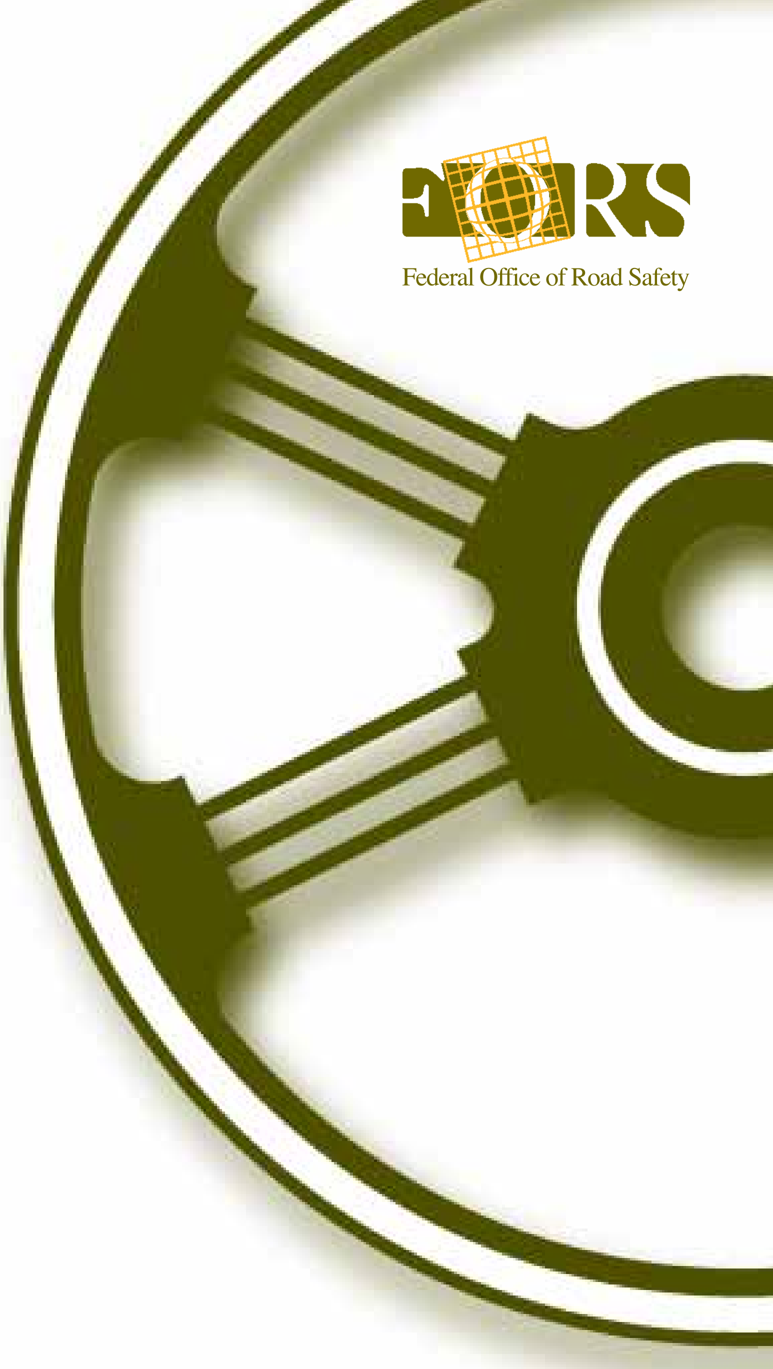
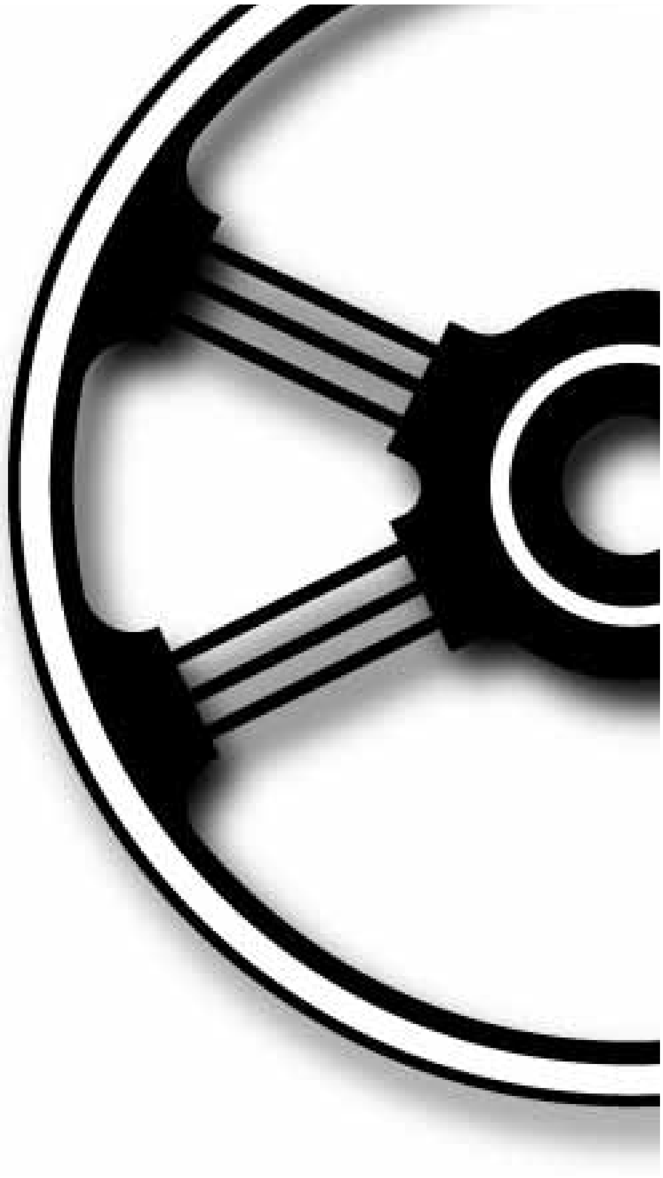


Federal Office of Road Safety

CR177

Review of Literature Relating to Male and Female Drivers

women Behind the Wheel



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Review of Literature Relating to Male and Female Drivers

R Over

women

Behind the Wheel

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Women behind the Wheel: Review of Literature Relating to Male and Female Drivers

Author

R.Over

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GPO Box 594
CANBERRA ACT 2601

Abstract

This report forms part of a series published by the Federal Office of Road Safety (FORS) on women and road safety. It reviews the existing literature on male and female drivers and the conceptual and methodological issues relevant to such analyses.

