Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/survophthal

Public health and the eye

A roadmap for interpreting the literature on vision and driving

Cynthia Owsley, MSPH, PhD[a,*], *Joanne M. Wood, PhD*[b], *Gerald McGwin Jr., PhD*[a,c]

[a] *Department of Ophthalmology, School of Medicine, University of Alabama at Birmingham, Alabama, USA*
[b] *School of Optometry and Vision Science and Institute for Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Australia*
[c] *Department of Epidemiology, School of Public Health, University of Alabama at Birmingham, Alabama, USA*

ARTICLE INFO

Article history:
Received 23 May 2014
Received in revised form
26 January 2015
Accepted 29 January 2015
Available online 7 February 2015
Donald Fong and **Johanna Seddon**, Editors

Keywords:
driving
vision
vision impairment
eye disease
research methods

ABSTRACT

Over the past several decades there has been a sharp increase in the number of studies focused on the relationship between vision and driving. The intensified attention to this topic has most likely been stimulated by the lack of an evidence basis for determining vision standards for driving licensure and a poor understanding about how vision impairment impacts driver safety and performance. Clinicians depend on the literature on vision and driving to advise visually impaired patients appropriately about driving fitness. Policy makers also depend on the scientific literature in order to develop guidelines that are evidence-based and are thus fair to persons who are visually impaired. Thus it is important for clinicians and policy makers alike to understand how various study designs and measurement methods should be interpreted so that the conclusions and recommendations they make are not overly broad, too narrowly constrained, or even misguided. We offer a methodological framework to guide interpretations of studies on vision and driving that can also serve as a heuristic for researchers in the area. Here, we discuss research designs and general measurement methods for the study of vision as they relate to driver safety, driver performance, and driver-centered (self-reported) outcomes.

1. Introduction

Just as in a literate society, the ability to read is important for quality of life, the same can be said for driving in a society dependent on the personal vehicle for mobility and transportation. Visual acuity testing is the most common functional method for determining eligibility for licensure world wide, in addition to on-road and knowledge tests. Yet there is little to no evidence that a visual acuity screening test, no matter which pass–fail cut-point is selected, enhances driver safety and performance.[91] The absence of evidence-based vision standards for licensure, together with the negative health consequences of not being a driver,[23,28,33,34,38–40,51,71,86,97] have prompted growing interest in the link between vision and driving by clinicians and researchers alike. For example, the number of literature citations on vision and driving indexed in

* Corresponding author: Cynthia Owsley, MSPH, PhD, Department of Ophthalmology, University of Alabama, 700 S. 18th Street, Suite 609, Birmingham, AL 35294-0009.
E-mail address: owsley@uab.edu (C. Owsley).
0039-6257/$ – see front matter
http://dx.doi.org/10.1016/j.survophthal.2015.01.005

PubMed has about tripled since the 1980s. In spite of the growth in this literature, there are widespread misunderstandings about the inferences that can be properly made from various types of study designs. These misunderstandings impede construction of a convergent evidence base, have the potential for wasting precious research resources, lead to conclusions that are erroneous and clinical recommendations that are potentially questionable, and have slowed our ability to provide coherent guidelines for clinicians and government policies. In an attempt to provide a clear conceptual framework for researchers and clinicians who use this information to counsel patients about driving, we present our perspective, formulated over 25 years of experience in vision and driving research, on how different types of study designs and methodologies can be properly utilized to address specific research questions and hypotheses and properly inform conclusions.

The ability to drive can be measured using several different methods that may not produce consistent findings, as each method is designed to measure a unique aspect of driving or its component skills. As a result, the types of inferences that can be made from each type of method are distinct, although theoretically related, because they all address aspects of driving behavior, albeit from different perspectives. We shall discuss these various constructs, the approaches used to measure them, and inferences that can be made in studies that use them.

