crashes are not included in the outcome measure. While impressive in sample size, offering useful information regarding the relationship between repeated driving assessment fails and subsequent crashes, the Keall and Frith (2004) study cannot tell the full story of whether an on-road driving assessment fail is related to measurably less safe driving in older adults.

An Australian study by Anstey, Wood, Caldwell, Kerr, and Lord (2009) provides a more specific measure of this question. This study followed a sample of 266 older drivers for 12 months following an on-road driving assessment with participants providing monthly self-reports of crashes over this period. No increase in the incidence of self-reported crashes was found for drivers who had received a score in the fail range of the on-road assessment. While this study more closely monitors the predictive validity of an on-road assessment, the follow-up time of 12 months is a short time to measure a low base rate outcome such as crashes. Secondly, reliance solely on self-reported information could be biased towards under-reporting. Third, the results reported do not allow the calculation of an odds ratio to compare to the Keall and Frith (2004) study to determine whether the effect sizes were similar.

State-recorded crashes are a rare event. In Keall and Frith's (2004) study, the prospective police-reported incidence of crashes over a 2-year period was only 0.8% of their total sample. In comparison, self-reported crashes have been recorded at a rate between 4% and 10% per year (Anstey et al., 2009; Marottoli, Cooney, Wagner, Doucette, & Tinetti, 1994; Sullman & Baas, 2004).

The commission of traffic offences has also been associated with an increased likelihood of having crashes, including in older drivers (Cooper, 1997; Keall & Frith, 2004; Parker, Reason, Manstead, & Stradling, 1995; Rajalin, 1994). People observed driving at higher speeds on public roads are significantly more likely to have a state-recorded history of crashes and traffic offences over the previous 7 years (Wasielewski, 1984). The relationship between traffic offences and crashes and the higher base-rate of offences compared to crashes may make traffic offences a more sensitive measure to determine which older drivers are at higher risk for negative on-road outcomes.

Demographic and driving exposure factors may also influence crashes and traffic offences. Older drivers with higher driving exposure have been found to be both more likely (Ball et al., 2006; Owsley et al., 1998), and less likely (Alvarez & Fierro, 2008; Hakamies-Blomqvist, Raitanen, & O'Neill, 2002; Janke, 1991; Langford et al., 2006) to have a crash. This latter finding is usually attributed to a core group of older drivers who are affected by cognitive or physical illness that both limit their driving and over-contribute to adverse events.

The current study followed 56 drivers aged 70 and over who had been recruited to study off-road indicators of on-road driving assessment outcome (Hoggarth, Innes, Dalrymple-Alford, Severinsen, & Jones, 2010). As with the Anstey et al. (2009) study, participants were allowed to continue driving following the assessment as a stipulation of their involvement in the study. Hence there was a rare opportunity to assess whether an on-road assessment fail score was associated with subsequent crashes and traffic offences. The association between crashes and offences over the following 2 years was compared

Table 1
People in Keall and Frith's (2004) study divided into those who passed or failed their first on-road test and those who had a police-recorded crash over the following 24 months.

First on-road test	24-month police-recorded crash involvement			
	No	Yes	Totals	% who had a crash
Fail	6863	80	6943	1.2
Pass	32,135	222	32,357	0.7
Totals	38,998	302	39,300	0.8

with kilometres driven per year at the first assessment point, as well as sex and age. Errors that occurred during the on-road test were noted by the driving occupational therapist and were compared between pass and fail groups.

There was little expectation of statistically significant results being found for low base rates of crashes and traffic offences. Instead, a comparison of odds ratio effect sizes with the Keall and Frith (2004) study provided a partial replication of their report, as well as an opportunity to see if the inclusion of traffic offences as an outcome measure could lead to a larger effect size and therefore a potentially more useful target for predicting future safe driving than crashes alone.

2. Methods

2.1. Participants

A convenience sample of 60 participants aged 70–84 years were recruited with 10 men and 10 women in each of three age groups (70–74, 75–79, and 80+ years). Exclusion criteria included a history of moderate to severe brain injury, diagnosed neurological or cognitive disorder, severe musculoskeletal disease, and acute psychiatric disorder. Participants had not been referred for a driving assessment or as part of licence renewal procedures. Participants completed standard neuropsychological tests (a standardised version of the Mini Mental State Exam, the Dementia Rating Scale-2, and the Trail Making Test A & B) and computerised sensory-motor and cognitive tests. These were used as independent measures to build a classification model for on-road assessment pass and fail outcome. Full details of the measures used are presented in Hoggarth et al. (2010). Participants completed a 45-min on-road driving assessment where sixteen of 60 participants (26.7%) received a fail score.