There are two other reports in this series: a statistical overview of female driver crash involvement and an analysis of attitudes and driving behaviours of young and middle-aged women obtained through a recent survey of women from across Australia.

Keywords

Female Drivers, Male Drivers, Road Safety

Notes

(1) FORS research reports are disseminated in the interests of information exchange.

(2) The views expressed are those of the author(s) and do not necessarily represent those of the Commonwealth Government.

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1. SUMMARY

In contrast to an extended literature comparing older and younger drivers, limited direct attention has been given to the safety of women as drivers relative to men. As well as reviewing material bearing on this latter issue, the commentary is a technical report that identifies conceptual and methodological issues that need to be addressed in comparing men and women as drivers.

Limited direct consideration has been given to the relative safety of men and women as drivers. Although sex differences have sometimes been noted through secondary analysis of measures, studies have often reported data for men and women combined. Where there have been explicit attempts to identify relative risk for men and women, the analyses typically have been no more than descriptive in orientation. Even at a descriptive level there are substantial methodological issues that need to be addressed in determining whether men and women differ in safety as drivers (or if relative driver safety has changed over time). Additional requirements bearing on validity of inference need to be satisfied if data on men and women as drivers are to be interpreted in theoretical or explanatory terms. Research to date on sex differences in driving is deficient on methodological and conceptual grounds.

When comparing men and women it is important to keep in mind that sex as a variable is inevitably confounded with many processes that potentially impact on the outcome of interest. The question then arises as to whether differences obtained in outcome between men and women are more appropriately attributed to the confounds than described as sex differences. As an example, there are driving exposure differences between men and women. Since crash risk varies with exposure, the issue is whether crash differences between men and women reflect anything more than exposure differences. One strategy has been to adjust crash statistics by making allowance for exposure. Hence fatality rates are generally expressed with reference to distances driven. Even exposure based risk estimates can be confounded by a number of factors such as driver age, trauma consequence, driver experience, vehicle characteristics, and driving habits.

2. Introduction

In contrast to an extended literature comparing older and younger drivers, limited direct attention has been given to the safety of women as drivers relative to men. As well as reviewing material bearing on this latter issue, the commentary that follows identifies conceptual and methodological issues that need to be addressed in comparing men and women as drivers. For reasons such as those outlined by Langley (1988) and Loimer and Guarnieri (1996), the term "crash" is used instead of "accident" throughout the commentary. Following Eagly (1987), the term "sex" is used when the contrast is between men and women as biologically specified, and reference will be made to "gender" only when the contrast relates to social role attributes (e. g., sex roles).

Limited direct consideration has been given to the relative safety of men and women as drivers. Although sex differences have sometimes been noted through secondary analysis of measures, studies have often reported data for men and women combined. Where there have been explicit attempts to identify relative risk for men and women, the analyses typically have been no more than descriptive in orientation. Even at a descriptive level there are substantial methodological issues that need to be addressed in determining whether men and women differ in safety as drivers (or if relative driver safety has changed over time). Additional requirements bearing on validity of inference need to be satisfied if data on men and women as drivers are to be interpreted in theoretical or explanatory terms. Research to date on sex differences in driving is deficient on methodological and conceptual grounds. The commentary that follows will address these issues before reviewing studies that have compared men and women as drivers.

3. BACKGROUND

In Western countries there has been a substantial increase over time in travel by car. Car registrations in the United States increased from 2 per 100 persons (2% of the population) in 1915, to 22% in 1929, 41% in 1960, 53% in 1980 (Fife & Whitfield, 1988). Between 1980 and 1990 there was a further increase of 17% in vehicle registrations, while overall miles travelled increased by 41% (and by 51% in urban areas). It is projected up to 2009 there will be an annual increase of 2.5% in miles travelled (Retting et al., 1995). These changes to a substantial degree reflect a greater participation over time in driving by women. By 1990 92% of men and 85% of women of license age in the United States held a driver's license. Up to age 45 most women as well as most men (90% or more) were licensed. However, at subsequent ages men were substantially more likely than women to be licensed. This difference is primarily a secular effect (women from earlier birth cohorts were much less likely than men to ever drive) than an aging effect (although it is the case that women are more likely to cease driving with age on a voluntary basis than men).

The trends noted above have several important implications for assessing sex differences in driving. First, comparison of men and women without taking age into account is misleading, since there currently are substantially more older male than female drivers. Second, among older drivers women are a more select subgroup within their birth cohort than men are (older women drivers are less representative of older women in general than older male drivers are of older men in general). Third, the proportion of women among licensed drivers has increased over time. Fourth, the proportion of women among licensed drivers will continue to increase, and by 2020-2040 it is likely that licensing rates for older women will match those for older men. For these different reasons it is most important that sex differences in driving be analysed with reference to cohort as well as to age of driver.

Most of the sex difference comparisons noted below are based on data for a single time period. Although sex differences have often been reported for different age groups, cross-sectional comparisons do not offer a sound basis for separating secular/cohort effects from aging effects. For example, drivers aged 70 might perform worse than drivers aged 30 at least partly due to skills they developed at the time of learning to drive rather than through the process of aging alone. Developmental psychologists have employed a range of cohort/sequential designs in an attempt to separate aging and cohort effects. These designs generally involve replicating cross-sectional analyses at several points in time. Trends are interpreted by consideration of three sets of data simultaneously. The questions of interest in relation to sex differences in driving outcomes would be:

(a) are cross-sectional gradients (age by sex) for the outcome measure identical at different points in time?

