EXAMINING THE FMCSA VISION STANDARD FOR COMMERCIAL MOTOR VEHICLE (CMV) DRIVERS

PEER REVIEW REPORT SUMMARY

DATE: July 2019

PEER REVIEWERS: Dr. Matthew Rizzo, Dr. Joanne Wood, Ph.D., and Dr. Jeffrey Dawson, Ph.D.

PROJECT SCOPE

This study addressed several questions related to the visual requirements for commercial motor vehicle (CMV) drivers, including:

- Is monocular vision associated with an increased crash risk?
- Do red-green color deficiencies increase crash risk?
- Is visual field loss associated with an increase in crash risk?
- Is visual acuity worse than 20/40 associated with an increase in collision rate?
- What other visual performance measures related to driving should be evaluated, if any?

To address these questions, the research team reviewed road safety records for more than 100,000 CMV drivers, as well as data (from a third-party dataset containing U.S. Department of Transportation (DOT) medical examination records) on drivers' vision-related conditions and impairments. A cohort study design was used, given that the dataset contained pre-existing measurements of potential risk factors from DOT medical examination records. These data were merged with crash records in the Motor Carrier Management Information System (MCMIS). Only those collisions occurring subsequent to the DOT medical examination were used in the analysis.

PEER REVIEW PROCEEDINGS

Two peer review meetings with three experts who have knowledge of the Federal Motor Carrier Safety Administration's (FMCSA's) medical and physical qualifications were conducted. The final selection and invitation of panel members was at the discretion of FMCSA. During the first peer review meeting, study methodology and data collection technique were reviewed. The second peer review meeting reviewed study findings and conclusions. To minimize costs and improve accessibility to possible international experts, tele-conferencing approaches were used in lieu of in-person meetings.

PEER REVIEW TEAM

Across the two reviews, the peer review team focused on soundness of methodology, potential truck safety and policy implications, and overall technical content. Three peer reviewers ultimately provided constructive feedback on the workplan.

- Dr. Matthew Rizzo is a Professor and the Chair of the Department of Neurological Sciences at the University of Nebraska Medical Center (UNMC) and Co-Director of the Nebraska Neuroscience Alliance. Dr. Rizzo received his M.D. from the Johns Hopkins University School of Medicine in Baltimore, MD. He also attended the University of Iowa in Iowa City, IA to complete his residency in neurology and his fellowship in Behavioral Neurology and Cognitive Neuroscience. Prior to joining the UNMC faculty in April 2014, Dr. Rizzo was a Professor of Neurology at the University of Iowa College of Medicine; Vice Chair of Transitional and Clinical Research, Department of Neurology at the University of Iowa College of Medicine, and also the Director of the Aging Brain and Mind Initiative, Office of Provost at the University of Iowa. Currently, Dr. Rizzo manages the care of patients with memory disorders and participates in several studies related to addressing behavioral consequences of aging and neurological disorders. He is well known as a primary organizer of the Driving Assessment Conference, which meets every other year, and for his research program on driving simulation and driving assessment.
- Dr. Joanne Wood, Ph.D., is a Professor of Optometry and Vision Science at the Queensland University of Technology, Australia. Dr. Wood and her team have investigated how vision and vision impairment affect driving performance under closed and open road conditions and have sought to identify which tests best predict driving performance. One particular area of her expertise is focused on older drivers and the difficulties they face when driving. Vision is believed to be essential for safe driving, and hence the deterioration of vision through normal aging and eye disease is likely to be a major contributing factor to the changes in driving performance seen with increasing age.
- Dr. Jeffrey Dawson, Ph.D., is a Professor of Biostatistics and the Associate Dean for Faculty Affairs in the College of Public Health (CPH) at the University of Iowa. Dr. Dawson received his academic degrees from Brigham Young University and Harvard University. He has served as Director of Graduate Studies in Biostatistics, a Faculty Senate member, a member of the Institutional Review Board, and the chair of the CPH Faculty Council. He has collaborated with over 20 departments in the health sciences and is particularly known for his collaborative work in elderly and neurologically impaired drivers, as well as in cardiovascular research. His methodological interests include longitudinal data and clinical trials. His outreach activities include educational, research, and public health efforts in Haiti. He has served as the CPH Associate Dean for Faculty Affairs since 2011.