Participants were invited to participate in a 2-year follow-up (the current study) which included telephone contact at 12- and 24-months following the on-road assessment. Permission was sought to access officially-recorded traffic offence and crash data. One participant refused to take part in the follow-up study and one refused to give access to official crash and offence records. A further participant died before the 24-month follow-up and another could not be located, leaving full data for 56 participants (one of the participants lost to follow-up had failed the on-road assessment, and the other three had passed). At the end of 24 months, the mean age of the sample was 78.7 years (SD = 4.1) with a range of 72–85 years (27 males and 29 females). Forty-one (73.2%) of these participants had initially received an on-road pass and 15 (26.8%) received an on-road fail. Participants gave informed consent and both studies were approved by the Upper South A Regional Ethics Committee, Canterbury, New Zealand.

2.2. On-road assessment

At baseline, the on-road assessment was administered by an experienced driving occupational therapist and a driving instructor from the Driving and Vehicle Assessment Service at Burwood Hospital, Christchurch. The driving instructor sat in the passenger seat and provided instructions on the driving path to be taken and maintained vehicle safety. The occupational therapist sat in the rear and assessed driver performance. Assessors were blinded to all off-road testing results used in the previous study (Hoggarth et al., 2010). Participants drove the same route on public roads with hazards such as single-lane roundabouts, dual-lane roundabouts, dual-lane roads, controlled and uncontrolled intersections, and changes in speed zone (i.e., 50 km/h, 60 km/h, and 80 km/h sections). There was no pre-determined list of errors used to decide whether a person passed or failed the assessment. The occupational therapist observed the participants behaviour, noted the performance of driving errors, and came to a global decision of pass or fail after consultation with the driving instructor. This assessment followed standard practice for already-licenced drivers in New Zealand who are referred for assessment of medical fitness to drive.

2.3. Driving exposure

As part of the original study participants logged their driving behaviour over a 1-week period prior to the first assessment appointment. Participants were provided with a 7-day driving log where they recorded their odometer readings before and after each driving trip. At the first assessment information was obtained on any driving destinations outside Christchurch over the previous 12 months. The distance of these excursions was calculated using the Google Maps function (http://maps.google.co.nz/) and added to the extrapolated daily driving log records thus estimating driving exposure over the previous 12 months.

2.4. Crash and traffic offence data

Crash data provided by the New Zealand Ministry of Transport recorded crashes attended by police that involved injury or death. Traffic offence data provided by the New Zealand Transport Agency recorded offences issued in person by police officers but did not include parking offences or stationary speed radar camera offences. Participants were telephoned 12- and 24-months following the on-road assessment and were asked to self-report involvement in crashes and receipt of traffic tickets in the preceding 12 months.

2.5. Data analysis

Analyses comparing on-road pass and fail outcomes with subsequent crash and offence involvement were performed in two steps. First, one or more instances of self- or officially-reported crashes over the 24-month follow-up period was used as the binary dependent variable and an odds ratio and confidence interval were computed. This allowed for the results to most closely match the study designs of Keall and Frith (2004) and Anstey et al. (2009) studies. A second analysis was then performed where the dependent variable was one or more instances of either a self- or officially-reported crash *or* traffic offence over the 24-month follow-up period. This second analysis may be expected to be more sensitive given the inclusion of traffic offences. Fisher's Exact Test was used to compare pass and fail outcomes with subsequent crashes or offences for both analyses, and an odds ratio calculated.

Exposure data was compared between crash/offence and no-crash/offence groups using a Pearson's bivariate correlation. This statistic was also used for comparing age with crash/offence status. A Fisher's Exact Test was used to compare sex (male/female) with crash/offence outcome, and again to find any differences in the performance of certain on-road errors between pass and fail groups.