(b) are sex differences on outcome for a specific age the same at different points in time?

(c) for each birth cohort, are changes in outcome over time the same for men and women?

Several investigators have used cohort/sequential designs with the aim of analysing sex differences in driving with reference to cohort as well as age/aging. Unfortunately these studies are flawed in ways that limit interpretation of the results that are reported. Whitfield and Fife (1987) used United States Vital Statistics mortality data to compare motor vehicle fatalities for men and women in 1940, 1950, 1960, 1970 and 1980. However, the data combined drivers with other car occupants. An age-period-cohort analysis of motor vehicle mortality in Taiwan covering the period 1974 to 1992 (Tsauo, Lee, & Wang, 1996) did not distinguish in data analysis drivers from other car occupants or from pedestrians. The sequential analysis by Evans (1993) based on United States fatality rates over the period 1975 to 1990 was limited only to drivers. Evans compared longitudinal trends, cross-sectional gradients, and time-lag comparisons for specific ages in comparing men and women as well as asking "how safe were today's older drivers when they were younger?". However, there is a primary problem of validity of inference since safety was indexed by car-driver fatalities per million of population. Evans did not factor in the substantial change that has occurred over time in the proportion of women as drivers, and in particular the different representation of men and women at different ages among drivers at the several points in time. The analysis of Michigan crash data for the period 1978-1988 by Stamatiadis and Deacon (1995) is discussed later.

Cohort/sequential methodology is the preferred mode of analysis for assessing the relative safety of men and women as drivers, since the data allow comparisons at different points in time, indicate changes over time, and reveal age trends. In terms of overall objectives, Whitfield and Fife (1987), Tsauo, Lee, and Wang (1996), and Evans (1993) were markedly in advance of the methodologies employed by other investigators. However, each analysis was flawed to an extent the data cannot be validly interpreted. Although the same problems do not arise in the case of Stamatiadis and Deacon (1995), the trends they established need to be replicated using other sets of data (e. g., fatality in addition to collision records). Possibly the Australian fatality records that Wylie (1996) used to identify age trends will permit sex differences to be examined through age-period-cohort analysis. Conducting such an analysis will advance knowledge about the relative safety of men and women as drivers.

Several studies have sought to identify changes in the relative risk of men and women as drivers by comparing driving outcomes, such as fatalities, at different points in time. The trends identified by Anderson, Adena, and Montesin (1993) suggested that fatalities per 100,000 population increased for Australian women drivers between 1970 and 1990, but decreased for men over this same period. Age was also considered and it was shown that the increase was only evident for the youngest (<30) and oldest (70+) women drivers. Fatal crash involvement rates in the years 1985, 1988 and 1991 per distance travelled were compared for male and female car drivers, both with and without adjustment for age (Ginpil & Attewell, 1994). There was no significant difference between males and females in the decreasing trends in the rates over time. Adjustment for age had no impact on the male to female relative risk, but detailed analysis with respect to age was limited by the denominator data. However, the analysis of fatal and injury crash statistics for New Zealand between 1981 and 1991 provided by Wylie (1995), as well as Wylie's attempt to compare New Zealand, Australian, and United States statistics did not take into account the sex ratio of drivers at different ages.

Driving skills can be studied directly by assessment of on-road performance. Several recent studies (e. g., Odenheimer et al., 1994) have developed standardised and reliable measures for identifying not only global driving competence but the capacity of the driver to deal with specific driving demands. Such a methodology may provide a sound basis for evaluating whether people with particular problems should continue to be allowed to drive, but for cost and logistic reasons it is unlikely that on-road tests will become a primary methodology for comparing male and female drivers. Further, the external validity of current on-road tests has yet to be demonstrated. Driving simulators assess driving-like skills in an analogue context. Several recent simulator studies have compared men and women. For example, Caird and Hancock (1994) found that women were less accurate in estimating arrival time, and were more conservative in decision making, on a simulation task that involved taking into account an oncoming vehicle when turning left. In further simulation studies Oei and Kerschbaumer (1990) found that men drove more dangerously, and Brien and Hedman (1995) reported that men demonstrated greater control than women in pursuit tracking on a simulated slippery road surface. However, these studies, which have unknown external validity, typically employed very small samples. Although there is scope for comparing men and women in terms of performance on a standardised driving test or on driving simulations, findings will have value only if they translate to driving as it in fact occurs (see Schiff et al., 1994).

The primary strategy for studying sex differences has been to infer driving skill or competence from crash statistics. Analyses have been based self-report measures, insurance claims, police records, or on regional or national statistics reported annually by government agencies. Self-report is now rarely used as primary data because of concerns over accuracy of disclosure (see Elander et al., 1993), and it is generally recognised that insurance records are likely to provide information relating more to the claims process than to road events. For the other measures, problems such as comprehensiveness in coverage, consistency in reporting standards, and bias in assessment need to be kept in mind. Comprehensiveness is more likely to be a problem in studies where the dependent variable is collision resulting in property damage and/or injury, since property damage without injury no longer needs to be reported. Western Australian comparisons of police and hospital records have shown that traffic injuries often are not reported to the police (Rosman, Knuimanand Ryan, 1994; Cercarelli, 1996). Whether police were notified was found to be related to driver ethnicity, sex, and age. A telephone survey in the Netherlands (Harris, 1990) also identified substantial underreporting of traffic injuries. However, it is less likely that crashes causing serious injury or death are seriously underreported, although definitional issues do cause problems (e. g., the period within which death must occur following a collision for the incident to be classified as a traffic fatality).