PEER REVIEW 1 SUMMARY

The University of Alabama at Birmingham (UAB, subcontractor) developed a detailed work plan for FMCSA contract DTMC75-14-D-00011L, “Examining the FMCSA Vision Standard for Commercial Motor Vehicle Drivers,” and submitted the plan to the Virginia Tech Transportation Institute (VTTI) and FMCSA on December 19, 2016. In January 2017, three peer reviewers (listed above) were identified to evaluate the work plan.

The peer review was conducted over Skype on February 22, 2017, beginning at 5:00 p.m. central time to accommodate the time difference in Australia. Initial conversations about the work plan were related to the overall project. Specifically, reviewers wanted clarification on which questions or disorders were specified in the call for proposals (i.e., by FMCSA), and which were added by the UAB and/or VTTI in the proposal submitted to FMCSA. The research team clarified this throughout the review of the work plan. In addition, peer reviewers asked questions related to how this project differed from previous studies evaluating medical and visual risk factors for CMV drivers.

This section summarizes the peer reviewers' comments on the draft workplan.

Project Strengths

- The proposed datasets to be merged, including both CMV medical examinations and MCMIS crash data to address the research questions.
- The creation of a public-use dataset so that other scientists can analyze the data.
- The large number of CMV drivers included in the datasets.
- The proposed approach to match the medical data with the crash data.

Project Weaknesses

- Mileage will not be available for the analysis on a driver-by-driver basis.
- While the analyses will focus on vision and the vision standards currently in place, access to other driver-specific information, which could also impact driving competence (cognition, physical function), will be limited.
- Carrier-level information (e.g., safety management techniques) will be limited, and CMV drivers are known to switch carriers frequently.
- Driver fault will be unknown for many of the crashes.
- The use of DOT-recorded crashes may exclude at least a portion of the less severe crashes.

Peer Review 1 Specific Comments

Three topics were discussed at length:

1. All reviewers had questions with respect to the procedure that the UAB team would use to convert text files to data (e.g., the examiner's notes specify that the driver has or does not have a cataract[s]). It was emphasized that the research team needs a procedure to ensure that every participant case in the dataset is treated in the same manner. Reviewers also emphasized that any individuals who might read the text files should not be aware of the driving or crash history of any of the examinees.
2. With respect to the planned data analysis, reviewers asked the research team to clarify whether rate ratio or Cox proportional hazard would be used. Another question was whether there were surrogate outcomes for time-dependent covariates (e.g., season, weather,

temperature). Another analysis-related question concerned the timeline for analysis and how driver fault would be established.

3. With respect to the literature review, the peer review team asked whether disease diagnosis would be included in the literature search. Discussion centered on which diagnoses should be included. Diabetic retinopathy, macular degeneration, stroke with hemianopia, pituitary tumor, neurovascular, multiple sclerosis, and optic neuritis were mentioned. The research team's proposed literature review is focused on (1) papers evaluating predictors of crash risk among CMV drivers, and (2) papers evaluating predictors of crash risk among non-CMV drivers (most of these are older drivers), who would be more likely to have visual limitations.

Research Team Responses to Peer Reviewer Comments

Response to Topic 1

The research team planned to first identify key words/phrases for conditions, impairments, or situations of interest, and then search for those key words or phrases in the text strings. One of the researchers stated that he has significant experience with such programming, which is often referred to as "natural language processing." He also stated that an a priori list of terms is step one, although this is often an iterative approach wherein the list could be modified as programming ensues.

The need for a quality control check was also identified; researchers would visually verify (eyes on the raw data) that the text files are being interpreted correctly. In other words, if the term "cataract" appears in the text string, the research team will need to confirm that the presence or absence of that condition is being interpreted correctly. It was agreed that the individual reading the text files would be masked to other driver characteristics and programming would be refined as needed.

Response to Topic 2

In the second set of questions related to the planned data analysis, the research team was asked:

1. To clarify whether rate ratios or Cox proportional hazards would be used.
2. Whether there were surrogate outcomes for time-dependent covariates such as weather.
3. To define the timeline for analyses and how driver fault would be established.