3. Results

At baseline the mean score for the initial 60 participants on a standardised version of the Mini Mental State Examination was 28.8 (none scored below 27). The mean age and education adjusted scale score for the Dementia Rating Scale-2 was 10.9 (41–59th percentile). Two participants received a scaled score of 5, in the "Moderately Impaired" range. One of these participants passed the on-road assessment and one failed. The remainder of participants received scaled scores between 7 and 17. Mean scores on the Mini Mental State Exam between pass and fail groups were both 28.8 ($p = 0.70$), and for the Dementia Rating Scale-2 were 11.1 and 10.1 respectively ($p = 0.21$).

At the baseline time point the number of km driven in the previous 12 months was compared between pass and fail groups to test whether driving exposure was related to on-road assessment outcome. The median km driven by the pass group was 7310 compared to 7176 by the fail group (Mann–Whitney U, $p = .34$).

Over the 24-month follow-up period 16 of the 56 participants had self-reported crashes and/or traffic offences (10 with offence only, 5 with crash only, and 1 with a crash and an offence). There were no officially-reported crashes. There were 4 officially-reported offences (all for excess speed), all of which were also self-reported.

The odds ratio for incidence of prospective self-reported crashes following an on-road fail score was 1.42 (95% CI: 0.23–8.71). This indicates that drivers who received a fail were 42% more likely to experience a self-reported crash in the following 2 years. This difference was not significant (two-tailed, $p = .65$) (see Table 2).

The odds ratio for incidence of prospective self-reported crashes and traffic offences following an on-road fail score was 1.36 (95% CI: 0.38–4.89). This indicates that drivers who received a fail on the on-road assessment were 36% more likely to experience a crash or traffic offence in the following 2 years. Again this difference was not significant (two-tailed, $p = .74$) (see Table 3).

For the exposure variable, there was a significant correlation indicating that a higher number of km travelled was associated with a higher rate of crashes and traffic offences 2 years later ($r = .31$, $p < .02$). Those in the crash/offence group reported driving an average of 18,661 km at the first time point, compared to an average of 7875 in the no-crash/offence group. Between 2004 and 2008, New Zealand drivers aged 65–74 drove an average of 6870 km/year; drivers aged 75 and above drove an average of 3150 km/year (Ministry of Transport, 2012). The current sample drove longer distances than this officially collected data, particularly those who had a crash or offence over the follow-up period. Within the crash/offence group was a driver whose km driven were 3.5 times higher than the next highest km driver (103,532 km versus 29,770). To determine the extent to which this driver's exposure data was skewing the results, the analysis was rerun with this driver excluded. The results still found a significant association between higher km driven and crashes and offences 2 years later ($r = .27$, $p = .05$).

There was no relationship between sex and crashes and offences (Fisher's Exact Test, two-tailed, $p = .38$) or age and offences and crashes ($r = .19$, $p = .15$).

Comparison of the percent of different types of on-road errors made by the pass and fail groups are shown in Table 4. Differences between the two groups were evident for eleven types of error. The largest differences occurred with respect

Table 2
Participants who passed or failed the on-road assessment and those who had a self- or officially-reported crash over the following 24 months.

On-road outcome	24-month crash			
	No	Yes	Totals	% who had a crash
Fail	13	2	15	13.3
Pass	37	4	41	9.8
Totals	50	6	56	10.7

Table 3
Participants who passed or failed the on-road assessment and those who had a self- or officially-reported crash or traffic offence over the following 24 months.

On-road outcome	24-month crash or traffic offence			
	No	Yes	Totals	% who had a crash/offence
Fail	10	5	15	33.3
Pass	30	11	41	26.8
Totals	40	16	56	28.6

Table 4
On-road errors which appeared more frequently in the fail than the pass group.[a]

On-road error	Incidence in fail group (n = 16) (%)	Incidence in pass group (n = 44) (%)	p Value (two-tailed Fisher's exact test)
Does not response to speed sign	62.5	31.8	.041
Incorrect use of give way rules	50.0	4.5	<.001
Inappropriate gap selection	50.0	13.6	.006
Slow driving	50.0	15.9	.015
Difficulties with gear selection	43.8	0	<.001
Incorrect indication	25.0	4.5	.038
Driving on wrong side of road	18.8	0	.016
Missed an instructed turn off	18.8	0	.016
Tyres contacted curb	18.8	0	.016
Slow to start at traffic lights	18.8	0	.016
Incorrect use of roundabout lanes	18.8	0	.016

[a] Thirty-eight additional errors were recorded that were not significantly different in rate between groups. Errors that were equally common to both groups were fast driving (38% fail group, 36% pass group), and lack of blind spot check when changing lanes (44% fail group, 46% pass group).

to incorrect gear selection, use of give way rules and choosing appropriate gap sizes for entering the traffic flow at intersections.