Sex bias in measures needs to be considered in comparing men and women as drivers. As an example, Koehler and Willis (1994) showed that citations for traffic offences reflected the relative gender of the police and drivers who were involved. Male police issued a higher proportion of their citations to men than female police did, whereas female police were more likely than male police to book women. Koehler and Willis suggested that such bias occurs because gender identity includes norms for positive treatment of other-sex persons. Much of the research on driver safety has been based on driver statistics, often with one driver in a two-vehicle collision being classified by police as at-fault and the other driver as not-at-fault. The possibility that this form of categorisation is also open to sex bias has not been addressed empirically, or even recognised by investigators using induced exposure methodology.

Because of validity problems with other measures, the focus in statistical analysis of driving safety is often on fatalities. However, it needs to be kept in mind that fatality is a rare outcome in driving (fatality rates across all drivers are about 0.5 per 100 million km driven). Further, fatality is a measure potentially biased against specific categories of driver. For example, the elderly more often than the young have types of crashes (side-impact) where the driver is poorly protected through car design and is particularly vulnerable to serious injury (see, for example, McLellan et al., 1996; Dischinger et al., 1993, Viano et al, 1990; Ginpil et al, 1995). Further, elderly persons often are frail and suffer from chronic illness or disability, and hence are more adversely affected (and less likely to recover) than younger people by an accident of the same severity (see Evans, 1988). Van der Sluis et al. (1996), in a comparison of young and elderly drivers admitted to a trauma centre with comparable, severe injuries, found post-injury mortality rates were twice as high for the older drivers.

Evans (1988) used fatality statistics to identify the relative risk of male and female drivers dying as a result of comparable collisions. As outlined by Evans (p. 369):

"The method uses two sets of fatal crashes. The first set consists of crashes involving cars each containing a female driver and a male passenger, at least one of whom was killed. From the numbers of female driver and male passenger fatalities, a female driver to male passenger fatality ratio is calculated. From a second set of crashes involving cars containing male drivers and male passengers, a male driver to male passenger ratio is similarly calculated....Dividing the first fatality ratio by the second gives the probability that a female driver is killed compared to the corresponding probability that a male driver is killed, other factors being equal. This is the fatality risk factor sought".

Evans provided age-related risk functions separately for men and women. Although these values have been used for corrective purposes in comparing fatality rates for younger and older drivers (e. g., Wylie, 1996), such an approach has not been adopted in the study of sex differences.

It is generally recognised that the number of fatalities per se is not a valid index of a group's driving risk. For example, age groups are not evenly represented within the population or among licensed drivers. In addition, women have historically been underrepresented among drivers, and currently the sex ratio of drivers varies substantially with age. Risk for a group has therefore been identified by dividing number of fatalities by a specific index. As argued earlier, it is invalid to specify risk for a group by fatalities per 100,000 persons in the group when groups differ in terms of driver participation. The alternative of expressing risk as fatalities per 100,000 license holders in the group is also problematic. Hakamies-Blomqvist. et al. (1996) showed that the number of driver licenses is not a sound measure of older drivers' exposure. This study compared statistics for Sweden, where most drivers keep their license for life, and Finland, where stringent testing at age 70 leads many elderly to stop driving. For persons over 70 there were no differences in driver fatalities per head of population between Sweden and Finland, but an analysis of the same data showed much higher fatalities per licensed driver in Finland than in Sweden.

Exposure can be indexed not only by reference to driver numbers but distance driven. It has been consistently demonstrated that men on average drive longer distances per annum than women, and that within each sex distance driven is negatively related to age. Absolute mileage levels per driver have increased sharply over time, and the differences related to sex of driver and age of driver are becoming less. A number of analyses have expressed fatalities for a group with reference to the average annual mileage for the group as identified through survey. It has been shown, however, that the manner in which fatality numbers are corrected for exposure influences the extent to which crash outcomes are identified as being related to age or sex of driver. Chipman et al. (1993) demonstrated that using the number of licensed drivers, average miles driven per driver, and average time spent driving as the denominator affected age trends for injury or fatality. Further, any specific correction had different effects on risk rates for urban and rural drivers, as well as for male and female drivers. Evans (1993) similarly showed that the relative corrected fatality rate for male and female drivers differs substantially in accord with whether correction is made according to population size, number of licensed drivers, or average distance driven.

A further problem is that using a gross measure such as miles driven per year disregards the context in which driving occurs. Older drivers on average cover substantially fewer miles per year than younger drivers, but much of their driving may be done in two-way traffic streets with many intersections, as opposed to multi-lane, restricted traffic, divided highways. On this basis, older drivers would have more opportunity for collision per mile driven (see Janke, 1991). However, in other respects (e. g., avoiding peak hour traffic, driving mainly in daylight hours) older drivers adopt driving patterns that reduce opportunity of crash per mile driven. The point remains, however, that risk needs to be assessed with reference to exposure and that use of insensitive or biased measures of exposure can distort age-trends on measures such as traffic fatalities. A similar comment applies in the case of sex differences. This was addressed in the study by the Federal Office of Road Safety which computed fatality rates based on detailed estimates of kilometres travelled obtained through a survey of 18,000 households conducted in 1985 (Anderson et al, 1989). It was reported that the fatality rate varied by time of day with rates increasing from day time through evening to the highest rates at night. Age specific fatality rates for female car drivers were found to be lower than the corresponding rates for male car drivers at all times of day except day time rates among the oldest age groups. Higher fatality rates were also estimated for weekends compared with week days and this differential was highest for the youngest age groups. Women drivers had lower fatality rates than males on both weekdays and weekends in all but the oldest age groups.

A further problem with many analyses is that fatality is used as the unit of measurement without reference to type of collision. Several crash typologies have now been developed. Massie et al. (1993) identified from accident records 18 configurations covering the number of vehicles that were involved, their relative orientation at the time of collision, whether the collision was at an intersection, whether passage was regulated by traffic controls, and whether the vehicles were turning. Retting et al. (1995) identified crash types, of which five accounted for 76% of all incidents and 83% of all injuries to a driver. A frequent finding from crash analyses is that elderly drivers are more likely than young drivers to be involved in (and responsible for) side-impact collisions, while the reverse pattern is found for rear-end crashes and frontal collisions.

