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Independent Review of Vision-Testing Research

Summary of brief

The following report is divided into two parts. In the first part I review the methodology of the two studies presented in the NZ Transport Agency's report titled "Driver Licensing Review Crash Study: Impacts of Vision Testing". In the second part I summarize the vision testing and safe driving literature provided by the submitters. Finally, I summarize the discussions made in both parts of the report and make some recommendations.

I. Comments on Methodology of NZTA studies

1. Was the sample of data used in this study sufficient to test the hypotheses?

The two studies conducted by the NZTA have used adequate sample sizes. I would recommend that some descriptive information about the sample (e.g., age range, gender etc.) is presented to get a better idea about whether this sample is representative of the population. I also recommend checking for age and gender effects. Age effects can be investigated by splitting the sample into younger and older adults to see if these two groups differ in their associations between vision testing and driving performance. The studies have used a reliable outcome measure of driving safety i.e. at-fault crashes from the Crash Analysis System (CAS) database as opposed to all crashes or self-report data which have both been shown to be fairly unreliable (Owsley & McGwin, 2015).

2. Were the correct statistical tests used?

The statistical tests used by the NZTA are appropriate for the research question and further statistical tests to determine effect size are recommended (see comment 3. about effect sizes). Effect size is an objective measure of the magnitude or strength of an observed effect. It is a standardized measure which means effects can be compared across studies that use different outcome measures. I would suggest calculating Cohen's d (Cohen, 1988) as a measure of effect size as it is recommended for comparison of groups with different sample sizes. An effect size of d = 0.2 is considered a *small* effect size, d = 0.5 a *medium* effect size and d = .8 a *large* effect size.

3. Are the conclusions reasonable based on the methodology used?

   I consider the overall conclusions of the two studies made by the NZTA to be logical. I would recommend presenting more statistical information to back the results of Study 1 in particular. The conclusion made in Study 1 was that drivers granted a license with condition to wear lenses did not significantly differ from those who were granted license without condition to wear lenses (p = .05155). The p-value is only marginally not significant ($p < .05$). I recommend calculating an effect size to quantify if this result is truly meaningful. A possible reason for the trend of drivers who failed the eyesight check to have fewer crashes than the general population could be because of less driver exposure (km's driven per week or days driven per week) due to self-regulation. If drivers felt their eyesight was diminishing they may have minimized the amount they drove, this could be added as a point of discussion.

4. Given that all drivers in this study would have their eyesight tested every 10 years is it appropriate to extrapolate these findings over a longer period of time? Do you have any recommendations for methodological improvement given the existing datasets available?

   The results of the two cross-sectional studies conducted by NZTA demonstrate that eyesight checks conducted at licensing agents do not increase crash risk. Based on the existing literature which has shown that severe decrements in vision mainly occur in older drivers (60 years and older), I would think that regular vision testing would only be required after a critical age threshold is reached (when they are more likely to suffer from vision impairments). Currently there is no consensus about what this critical age threshold is. Information provided by the American Optometric Association (2016) suggests that people over the age of 40 years are likely to experience vision problems which provides some insight into the issue.

   The age threshold and the regularity with which vision testing is conducted in older adults varies widely between countries. For instance, in Finland drivers are required to have a compulsory re-assessment of vision at 45 years of age, and then every 5 years from the age of 70 whereas in Denmark drivers are required to have a compulsory re-assessment of vision at the age of 70, and then every 2 years from the age of 74 (European Council of Optometry and Optics, 2011).

   New Zealand could adopt a risk based approach of vision testing similar to countries like Finland until more is known about the critical age threshold. Future work by the NZTA could include longitudinal studies that follow cases over a number of years detecting changes in vision and driving performance while accounting for confounding factors (e.g., driving exposure, visual impairments).