4. Discussion

4.1. Principal findings

This study presented a rare opportunity to follow a group of older drivers who had been rated as a pass or fail after a formal driving assessment to determine whether those who failed were at increased risk of being involved in crashes or traffic offences in the following 2 years. The use of self- and officially-reported traffic offences as the outcome measure did not boost the effect size noticeably compared to using the incidence of crashes alone. The effect sizes found in the current study are similar to the effect size found in the Keall and Frith (2004) study. Higher kilometres driven at the first time point were associated with a higher incidence of crashes and offences over the subsequent 2 years.

The practicality of using an on-road driving assessment for determining the future rate of unsafe driving as measured using crashes and traffic offences in a group of older drivers without significant cognitive impairment seems questionable. The Keall and Frith (2004) study found that only 1.2% of drivers who failed at least one on-road assessment went onto have a serious crash in the following 2 years. Thus, to prevent one crash, an average of just fewer than 100 drivers would have needed to be taken off the road. Given that driving cessation in older adults is associated with decreases in physical functioning (Edwards, Lunsman, Perkins, Rebok, & Roth, 2009), increases in depressive symptoms (Ragland, Satariano, & MacLeod, 2005), decreases in out-of-home and social activity participation (Marottoli, Mendes de Leon, Glass, Cooney, et al., 2000; Mezuk & Rebok, 2008; Edwards, Lunsman, et al., 2009), increases in the likelihood of entry into long-term care facilities (Freeman, Gange, Munoz, & West, 2006), and increases in mortality (Edwards, Perkins, Ross, & Reynolds, 2009), it is relevant to consider the balance between the amount of harm being caused to older drivers who have to cease driving versus the rare instances of a serious crash. This is particularly important given that 0.7% drivers in the Keall and Frith study who passed on their first on-road assessment had serious crashes in the following 2 years which is not convincingly (albeit statistically significantly) lower than those who failed.

Our finding that higher driving exposure was related to a higher incidence of crashes/offences over the subsequent 2 years is in agreement with some prior studies, but not others. Owsley et al. (1998) found that older drivers who reported driving fewer than 7 days a week had a lower rate of officially-reported crashes than those who reported driving daily. Ball et al. (2006) found that older drivers with higher self-reported miles per year were more likely to have officially-reported crashes. On the other hand, three studies that used self-reported km/year data across three predefined levels (<3000 km, 3000–14,000 km, >14,000 km) found more self-reported crashes in older drivers in the lowest exposure group (Alvarez & Fierro, 2008; Hakamies-Blomqvist, Raitanen, & O'Neill, 2002; Langford et al., 2006). Janke (1991) argued that there is no linear association between exposure and crashes due to different travel patterns reflected in these numbers, i.e., a person

driving shorter distances will likely be doing this in a more suburban built up area where the likelihood of a crash is higher than in a less complex highway scenario.

It is possible that older drivers with cognitive impairment are over-represented in the lower km category due to limits they place on their driving which do not in practice reduce their risk on the road. It is possible that the association between higher km driven and higher rates of crashes is limited to cognitively healthy older drivers and is simply due to increased time on the road. It may be that our study used a more accurate measure of driving exposure, rather than simply asking drivers to estimate how many km they drove in a year, and thus produced results that differed from other studies. Finally, our outcome measure consisted mostly of traffic offences, which were not included in the above studies and may have a stronger relationship to time spent on the road than crashes.

Eleven types of on-road errors occurred more frequently in the fail group than the pass group. However, it is important to note that there were no standardised weightings of errors to determine pass or fail outcome by the on-road assessor. It should also be mentioned that those failed drivers who drove on the wrong side of the road (3 drivers in total) did so for only brief periods of time following turning at intersections, and all rapidly self-corrected.