The research team responded that there are a number of nuances to the first issue under topic 2, but if the data is available to calculate both a risk and a rate ratio, then it would make sense to run both a risk and rate ratio and a Cox analysis and compare/contrast the results. Each measure would provide unique insight. The final decision as to what analysis methods will be used will be dependent on what information is available in the dataset. (Ultimately Poisson regression was used and rate ratios were calculated.)

With respect to the second issue under topic 2 of covariates to be used in the analysis, there was a discussion of which variables would be considered outcomes, and which would be potential confounders or effect modifiers. One of the researchers stated that how these variables would ultimately be employed in any analysis would depend on the model and the question being asked, but that issues such as weather and road conditions would typically be considered as potential confounders rather than outcomes.

As to the third issue raised under topic 2, there was a discussion based on information obtained at the kickoff meeting. Based on that meeting, it seemed clear that the research team would not have exposure data in the form of how many miles a CMV driver logged in a prospective window of time. Obtaining that data from trucking companies would not be feasible. At most, with respect to exposure, it would be possible to determine the time period (number of days) between the medical examination completion and a crash. In some instances, more than one medical examination will exist for a particular driver. Therefore, a particular crash could be considered both retrospectively and prospectively over time, although our emphasis would primarily be prospective. A member of the research team stated that not knowing the structure of the dataset or the design of the database makes it difficult to make any related decisions at this point in time. We will be analyzing data merged from a third-party provider (medical examination data) and the MCMIS dataset (crash reports) obtained from FMCSA.

Response to Topic 3

Peer reviewers and researchers agreed that including the most common conditions makes sense. Yet there is sometimes a small amount of literature on some of the less common, or even "rare" conditions. If our literature review is intended to inform our analysis of the data, then the relevant question becomes whether a condition is prevalent enough in the database to analyze, and what sort of statistical power would be available to actually look at associations between a condition and crashing. A related issue is attributable risk percent; that is, conditions with a low prevalence but a strong increased risk may be equally or more important than those conditions with a higher prevalence but small relative risk. The research team agreed to expand our literature search to include the less prevalent conditions discussed during the peer review call (i.e., diabetic retinopathy, macular degeneration, stroke with hemianopia, pituitary tumor, neurovascular conditions, multiple sclerosis, and optic neuritis). Related to the issue of determining prevalence, a member of the research team who has conducted commercial driver's license examinations noted that these examinations are completely self-report and only reviewed by the examiner, so it is totally incumbent on the driver to state if they have any of the conditions of interest. It would not be likely that a medical examiner would specifically ask about these conditions unless triggered to do so by the driver, (e.g., in a case where there is a history of eye surgery).

The research team intends to expand the literature search and ask about less common conditions when interviewing experts in order to determine the prevalence of these conditions in the dataset and decide whether there is sufficient power to include them. Our original proposed literature review was focused on (1) papers evaluating predictors of crash risk among CMV drivers, and (2) papers evaluating predictors of crash risk among non-CMV drivers (most of these are older drivers). The research team agreed to develop a list of specific diagnoses that might be of interest.

Peer Review 2 Summary

The peer review team examined the final report and research brief with specific emphasis on the soundness of the methodology, the implications for potential truck safety and policy implications, and overall technical content. The same three peer reviewers (described above for the initial peer review) provided the feedback. This section summarizes the peer reviewers' comments on the final report and research brief.

Project Strengths:

- Cautious, principled review of a broad, shallow database on vision and CMV drivers.
- Large dataset with greater than 100,000 CMV drivers.
- The project involves a very large sample size across a broad range of drivers and thus provides a unique opportunity to explore the relationship between vision measures and crash rates with a high level of statistical power.
- Strategic use of cohort study design. Cohort followed prospectively with subsequent status evaluations to link participant vision profiles with longitudinal driving outcomes.
- The analysis involves prospective crash data that is much more likely to enable the relationship between vision function and crashes to be explored meaningfully.
- The research team are leaders in this field and collectively provide world-class expertise to address the research questions posed by this project.
- The report is well researched in terms of the background literature, the analysis is rigorous, and the resulting report is very well written.
- Eight experts surveyed (visual healthcare, occupational medicine, academics) for their opinions, offering potential to compare with cohort study results.
- Importance of questions being considered.
- Statistical approach appears reasonable overall.
- Overall recommendation (to not make the criteria stricter) appears to be supported by the analysis.