Overall Comments:

The two studies conducted by the NZTA are methodologically sound. Overall, the results suggest there are no associations between vision testing and driving performance. As mentioned above, I recommend calculating effect sizes for the studies to determine the strength of the findings. I also suggest that further analysis on the current sample of participants is done to investigate age effects i.e., whether associations between vision testing and driving performance differ between younger and older adults. If no significant associations are found between vision testing and crash risk for younger adults this would provide even stronger evidence for the removal of regular vision testing for younger adults. Similarly, investigating the association between vision testing and crash risk for older adults could help determine at what age older adults might require regular vision testing. Future work could also include longitudinal studies.

II. Summary of the Findings of the Vision Testing and Safe Driving Literature Provided by Submitters and the Risks of Eyesight Degradation over Time.

Driving requires a heavy reliance on the visual sensory system. Most individuals around the world are required to meet a certain pre-defined criteria of visual acuity before they can become licensed drivers. In New Zealand this criteria is 0.5 (6/12) on the Snellen scale which is not different from other countries like Australia, United States of America, Canada and the United Kingdom. In addition, New Zealand requires non-commercial drivers to have regular vision tests at every license renewal.

On the basis of the literature provided by the submitters, two main issues will be addressed in this summary. The first issue concerns the effectiveness of vision tests which will be addressed by assessing the evidence about the predictive validity of current vision tests. The second issue concerns whether repeated vision tests are essential for every driver license renewal. The frequency of vision testing for driver licensing vary with some countries requiring regular vision tests (e.g., New South Wales, Spain, Estonia, Italy) and others requiring regular vision tests for older people (e.g., the Netherlands, Greece, British Columbia). There are yet other countries like the U.K, France and Germany that do not require re-assessment of vision after the driver license has been issued for the first time (European Council of Optometry and Optics, 2011).

Vision Tests and Driving Performance

Most vision tests for driver licensure include a test of static visual acuity (under high luminance and contrast conditions) and visual field (Leveccq, Potter & Jamart, 2013; Owsley & McGwin, 2010). Thus typical vision tests at driver licensing agents do not account for other important aspects of vision such as contrast sensitivity, visual processing and divided attention. There is a growing body of evidence suggesting the lack of association between static visual acuity and driving performance (Owsley & McGwin, 2010; Young, Flood, Blakeney, & Taylor, 2012). A large scale study by Cross and colleagues (2009) looked into associations between various aspects of vision and motor vehicle collisions (MVC) and found no significant association between visual acuity and MVC involvement, however, a Useful Field of View (UFOV) test which measures visual processing speed and divided visual attention was associated with an increase in MVC involvement. Another large population-based prospective study that examined 1801 drivers found that glare sensitivity, visual field loss and UFOV significantly predicted crash involvement but visual acuity, stereoacuity and contrast sensitivity were not associated with crashes (Rubin et al., 2007). Given that driving is a dynamic task it is not surprising that aspects of vision that test motion perception are more predictive of crashes. Wood (2002) found that a combination of visual tests that measured central motion sensitivity, UFOV, contrast sensitivity and dynamic acuity strongly predicted[1] driving performance on a range of tasks (e.g., manoeuvring, reversing) in a closed-road circuit.

Apart from static visual acuity, New Zealand also requires visual field testing. Drivers require a certain standard of horizontal field of view to be able to see other vehicles and pedestrians that might be in their peripheral vision. The evidence on the effectiveness of visual field testing, however, is inconclusive. The first population based study conducted by Johnson & Keltner (1983) found an association between drivers with binocular visual field loss and involvement in traffic accidents, however this study did not account for driver exposure (km's driven per week or days driven per week). Subsequent studies which have accounted for driver exposure when testing visual field impairment and crash involvement have failed to replicate these findings (Owsley, Ball et al., 1998; Hu, Trumble & Lu, 1997).