5. Limitations

There are several limitations to this study, the most obvious being the small sample size to detect the low base-rate outcomes of crashes and offences in a neurologically-unimpaired sample. We were fully aware of this fact when planning the study but considered the study was worth performing due to the paucity of studies that have been able to follow drivers after the receipt of an on-road fail score.

Another limitation of the study is the on-road assessment. Although administered by the same pair of assessors on the same route for all participants, it followed standard practice for New Zealand medical driving assessments and did not utilise a standardised scoring system for determination of pass and fail outcomes. The use of non-standardised driving assessments is unfortunately a common practice. A survey of 114 American and Canadian driving assessors found that only 24% of assessors used a standardised scoring system for on-road assessments, and only 10% used a cutoff score to assess driving competency (Korner-Bitensky, Bitensky, Sofer, Man-Son-Hing, & Gelinas, 2006). Only two respondents reported using a standardised road test. Some standardised assessments have been tested for interrater and test–retest reliability, with the former usually found to be moderate to high, and the latter in the moderate range (Fitten et al., 1995; Hagge, 1994; Hunt et al., 1997; Janke & Eberhard, 1998; Romanowicz & Hagge, 1995). Investigations into the validity of standardised road tests have found some associations to real-world crashes or infringements (Fitten et al., 1995; Keall & Frith, 2004; Romanowicz & Hagge, 1995), although these studies suffer from the same problems as the current study regarding following drivers with both pass and fail scores over time.

There was no control group in the current study, thus we cannot determine the influence of exposure to the driving assessment on the driving behaviour of the participants. For example, taking part in the assessment may have improved the driving of previously poor drivers by pointing out areas of weakness. Furthermore, as those in the study consented to take part in the driving assessment, they likely had higher average levels of driving confidence than the general population of older drivers.

The use of driving exposure data to compare to crashes and traffic offences 2 years later fails to provide information about how driving habits may have changed for drivers over the 2 year period. For example, a driver with a previously high rate of km/year may have had to reduce driving due to poor health. This may have led to a crash or offence that in the current data set would be seen to be associated with their previous high level of driving, rather than the more proximal cause of ill health or loss of confidence.

We were unable to establish whether participants were at fault for crashes because there was no officially reported crash data in the 24-month follow-up period. We decided that we could not rely upon self-reported fault due to a potential bias to blame the other driver. We believe determination of fault is a serious issue, and that ideally crashes that are clearly not the fault of the study participant (as judged by an independent and knowledgeable party) should not be included in the outcome measure.

Self-reported data relating to crashes and offences is often necessary due to difficulties in obtaining relevant officially recorded data. Studies investigating the agreement between self- and official-report have found differing results. Owsley, Ball, Sloane, Roenker, and Bruni (1991) found only a small correlation ($r = .11$) between 5 year retrospective self-report versus official-report of crashes in a sample of older drivers. Another study found moderate agreement ($K = .45$) between 5 year retrospective self-reported and state-reported crashes in older drivers, with lower agreement when the number of reported crashes was compared ($K = .25$), with people under-reporting crashes (McGwin, Owsley, & Ball, 1998). One study with a younger cohort of 1037 drivers found agreement ranging from 76% to 100% for the details of 3 year retrospective self- and officially report crashes (Begg, Langley, & Williams, 1999). Another study found rates of agreement of 85% for 1 year retrospective self- and officially-reported crashes, and 83% for traffic offences in a sample of 2991 young drivers (Boufous et al., 2010). Clearly the agreement of self-report data to officially-reported data varies between studies.

The current study found no police-reported crashes over the 24 months, but 6 self-reported crashes. Additionally, all traffic offences that were officially-reported were also self-reported, plus several additional offences. We believe the current sample was remarkably honest in their reporting of crashes and offences, yet acknowledge that the use of self-report data is contentious and requires careful procedures for recording, ideally across short time intervals.

Another limitation was that a standardised error list was not used by the assessor, so some errors may not have been recorded. Similarly, the assessor may have been more likely to recall errors while writing reports for drivers who were rated as a fail than those who passed. Both of these difficulties could be corrected by using an error list to be completed for each participant. This was subsequently done using these data for a study of drivers with Alzheimer's dementia and mild cognitive impairment, the results of which have been published elsewhere (Hoggarth, Innes, Dalrymple-Alford, & Jones, 2011).