Project Weaknesses:

- Differences between CMV cohort and the non-CMV driver vision impairment made it difficult to study effects of disease.
- Eye disease is not coded regularly in the CMV examination. Concerns on eye disease under-representation, this might reflect in part some process (e.g., in hiring, self-selection) that filters out the afflicted.
- The crash data do not provide information regarding whether the crashes were at-fault or not, thus the drivers involved in the analyses may not necessarily have caused the crashes, hence the link between visual function and crashes is weakened.

- While some of the associations between visual function and crash risk were significant, the effects are small and this needs to be considered when discussing the results.
- Secret "third party" dataset raises concerns on data provenance and quality.
- Not entirely clear what comprises a crash. Just CMV? What about crashes by CMV drivers in their own non-CMV vehicles. Anything on severity?
- Exposure is not coded or factored into data in usual way (person day of travel instead of per mile). The meaning of this is not clear. One day of travel can be very different from another in terms of number of trips, miles, etc.
- Role of confounding medical and functional factors: e.g., OSA, diabetes, back problems not interpretable.
- Unclear whether Poisson regression was justified (e.g., whether there was inflated variance indicating the need for other models, such as zero-inflated models, negative binomial regression, or generalized negative binomial regression).
- Possibly incomplete data on uncorrected and corrected vision (i.e., if uncorrected vision was recorded, are we sure that glasses were not worn by those drivers?).
- Some results may call for additional discussion that did not appear to be present. For example, why would having one eye worse than 20/40 vision have a reduced crash risk compared to both eyes being 20/40 or better?
- It was mentioned in the report that adjustments for multiple variables were made, but it was unclear whether the actual model estimates (e.g., Table 1 of the research brief or Table 3 of the report) were based on crude or adjusted analyses.
- The report refers or alludes to the weak associations and the likely poor sensitivity, specificity, and predictive values of having stricter criteria. It would be helpful to see some actual calculations of the levels of those characteristics, since the recommendation to not make changes is based in part on the premise that those are in unacceptable ranges.
- I realize that the data could be analyzed either via counts per day or via a survival analysis approach, and I am fine with the "count" approach. However, even if the formal statistics are on a scale of counts per day (via Poisson regression), it would be useful to see a Kaplan-Meier plot of time-to-first crash for high- vs. low-risk groups.

General Comments

1. This is a thoroughly researched and well-written report involving rigorous analysis of a very large sample size using prospective data. The research team are world leaders in this field and extremely well placed to undertake this task.
2. There are limitations in the data available for analysis and these need to be highlighted in the final report. These limitations were discussed with the research team who were extremely responsive to feedback.
3. Makes good use of incomplete data.
4. Useful findings.

5. Good to know that monocular vision and color deficiencies are not factors in crash risk.
6. Validation that contrast sensitivity and useful field of view is helpful.
7. Results may be useful to inform CMV vision testing policies and procedures, e.g., dropping red-green color blindness testing, other marginal tests to reduce burden of CMV driver testing.
8. Findings on visual field are weak.
9. Good section on limitations.
10. Overall, this was a clear report, with recommendations that are consistent with the data and the results.