The question of whether crashes by men and women differ systematically by type is addressed later. It is important to give consideration to type of crash, since some collisions have much more severe consequences for the driver than other collisions do. Safety devices in automobiles, such as seatbelts and airbags, as well as automobile configuration and design generally, offer maximal protection for frontal or rear-end collision. Side-impact collisions often result in life-threatening and disabling injuries as a result of the limited protection provided to the driver (see Haland et al., 1993). The severe consequences of side-impact collisions relative to other types of crash are well documented (see Fildes, Lane, Lenard, & Vulcan, 1994; McLellan et al., 1996; Dischinger et al., 1993).

Although more refined measures of exposure can be obtained through survey and then allowed for in data analysis, investigators have instead sought a methodology that intrinsically controls for exposure. Induced exposure analyses calculate for drivers at a specific age the relative likelihood of being involved in crashes as the blameworthy rather than as the innocent party. Standardised accident assessment protocols have been developed for assigning crash responsibility between drivers in a two-car collision. Although some level of responsibility generally can be assigned to both drivers, it is conventional to identify one driver as the perpetrator (at-fault) and the other driver as the recipient (not-at-fault). Since the perpetrator and the recipient are driving in the same locale, at the same time of day, and under similar road conditions, they are treated as though matched on exposure characteristics. Specific categories of drivers (e. g., older drivers, women) can be thought of as being at risk if data analysis indicates they are more heavily represented among crash perpetrators than among crash recipients. Stamatiadis and Deacon (1997) have outlined the history of quasi-induced exposure measures of risk, and provided evidence seemingly in support of the methodology

Analyses undertaken within the induced exposure perspective have generally found a U-shaped function between age and crash outcome that is quite similar to the function also identified using gross correction for exposure. The age trend is such that crash risk or outcome is high for teenagers, drops and then remains stable until later middle age, and thereafter increases so that by age 70 risk is cumulatively exceeding even the value found for young, inexperienced drivers (e. g., Perneger & Smith, 1991). In absolute terms elderly drivers have fewer fatal crashes than younger drivers, but their fatality risk is assessed as greater since the elderly have a substantially higher proportion of at-fault fatal crashes than younger drivers. Perneger and Smith (1991) reported an odds ratio of 22.1 for drivers over 80 relative to drivers aged 40-49.

Hakamies-Blomqvist (1994), in an analysis of all fatal crashes in Finland between 1984 and 1990, found sex differences as well as age differences in at-fault to not-at-fault ratios. Across all ages 62% of female drivers killed in a two-vehicle crash were at-fault in contrast to 58% of male drivers. Although it might be concluded from such data that female drivers have a slightly higher fatality risk than male drivers, it is important to note just what such a statement means. Women (and the elderly) are overrepresented among traffic fatalities at least partly because of their higher vulnerability to physical trauma. Further, the types of crashes often experienced by elderly drivers (side-impact through the elderly driver failing to give right-of-way), and claimed also for women drivers by Hakamies-Blomqvist (1994), increase the probability of trauma resulting in fatality. If analysis of driver safety is based on fatalities, the data set will properly represent elderly drivers and female drivers in terms of the rate at which they are killed, but overrepresent these two groups in terms of collision involvement. Many collisions in which an elderly driver or a female driver dies would not have resulted in a fatality if the same incident had involved two young, male drivers. It is doubtful whether the ratio of at-fault fatalities to not-at-fault fatalities for a specific category of driver provides an index of driving risk beyond what is specified operationally.

4. CONFOUNDING FACTORS

When comparing men and women it is important to keep in mind that sex as a variable is inevitably confounded with many processes that potentially impact on the outcome of interest. The question then arises as to whether differences obtained in outcome between men and women are more appropriately attributed to the confounds than described as sex differences. As an example, there are driving exposure differences between men and women. Since crash risk varies with exposure, the issue is whether crash differences between men and women reflect anything more than exposure differences. One strategy in allowing for confounds is to compare the crash records of men and women with comparable exposure patterns. The more common approach has been to adjust crash statistics by making allowance for exposure. Hence fatality rates are generally expressed with reference to distances driven, where the correction is based on average annual distance for men and women as established through periodic survey.

One objective in the present section is to identify confounds that need to be considered in assessing the relative safety of men and women as drivers. For purposes of comprehensiveness, some material already covered will again be cited. A second objective is to comment on strategies by which the extent to which confound variables mediate sex differences in driver safety can be identified. This issue has not been addressed properly in the literature, and methods so far used to correct or allow for confounds have been primitive in the extreme. The commentary in the present section is aimed at providing a basis for assessment of recent analyses that have sought to compare the relative safety of men and women as drivers.

(a) driver age as a confound. As noted earlier, women are as well represented as men among younger drivers, but men substantially outnumber women among older drivers. Comparing men and women as drivers without reference to age is thus invalid. Even when men and women of the same age are contrasted, there are, at least for older drivers, several potential confounds related to cohort representativeness. The older women who drive are probably a select group within their cohort in terms of socioeconomic, educational, and other status measures, some of which may be related to driver safety. A further confound associated with age is that older women are more likely than older men to cease driving voluntarily as they experience disability and health conditions that affect driver safety (see Campbell et al., 1993).

(b) trauma consequence as a confound. As noted above, women tend to experience a higher level of trauma than men in a collision of similar severity. Trauma level depends on a range of factors (including the relative mass of the vehicles that collide and whether the collision is frontal or side-on) on which there may also be sex differences. It may be that women are overrepresented among fatalities relative to collisions primarily because collision characteristics differ between men and women and collisions have different traumatic consequences for men and women.