6. Conclusion

The odds ratios of the relationship between failing an on-road assessment and going onto have a crash or traffic offence are very similar to those found by Keall and Frith (2004). As with both studies, odds ratios can be misinterpreted if not understood within the context of the base rate of the studied behaviour. In both studies, the incidence of the dependent variable was so low as to question the usefulness of on-road driving assessments for drivers who may appear to their doctors as low-risk due to the absence of diagnosed cognitive disorder. These results provide some empirical evidence to support the often stated opinion that low-risk older drivers need not be subjected to on-road driving assessments (De Raedt & Ponjaert-Kristoffersen, 2000; Langford & Koppel, 2006; Langford et al., 2006; Organisation for Economic Co-operation and Development, 2001).

Disclosure statement

The authors believe there are no actual or potential conflicts of interest present that would lead to biasing of data collection, interpretation, or presentation.

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References

Alvarez, F. J., & Fierro, I. (2008). Older drivers, medical condition, medical impairment and crash risk. *Accident Analysis and Prevention, 40*, 55–60.

Anstey, K. J., Wood, J., Caldwell, H., Kerr, G., & Lord, S. R. (2009). Comparison of self-reported crashes, state crash records and an on-road driving assessment in a population-based sample of drivers aged 69–95 years. *Traffic Injury Prevention, 10*, 84–90.

Ball, K. K., Roenker, D. L., Wadley, V. G., Edwards, J. D., Roth, D. L., McGwin, G., et al (2006). Can high-risk older drivers be identified through performance-based measures in a Department of Motor Vehicles setting? *Journal of the American Geriatrics Society, 54*, 77–84.

Begg, D. J., Langley, J. D., & Williams, S. M. (1999). Validity of self reported crashes and injuries in a longitudinal study of young adults. *Injury Prevention, 5*, 142–144.

Boufous, S., Ivers, R., Senserrick, T., Stevenson, M., Norton, R., & Williamson, A. (2010). Accuracy of self-report of on-road crashes and traffic offences in a cohort of young drivers: The DRIVE study. *Injury Prevention, 16*, 275–277.

Cooper, P. J. (1997). The relationship between speeding behaviour (as measure by violation convictions) and crash involvement. *Journal of Safety Research, 28*, 83–95.

De Raedt, R., & Ponjaert-Kristoffersen, I. (2000). The relationship between cognitive/neuropsychological factors and car driving performance in older adults. *Journal of the American Geriatrics Society, 48*, 1664–1668.

Edwards, J. D., Lunsman, M., Perkins, M., Rebok, G. W., & Roth, D. L. (2009). Driving cessation and health trajectories in older adults. *Journal of Gerontology: Medical Sciences, 64A*, 1290–1295.

Edwards, J. D., Perkins, M., Ross, L. A., & Reynolds, S. L. (2009). Driving status and three-year mortality among community-dwelling older adults. *Journal of Gerontology: Medical Sciences, 64A*, 300–305.

Fitten, L. J., Perryman, K. M., Wilkinson, C. J., Little, R. J., Burns, M. M., Pachana, N., et al (1995). Alzheimer and vascular dementias and driving: A prospective road and laboratory study. *Journal of the American Medical Association, 273*, 1360–1365.

Freeman, E. E., Gange, S. J., Munoz, B., & West, S. K. (2006). Driving status and risk of entry into long-term care in older adults. *American Journal of Public Health, 96*, 1254–1259.

Hagge, R. A. (1994). *The California driver performance evaluation project: An evaluation of a new driver licensing road test*. Sacramento, CA: California Department of Motor Vehicles (Report No. 150).

Hakamies-Blomqvist, L., Raitanen, T., & O'Neill, D. (2002). Driver ageing does not cause higher accident rates per km. *Transportation Research Part F, 5*, 271–274.

Hoggarth, P., Innes, C., Dalrymple-Alford, J., & Jones, R. (2011). On-road driving assessment errors associated with pass and fail outcomes for older drivers with cognitive impairment. In *Sixth international driving symposium on human factors in driver assessment, training and vehicle design*. Lake Tahoe, California.

Hoggarth, P. A., Innes, C. R. H., Dalrymple-Alford, J. C., Severinsen, J. E., & Jones, R. D. (2010). Comparison of a linear and a non-linear model for using sensory-motor, cognitive, personality, and demographic data to predict driving ability in healthy older adults. *Accident Analysis and Prevention, 42*(6), 1759–1768.