2. Safety

Safety in the context of driving is typically defined by motor vehicle collisions (MVCs). The U.S. Department of Transportation's National Highway Traffic Safety Administration characterizes driver safety in this way, as do most other countries.[F] From the standpoint of understanding the impact of vision on driving, MVCs in which the driver is at fault[11,73,88] are of greater interest than those where the driver played no role other than being on the road (e.g., hit from behind when stopped at a red light). Associations between vision impairment in older drivers and MVCs tend to be stronger when at-fault MVCs are the outcome measure compared with when all MVCs are used.[24,73] The vision and driving literature, however, is replete with studies using all MVCs, regardless of fault, as the outcome measure.[11,29,47,89,90,103] This is the preference of many investigators because MVCs are rare events, and thus utilizing all MVCs instead of at-fault MVCs increases the number of outcome events. In our research the proportion of MVCs that are determined to be the fault of the older driver is between 35% and 50%. The increase in statistical power often associated with an increase in the number of outcomes is potentially offset in this context because the effect size is diminished. Objective information on the occurrence of MVCs, including attribution of fault, for an individual driver can be acquired from motor vehicle administrations in the form of accident reports (electronically or on paper), although the availability and reliability of these reports is subject to laws and regulations regarding public access to them.

Information on the occurrence of MVCs can also be obtained by self report (i.e., reported by the driver being studied).[55,69,70,116] This approach is easier and cheaper when compared to acquiring MVC data from a jurisdiction's motor vehicle administration. The convenience of self report, however, may be offset by a number of factors, including the inability to obtain an objective assessment of fault. Even when accident reports are available and obtained, collecting self-reported information is valuable, as several studies have shown that there is a poor association between self-reported collisions and accident reports.[7,9,70,75,108] There are many possible reasons for this lack of agreement, including faulty memory, social desirability, and privacy concerns. Critics of the reliance on police-reported MVCs observe that accident reports do not exist for all MVCs (e.g., those on private property, when the driver and any other involved drivers do not choose to report to police, those in jurisdictions where police do not routinely submit reports).[6,70] Thus, although neither source captures all collisions that a driver incurs, this is not necessarily the primary goal. Rather, if the goal is to obtain an unbiased measure of MVC occurrence, police-reported MVCs are more desirable. Collecting information via both mechanisms is also valuable in that it aids in the conduct of sensitivity analyses—that is, conducting two sets of analyses, one using self-reported, the other using state-recorded, MVCs as the dependent variable. If both sets of analyses yield consistent results, the validity of the findings is enhanced. For a given risk factor (e.g., vision impairment), the association may be different when using self-reported versus police-reported MVCs, as McGwin et al have demonstrated.[75] This discrepancy is partly attributable to the fact that any lack of agreement between self- and police-reported MVCs is associated with the risk factor in question. An example would be if cognitive impairment is associated with MVC occurrence and drivers with cognitive impairment are more (or less) likely to report MVCs accurately. This issue not only has important implications for the internal validity of a single study, but also sheds light on why the results of independent studies on the same topic may yield differing results if the dependent variables are not identical. Thus, researchers and readers need to be aware of differences in MVC variables when designing, conducting, and comparing studies.

In general, cohort-based studies have the ability to estimate a number of measures of disease occurrence, the most common being risks and rates, the latter most frequently expressed as MVCs per miles driven. Research suggests that drivers can validly estimate the miles they drive per year, which is perhaps the most common measure of driving exposure.[13,61,83,D] Unlike the ubiquitous epidemiologic metric of person-years used as a uniform measure of time at risk, person-miles of travel may not be constant. This is because MVC risk varies geographically and chronologically; for example, MVC risk is higher at night. To date, there has been little work on methods to "discount" mileage for differences in the underlying MVC risk. Just as studies using police-recorded and self-reported MVCs can yield differing results, studies estimating risks and rates may reveal different associations, partly attributable to the failure to account for driving exposure. This can occur when one of the groups being compared, despite having a similar MVC risk, drives less and thus will have a higher MVC rate.

This problem can be obviated with the use of a randomized rather than an observational cohort-based study design. The