(d) exposure as a confound. As noted above, mileage driven per year may not validly index crash opportunity. Critical issues may include day vs night driving, urban vs rural, familiar vs non-familiar routes, extent of peak-hour driving, traffic density, and driving conditions (e. g., rain, snow). Massie et al. (1995) provide statistics on licensing rates for men and women by age, as well as for exposure by age and sex. The changes found on these measures between 1983 and 1990 indicate it is unsafe to draw conclusions about sex differences in driving outcomes and associated measures on data from a single time period as though there are durable and constant effects.

It is well documented (see Hakamies-Blomqvist, 1994) that older drivers employ risk-containment strategies by reducing or eliminating driving at night, in peak hour, under adverse road conditions, or on unfamiliar routes. These strategies serve a compensatory function, since they permit the older driver to maintain a higher safety level than would be expected in view of loss in capabilities (e. g., perceptual and cognitive processing) underlying driving. Failure to consider the contexts in which younger and older persons drive offers a misleading basis for interpreting age differences in driver safety. It may similarly be the case that valid study of male-female differences in driver safety will require analysis with reference to exposure specified on a much finer basis than distance driven. Limited attention has been given in the literature to sex differences (by age) in exposure.

(d) driver experience as a confound. Since most people now begin to drive as soon as they are eligible to gain a licence, inexperienced drivers typically are younger drivers. The high crash rates of younger drivers reflect age as well as inexperience, since older drivers (who are similarly inexperienced) have somewhat lower crash rates (Cooper et al., 1995). Although experience (indexed by lifetime miles driven) does not guarantee expertise (Duncan et al., 1991), as a general rule crash rate likelihood per mile diminishes per lifetime mile driven. Surveys have consistently shown that women on average drive fewer miles per year than men of comparable age, although the extent of sex difference on this measure is decreasing over time. The consequence is that women are less likely to be experienced as drivers than men who have held a driver's licence over the same period of time.

(e) vehicle characteristics as a confound. When cars of unequal mass crash into each other, the ratio of driver fatality risk in the lighter car to risk in the heavier car increases as a power function of the ratio of the mass of the heavier car to the mass of the lighter car (Evans & Frick, 1994). As well as occupants in a lighter vehicle being at a substantially higher risk than occupants in a heavier vehicle, the severity of outcome reflects the nature of the crash. Evans and Frick (1993) showed through analysis of United States fatality data for 1975-1989 that when one car crashes head-on into the side of another of equal mass, driver risk fatality in the side-impacted car compared to the frontally-impacted car is 4.5 times for right-side impacts (passenger side in the United States) and 10.1 for left-side impacts. Women would thus be more vulnerable to trauma than men if they tend to drive lighter cars and/or are relatively more likely to be involved in crashes where as a driver they experience side-impact.

Age of vehicle is also potentially a confound, since there have been changes over time in car safety features including seat belt design and airbags. It has been estimated, for example, that installation of airbags has reduced fatality rates by 24% in frontal crashes relative to the same vehicle fitted only with manual belts (Lund & Ferguson, 1995). However, car safety features often are designed with reference to a standard, male driver. Parkin et al. (1995) showed that short persons are required to sit closer to the steering wheel while driving, and hence are prone to head strikes on frontal impacts. Dischinger et al (1993) similarly argued that the higher incidence of lower extremity fractures for female than male drivers is mediated by driver height in conjunction with vehicle design. Safety devices that have beneficial consequences overall may disadvantage specific categories of driver. For example, three-point seatbelt restraints reduce trauma level across all drivers, but increase risk for chest injury when the frail elderly are involved in a collision (Martinez et al. 1994). It would be interesting to identify for different car models and types of crash the extent to which women are likely to experience increased trauma vulnerability relative to men.

(f) driving habits as a confound. The distinction often made between driving errors (slips, lapses, or mistakes due to faulty information processing) and driving violations (risky practices under social and motivational control) provides a useful framework for analysis of sex differences in driver safety. Several studies (e. g., Reason et al., 1990; Blockey & Hartley, 1995) have found that men report substantially higher violation levels than women. In a telephone survey in California in 1989, Hemenway and Solnick (1993) similarly found higher risk taking among men than among women, with men being more likely than women to report having driven after drinking, regularly exceeded the speed limit, and running a red light. In a study of New Zealand adolescents (Harre, Field, & Kirkwood, 1996), males were more likely than females to report having driven after drinking, to speed, and to engage in unsafe driving practices. Elander et al. (1993) have reviewed many other studies that compared men and women on driving style processes and seemingly indicate that males are more likely than females, particularly among younger drivers, to commit driving violations.

A number of analogue studies have shown that men are more likely than women to underestimate risk in driving situations. As an example, Trankle et al. (1990) asked men and women in several age groups (18-21, 35-45, 65-75) to classify 100 slides of traffic situations in terms of risk. An interactive effect of age and sex was found, with young male drivers underestimating risk relative to young female drivers, older male drivers, and older female drivers. In a similar study Mundt, Ross, and Harrington (1992) assessed risk across 100 driving scenarios, half including an intoxicated driver and half a sober driver. Men underestimated the probability of an accident relative to women. Such results are consistent with differences found when men and women report on risk taking when they themselves are driving, and are related to driving record (DeJoy, 1992) .

It has generally been found that women comply more than men with safe driving practices. Kirkham and Landauer (1985) analysed driving violations as detected by police in Western Australia over a two-week period in 1976. Although women then held 40% of licences, had 38% of collisions resulting in casualty, and drove 25% the mileage of men, they accounted for only 9% of all police driving charges, 13% of infringement notices, and 19% of police cautions. Seatbelt usage is higher among women than men (Shinar, 1993). Tipton et al. (1990) assessed seat belt usage 2 months before, 2 months after, and 16 months after legislation requiring seatbelt use.

Although both groups complied when the legislation was introduced, compliance rates were substantially higher for women than for men 16 months later. Australian figures show the same pattern. For example in 1996, 98% of women (aged 15 years and over) report that they always wear seat belts in the front seat (driver or passenger) compared with 93% of men (Mitchell-Taverner et al, 1996). A gender difference (89% females vs 82% males) was also reported for seat belt use in the rear seat. Women also are more law abiding than men after an accident involving a pedestrian. In the 18,000 pedestrian fatalities analysed by Sonick and Hemenway (1995), men outnumbered women among hit-and-run drivers, relative to drivers who remained at the site, by more than 60%.