Hunt, L. A., Murphy, C. F., Carr, D., Duchek, J. M., Buckles, V., & Morris, J. C. (1997). Reliability of the Washington University Road Test. *Archives of Neurology, 54*, 707–712.
Janke, M. K. (1991). Accidents, mileage, and the exaggeration of risk. *Accident Analysis and Prevention, 23*, 183–188.
Janke, M. K., & Eberhard, J. W. (1998). Assessing medically impaired older drivers in a licensing agency setting. *Accident Analysis and Prevention, 30*, 347–361.
Keall, M. D., & Frith, W. J. (2004). Association between older driver characteristics, on-road driving test performance, and crash liability. *Traffic Injury Prevention, 5*, 112–116.
Korner-Bitensky, N., Bitensky, J., Sofer, S., Man-Son-Hing, M., & Gelinas, I. (2006). Driving evaluation practices of clinicians working in the United States and Canada. *American Journal of Occupational Therapy, 60*(4), 428–434.
Langford, J., & Koppel, S. (2006). The case for and against mandatory age-based assessment of older drivers. *Transportation Research Part F, 9*, 353–362.
Langford, J., Methorst, R., & Hakamies-Blomqvist, L. (2006). Older drivers do not have a high crash risk – A replication of low mileage bias. *Accident Analysis and Prevention, 38*, 574–578.
Marottoli, R. A., Cooney, L. M., Wagner, D. R., Doucette, J., & Tinetti, M. E. (1994). Predictors of automobile crashes and moving violations among elderly drivers. *Annals of Internal Medicine, 121*, 842–846.
Marottoli, R. A., Mendes de Leon, C. F., Glass, T. A., Williams, C. S., Cooney, L. M., Jr., & Berkman, L. F. (2000). Consequences of driving cessation: Decreased out-of-home activity levels. *Journal of Gerontology: Social Sciences, 55B*, S334–S340.
McGwin, G., Owsley, C., & Ball, K. K. (1998). Identifying crash involvement among older drivers: Agreement between self-report and state records. *Accident Analysis and Prevention, 30*, 781–791.
Mezuk, B., & Rebok, G. W. (2008). Social integration and social support among older adults following driving cessation. *Journal of Gerontology: Social Sciences, 63B*, S298–S303.
Ministry of Transport (2012). *Driver travel: New Zealand household travel survey*. Wellington: Ministry of Transport.
Organisation for Economic Co-operation and Development (2001). *Ageing and transport: Mobility and safety issues*. Paris: OECD Publications.
Owsley, C., Ball, K. K., McGwin, G., Sloane, M. E., Roenker, D. L., White, M. F., et al (1998). Visual processing impairment and risk of motor vehicle crash among older adults. *Journal of the American Medical Association, 279*, 1083–1088.
Owsley, C., Ball, K. K., Sloane, M. E., Roenker, D. L., & Bruni, J. R. (1991). Visual/cognitive correlates of vehicle accidents in older drivers. *Psychology and Aging, 6*, 403–415.
Parker, D., Reason, J. T., Manstead, A. S. R., & Stradling, S. G. (1995). Driving errors, driving violations and accident involvement. *Ergonomics, 38*, 1036–1048.
Ragland, D. R., Satariano, W. A., & MacLeod, K. E. (2005). Driving cessation and increased depressive symptoms. *Journal of Gerontology: Medical Sciences, 60A*, 399–403.
Rajalin, S. (1994). The connection between risky driving and involvement in fatal accidents. *Accident Analysis and Prevention, 26*, 555–562.
Romanowicz, P. A., & Hagge, R. A. (1995). *An evaluation of the validity of California's driving performance evaluation road test*. Sacramento, CA: California Department of Motor Vehicles (Report No. 154).
Sullman, M. J. M., & Baas, P. H. (2004). Mobile phone use amongst New Zealand drivers. *Transportation Research Part F, 7*, 95–105.
Tefft, B. C. (2008). Risks older drivers pose to themselves and to other road users. *Journal of Safety Research, 39*, 577–582.
Wasielewski, P. (1984). Speed as a measure of driver risk: Observed speeds versus driver and vehicle characteristics. *Accident Analysis and Prevention, 16*, 89–103.