Specific Recommendations for Improvement

1. The report should clearly state that the crash data were not "at fault" and the potential limitations this incurs.
2. Was there any analysis of alternative visual acuity cut-points to determine whether there were any other levels that better differentiated between safe and unsafe drivers in the analysis?
3. There needs to be a clear explanation of how the following visual functions were measured: (1) visual acuity, (2) visual fields (does the horizontal field less than 70 degrees mean out to 70 degrees, i.e., a 140-degree horizontal field), and (3) how monocularity is defined in the standards.
4. It would be useful to include in the discussion some comment regarding why visual field loss in the right eye was more significantly associated with crash risk than in the left.
5. Could the data be broken down into day and night crashes – it would be a very interesting analysis.
6. In final recommendations, consider recommending naturalistic driving data collection.
7. Studies of CMV drivers using electronic medical records? Or the National Patient-Centered Clinical Research Network (PCORnet)?
8. Consider additional approaches to analyses of data, to discuss.
9. The report mentions that there were multiple crashes for some individuals. It would be interesting to know the distribution of these, including the max per driver.
10. Please clarify whether any driver had multiple examination dates.
11. In the third paragraph of the research brief, I think that it would be better to say something like "Further analyses of disease factors was not feasible," rather than "…not warranted." Not warranted makes it sound like the issue is not important, when it may in fact be.
12. In Table 1 of the research brief (and Table 3 of the report), please change one of the strict inequalities for the horizontal field of view, so that a value =70 degrees would be possible. Also, in that same section, it might be clearer to label the last three rows as something like "Neither eye <70 degrees," "One eye <70 degrees," and "Both eyes <70 degrees."

13. A brief summary of the survey portion of the study would be helpful to have in the executive summary.
14. Should state that the crash data were "not at fault" in the abstract.
15. Highlight that looking at different cut-points for the visual standards was not possible with the dataset provided (in the abstract).

Research Team Responses to Peer Reviewer Comments

There was a lengthy discussion of project weaknesses and limitations during the two peer review phone conferences. Specific topics addressed included:

1. **Eye Disease.** There was discussion relative to the discrepancy between the number of individuals with some mention of eye disease in the notes section of the examination, and the prevalence of eye disease in the general population. It was reiterated there were no specific questions in the examination that asked about eye disease explicitly, which does not necessarily mean that a given driver did not have a diagnosed eye disease. An eye disease diagnosis (for example, an early cataract), may or may not have an impact on visual function such as visual acuity. Since visual function standards are the basis of recommendations for or against CMV licensure, asking about eye disease specifically may only be relevant from the perspective of evaluating a driver more frequently. Additional discussion on eye disease is now included in the research brief as well as Section 4 and the discussion and conclusion chapters of the final report.
2. **"At fault" crashes.** There was a discussion relative to whether or not the CMV driver was "at fault" in the crashes analyzed. The MCMIS dataset provides only information that a crash occurred and not whether a particular driver was at fault. The literature on this topic demonstrates clearly that an analysis of "all crashes" weakens any relationships between driver characteristics and crash risk. Thus, the reported analysis would likely reveal stronger relationships between visual function and crash involvement if the CMV driver evaluated was deemed "at fault." Additional discussion on "at fault" analyses relative to all crashes is now provided in the research brief as well as Sections 3 and 4 of the final report.
3. **The relationships between visual function and crash risk were weak.** There was a discussion relative to the statistical significance of risk factors relative to its practical significance. Given the large size of the dataset, very small differences will be statistically significant. Additional discussion is now provided in the executive summary, as well as the results and conclusions chapters of the final report.
4. **Secret "third party" dataset.** The research team clarified that the source of the dataset was to be kept confidential, and that the dataset did not come from a single carrier.
5. **What comprises a crash?** The research team clarified that crashes in the MCMIS dataset are provided from State police accident reports. These are defined as DOT-reportable crashes, which include a tow-away or more severe crash. There are no off-duty crashes of CMV drivers in their personal vehicles in the MCMIS dataset. Injuries and fatalities, however, are recorded (see Appendix B of the final report for the crash data elements).
6. **Exposure is not reported in a typical fashion.** The research team clarified that the number of miles driven by any individual CMV driver per day was not available in the dataset.

Therefore, in order to calculate a ratio, while the norm in the literature may be crashes per mile driven, the only exposure information available for the analysis was the number of days in which an individual driver was licensed for CMV driving during the period in which MCMIS data was also available. This ratio was reported in terms of crashes per day (recognizing of course that a given driver may not be driving 7 days per week).