A further general finding is that among drivers involved in a crash, men are more likely than women to have been drinking (e. g., Soderstrom et al., 1996; Ostrom et al., 1995). In an analysis of South Australian driver fatalities between 1985 and 1992, Holubowycz (1994) found that 50% of men and 72% of women had a zero blood alcohol level. In contrast, 43% of men and 19% of women had a blood alcohol level above .08. There are indications that among drink drivers men have more severe problems with alcohol than women. Across a large sample of drink-driver first offenders, Lapham et al. (1995) reported higher mean scores for men than women on the MAC Scale of the MMPI-2, the Alcohol Abuse Inventory, the Michigan Alcoholism Screening Test, and the Drug Abuse Screening Test. However, with increasing alcohol consumption over time by women relative to men, there are indications that more women than previously are driving after drinking (see Popkin, 1991). Yu et al. (1992) analysed the files of more than 15,000 persons convicted of drink-driving between 1978 and 1988. Over time there was a decrease in young male offenders, but an increase in young female offenders. Further, from the mid-1980s the reoffence (recidivism) rate for women matched that of men.

Crashes caused by elderly drivers often involve information processing errors, with the driver failing to detect hazards (typically a laterally approaching vehicle that has right-of-way) in time to take preventive action. Although in some cases perceptual deficits seem responsible for the collision, often the driver is failing to allocate attentional resources appropriately. On the basis of experimental psychology research there is no reason to believe that men and women of comparable age and health status differ overall in perceptual and attentional processes related to driving. However, sex differences (and age differences) may be found on a situational basis. Since information processing capacity is limited, commitment of attention to one task must be at the expense of commitment of attention to other tasks. Driving demands such as visually-guided steering, hazard detection and avoidance, speed regulation, and manoeuvres relative to other vehicles require on-going information processing and decision making, although attentional load requirements vary substantially across contexts in which driving occurs. Distraction (attending to other input at the expense of information relevant to driving) can induce errors such as failures in detection or judgment. Distraction can potentially come not only from a range of external stimuli within the car (e. g., car radio, conversation with passengers, monitoring the activities of passengers) but in the more general driving environment (e. g., stimuli unrelated to driving requirements that catch the driver's attention).

There has been substantial interest recently in the extent to which the use of mobile telephones while driving entails competition for attentional resources, and leads in particular to inattentive driving and its consequences (e. g., Violanti & Marshall, 1996). Although situational attentional demands from other tasks while driving may vary as a function of driver age and sex, this issue has yet to be addressed systematically.

(g) attitudes and beliefs as confounds.

A number of studies have demonstrated that men are more likely than women to rate themselves as highly skilled drivers. For example, 26% of the men in contrast to 12% of the women tested by Williams, Paek, and Lund (1995) rated themselves as much better than average as a driver. Men were more likely than women to perceive themselves as a safe driver, as avoiding unnecessary risk, as choosing a safe driving speed, following at a safe distance, and approaching intersections carefully. Sex differences in assessment of self as a driver are, however, reduced (McKenna, Stanier, & Lewis, 1991), or disappear entirely (Groeger & Brown, 1989), when allowance is made for experience in driving.

In conjunction with overestimating one's own skill level, drivers often hold age-related and sex-related beliefs about the skill level of others. Nelson, Evelyn, and Taylor (1992), for example, found that younger drivers rated age peers as overly aggressive and discourteous but older drivers as overly cautious, too slow to act, apt to cause accidents, while older drivers rated age-peers as cautious, courteous, and aware of age-related limitations but younger drivers as aggressive and risky. However, the extent to which such stereotypes influence driving in ways that have negative outcomes is not documented.

It is rarely the case that statistical analyses comparing driving outcomes for men and women have made appropriate allowance for confounds. The most typical corrections have involved expressing driver fatalities relative to population levels, numbers of licensed drivers, or distance driven. Whether correction is undertaken, and the nature of the correction, can affect quite markedly the claims that are made about the relative safety of men and women. A recent analysis of deaths from bicycling injuries (Li & Parker, 1996) illustrates this point. Men outnumbered women by 640% in number of fatalities, but the fatality rate was slightly lower for men than for women when the number of fatalities per sex was corrected for exposure (bicycle trips taken).

In correcting for confounds, the objective is to allow for the influence of variables that are related to outcome and correlated with sex. The assumption is that residual differences between men and women on the outcome measure are more appropriately interpreted as sex differences. Confounds are conceptualised as having indirect effect (as mediators) rather than direct effect on outcome. Using bicycling fatalities (Li & Parker, 1996) as the example, the argument is along the lines that:

(a) men experience 6.4 times more fatalities than women,

(b) a reason may be that men have substantially greater exposure (bicycle trips taken) than women,

(c) fatality rates for men and women need to be corrected for trips taken,

(d) the number of fatalities per trip taken is slightly lower for men than women,

(e) on the basis of sex alone, men as bicyclists are no less safe than women as bicyclists.

The problem with the above line of argument is that it implies rather than directly demonstrates that sex differences in exposure is a mediating factor in sex differences in fatalities. More stringent requirements need to be met in order to prove that a variable has acted as a mediator (see Baron & Kenny, 1986, for detailed exposition of this line of argument). It is necessary to show not only that outcome (fatalities) is related to sex and that exposure (trips taken) is related to sex, but that outcome is related to exposure. Although the claims by Li and Parker (1996) imply that undertaking a larger number of bicycle trips increases risk opportunity and hence the likelihood of fatality, they fail to cite any data relevant to this proposition, which is a central aspect of the argument that exposure differences between men and women mediate sex differences in number of fatalities.