Vision Tests and Visual Impairment

Younger people (19-40 years) are less likely to suffer from visual impairments as compared to older adults (American Optometric Association, 2016). There is limited research which has examined the association between visual acuity and driving in younger adults (Hennessy, 1995). In contrast, there is a growing body of research that has examined the association between vision and driving performance in older adults who experience age-related visual impairments. In closed road-circuit settings, older drivers have been shown to perform worse on complex driving tasks than younger adults and this age effect is compounded by conditions that cause visual impairment (Wood, 2002). On road-confirmation for these findings has also been provided by Wood & Mallon (2001). The findings of this study revealed that in an in-traffic driving assessment provided by a driving instructor and a driver-trained occupational therapist, older drivers with visual impairments were rated as unsafe compared to middle aged and younger drivers.

Visual impairment in old age can be brought about by diseases such as cataract, age-related macular degeneration (AMD) and glaucoma. Drivers with cataracts are 2.5 times more likely to be involved in an at-fault MVC, despite the fact that they tend to drive less due to self-restriction (Owsley, Stalvey, Wells, & Sloane, 1999). Early diagnosis and surgical intervention for cataract patients can greatly reduce the risk of being involved in crashes primarily by improving contrast sensitivity rather than visual acuity (Wood & Black, 2016). Thus there is a need to encourage older patients

[1] The model with these factors explained 50% of the variance in driving scores.

to have regular thorough vision exams rather than relying on the very basic visual acuity tests of driver licensing agents (American Optometric Association, 2016).

Research on the effects of age-related Macular Degeneration (AMD) and driving performance has generated mixed results with some studies showing worse performance in AMD drivers compared to controls in simulated and real-world situations and other studies showing lower MVC risk associated with these drivers (Wood & Black, 2016). One explanation which has been put forth is that people who suffer from AMD self-regulate in terms of driving less and exercising more caution on the few occasions that they do drive. Other visual impairments such as glaucoma which targets peripheral visual field loss has been shown to be associated with higher involvement in MVC’s (Huisingh, McGwin, Wood, & Owsley, 2014; Kwon et al., 2016). In one of the websites provided by the submitters it has been stated that people can lose up to 40% of their vision before they realise they are visually impaired (Brake, 2014). More evidence-based research is required to identify the extent of visual field loss caused by glaucoma that is reached before it is noticed and before it manifests in driving errors.

Impaired vision can also be caused in the central visual field. A recent study by Lamble, Summala & Hyvärinen (2002) identified 5 individuals that had initially passed the eye test and then failed it when they were 45 years[2] due to impaired central visual field acuity and compared their driving performance to normal vision drivers. The results revealed that except for slightly slower break reaction times (0.2 seconds) no other differences in performance were observed. The authors concluded ‘visual acuity of 0.5 (The European Union norm) is not a necessary pre-requisite for safe driving, and should not be the absolute exclusion criterion in licensing...' (p.715). The small sample size of this study, however, does warrant caution in interpretation of these results.

Conclusion and Future Recommendations

There is a need to assess vision to ensure a standard acceptable for safe driving. The assessment of vision should be evidence-based so that effective practices are put in place for driver licensure.

The two studies conducted by the NZTA are a step in the right direction. The findings from the two NZTA studies are consistent with previous research which has shown that static visual acuity is not associated with driving performance (Owsley & McGwin, 2010; Young, Flood, Blakeney, & Taylor, 2012). Researchers have thus questioned the reliability of simple visual acuity tests (used in the current driver licensure system) in being able to identify unsafe drivers. It has been suggested that more thorough exams testing an array of visual aspects such as UFOV are required to be able to identify problems in vision that could impact driving (Rubin, 2007). However, thorough vision testing of the general population would be extremely costly and potentially unnecessary. Instead the focus should be on identifying portions of the

[2] In Finland, vision tests are required when the first license is issued and thereafter at 45 years and then every five years from the age of 70.

population who are likely to suffer from vision problems and developing vision testing policies for them.

The literature provided by the submitters highlights the vulnerability of older drivers due to the range of age-related visual impairments they experience. From the literature it is evident that there is a need for regular vision testing for older adults but it is less clear at what critical age threshold regular vision testing should be made compulsory. Until a consensus is reached about what the critical age threshold might be for regular vision testing in older adults, New Zealand could adopt a risk based approach to vision testing such as that implemented in Finland.

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