7. **Lack of confounding factors.** The research team clarified for the peer reviewers that it was not possible to control for potential confounding factors (e.g., diabetes, heart disease, and other medical variables obtained during the examination) given that those variables were not provided in the dataset. This was due to new regulations requiring all datasets to be made publicly available. Given that these variables were not available and not controlled for in the analyses, it is possible that a medical factor other than vision could have played a role in any crash involvement. Additional discussion is now provided several places throughout the final report.
8. **Other potential methods of analysis.** Several questions related to the analyses were addressed by the research team biostatistician. The assumptions were met for Poisson regression (e.g., goodness of fit). There was no indication or poor fit and no dispersion (inflated variance).
9. **Corrected and uncorrected vision.** There was discussion relative to the variables provided for corrected and uncorrected vision. Most drivers had only one measure of visual acuity, so their vision was either corrected or not based on how the driver presented for the examination. It is certainly possible that a driver presented without correction when correction was needed and/or that they may have forgotten to bring their correction with them. It is also possible that younger drivers with uncorrected vision worse than 20/40 could also benefit from seeing an eye care specialist and receiving correction. However, this information was not available in the database.
10. With respect to Table 3, the collision rate for "one eye worse than 20/40" was slightly better than both eyes 20/40 or better (1.55 vs. 1.68 collisions per 100 person years of driving). This relationship was marginal (not statistically significant). The research team confirmed that there was no clinical reason that having poorer vision in one eye would result in a reduced crash risk.
11. Table 1 in the research brief and Table 3 in the final report were based on unadjusted analyses. This is now clarified in the final report.
12. The report refers or alludes to the weak associations and the likely poor sensitivity, specificity, and predictive values of having stricter criteria. The research team discussed the fact that given the weak relationships, the predictive value for any given CMV driver would be very low. In consultation with FMCSA, additional analyses were not conducted given that it would not add any new information to the report.
13. Additional analyses and the inclusion of a Kaplan-Meier plot of time-to-first crash for high vs. low risk groups was also not added to the report based on consultation with FMCSA as stated above in #12.
14. Additional analyses related to the evaluation of different visual acuity cut-points were suggested by the peer reviewers. These analyses were not possible with the dataset provided.

15. There was discussion among the peer reviewers and the research team related to how the visual function measures were obtained. The research team clarified that the visual function measures were not provided by eye care specialists (e.g., ophthalmologists/optometrists), and that there are no prescribed methods for capturing visual acuity. With respect to monocular vision, the data provided was yes or no. No further information was provided on how the examiner defined "monocular" vision, but it can be assumed given the visual acuity results that it was not based on a visual acuity worse than 20/40 in a given eye. The visual function measures provided, and how they were defined, are included in Appendix A of the final report.
16. One reviewer noted that it would be useful to include in the discussion some comment regarding why visual field loss in the right eye was more significantly associated with crash risk than in the left. Given the relatively few number of drivers with visual field values less than 70 degrees in either eye, and even fewer in both eyes, the impact of even one or two crashes can have a relatively large impact on the collision rate and significance values. This is further discussed in the report.
17. Peer reviewers asked if the data could be re-analyzed based on day/night crashes or other conditions at the time of a crash. The research team re-iterated that this information was not included in the MCMIS dataset (see data elements provided in Appendix B of the final report).
18. A peer reviewer asked if other methods of measuring driving could be suggested in the report (for example naturalistic driving instead of crash records). While there are certainly other ways of measuring driving competence (simulation, instrumented cars, naturalistic driving with sophisticated monitoring techniques), this does not seem feasible at this time by the research team.
19. The research team reported that there were multiple examination dates for some of the CMV drivers and that the first examination date was used for everyone to provide the maximum window of exposure. This is now clarified in the final report.
20. A peer reviewer requested: "In the third paragraph of the research brief, I think that it would be better to say something like "Further analyses of disease factors was not feasible," rather than "…not warranted." Not warranted makes it sound like the issue is not important, when it may in fact be." This change was made in the research brief.
21. A peer reviewer requested: "In Table 1 of the research brief (and Table 3 of the Report), please change one of the strict inequalities for the horizontal field of view, so that a value =70 degrees would be possible. Also, in that same section, it might be clearer to label the last three rows as something like "Neither eye <70 degrees," One eye <70 degrees," and "Both eyes <70 degrees." These changes have been made in Table 3, and the research brief.
22. A brief summary of the survey portion of the study is included in the executive summary.
23. The report now states that the crash data were "not at fault."
24. The report now highlights that looking at different cut-points for the visual standards was not possible with the dataset provided.