The methodological requirements outlined by Baron and Kenny (1986) for demonstrating mediation need to be applied in studies that use crash statistics to compare men and women as drivers (or younger and older drivers). The present approach to correcting for confounds is based on the assumption that the variables being considered as confounds are potential mediators (e. g., as processes that mediate between sex of driver and sex differences in outcome). However, the proper tests for documenting mediation are not applied. Employing the strategies outlined by Baron and Kenny (1986) will allow stringent analysis of whether specific processes or variables mediate sex differences, and hence are confounds.

5. Recent Studies of male and female drivers

As noted earlier, several statistical analyses comparing men and women have been based on inappropriate measures (e. g., drivers were not distinguished from other car occupants or pedestrians) and thus are not open to valid interpretation. Other studies that have sought to compare men and women as drivers have employed small and/or unrepresentative samples and have relied on self-report measures of driving outcome. As an example, Mannering (1993) used hazard function analysis to identify the likelihood that drivers have an accident as a function of the interval since their last accident involvement. Although different trends were claimed for male and female drivers, the sample size was only 46 men and 110 women, all of whom were undergraduate students. Peck (1994) pointed to other substantial methodological problems that limit interpretation of Mannering's data. Other articles (such as Wylie, 1995) that by title have an explicit focus on the relative safety of men and women as drivers provide limited relevant data, and instead mainly offer commentary on issues, perceived problems, and potential countermeasures.

The following sections first describe several recent analyses comparing outcomes for men and women as drivers, and then provide integrative commentary on findings. The analyses will be considered by date of publication.

Perneger and Smith (1991)

The analysis was based on 6506 two-car collisions where fault was attributed to one of the two drivers. Odds ratios were calculated by comparing representation among at-fault relative to not-at-fault drivers. The data set had potential for detailed comparison of men and women (a number of confounds were coded), but the analysis as reported barely touched upon sex differences. Males were found to have an increased likelihood of being the at-fault driver when no allowance was made for blood alcohol level, but the odds ratio for being a male driver was reduced from 1.21 to 0.83 when only cases that did not involve alcohol were considered.

Hakamies-Blomqvist (1994)

The focus of this analysis, which was based on all drivers (N=2298) killed in Finland between 1984 and 1990, was on identification of factors associated with the sex and age of driver. Drink-driving rates were substantially higher for men than women, but the effect interacted with age (the likelihood of having a blood alcohol level of above .05 decreased with age for men, but was relatively stable with age in the case of women). Men were more likely than women (23% of male deaths vs 17% of female deaths) to have been killed in a single vehicle crash. Single vehicle crashes were also found with a much higher frequency for younger than older drivers.

Women involved in a two-vehicle collision were slightly more likely than men (62% vs 58% of such collisions) to have been the driver judged as at-fault. Among drivers at fault, younger drivers were more likely to die following head-on collisions, and older drivers following side-impact collisions. However, sex differences in fatality due to type of collision were strongly evident only beyond age 55, with women having higher involvement than men in side-impact crashes and lower involvement in head-on collisions.

All crashes were classified by standard format, with fault attributed to particular causes. Although a number of the crashes were consequences of violation, a number reflected driving error. The primary fault, irrespective of age, was identified as "general or specific lack of attention". Women at fault were more likely than men at fault to have died as a consequence of a crash resulting from lack of attention than from handling error. Analysis of measures of lifetime driving history showed that in each age range the deceased female drivers overall had less cumulative driving experience than the deceased male drivers. It should be remembered, however, that the analysis did not include a control group. The likelihood is that similar differences would be found generally among male and female drivers in Finland over this period.

Hakamies-Blomqvist (1994) concluded from the analysis that "sex differences were analogous to age differences ... When the sexes differed in accident characteristics, those of female drivers were more like the ones typically found in older drivers (e. g., attentional problems, being at fault, having a smaller frequency of alcohol-related accidents)...elderly-like accident characteristics showed earlier and became more marked in female drivers" (p. 289). However, she noted in commentary a number of difficulties that arise in interpreting the data. Although her analysis provided no basis for knowing whether sex differences in driver safety have changed over time, Hakamies-Blomqvist (1994) offered predictions for the future.

Massie et al. (1995)

Crash involvement rates per vehicle-mile of travel were calculated for men and women by age group from the 1990 Nationwide Personal Transportation Survey, the 1990 Fatal Accident Reporting System, and the 1990 General Estimates System. Although women had a lower overall fatality rate than men (2.2 vs 3.5 fatalities per 100 million miles), "the differential risk of fatal involvement between male and female drivers is strongly age dependent. Between age 16 and 39, men had from 1.6 to 2.5 times the risk of women in the same age group. Between age 40 and 59, men had just 1.2 to 1.3 times the risk of women the same age. At age 60 and over there was essentially no difference in the rates for men and women" (p. 76). However, for non-fatal injury (identified through police reports making up the General Estimates System), women had a higher rate than men (2.3 vs 1.8 involvements per million miles driven). Sex differences across age also differed from the pattern found for fatalities. For injuries "rates for teenagers are about the same for male and female drivers; the male rate is higher in the 20-24 group; and women have the higher rate in each female age group 25 and over. At age 25 and older, the injury involvement rate in each female age group is 1.2 to 1.8 times the corresponding male rate" (p. 76). Analysis of injury rates separately for day and night indicated that "during the day the rate for women was 1.2 times that for men, and at night the men's rate was 1.2 times the women's rate" (p. 82).

Across the United States there was a decrease in fatal accidents from 3.8 to 3.0 per 100 million miles travelled from 1983 to 1990. Although fatality rate by age is reported for these two years (in Fig. 14), sex by age values are not given. However, Massie et al. noted (p. 84) that fatal involvement rate declined by 22% for women and 17% for men over the seven-year interval.

Stamatiadis and Deacon (1995)

This analysis employed an age-cohort-period design and was based on two-vehicle crash records for Michigan between 1978 and 1988. Only non-freeway crashes identifying a driver at fault were used. Driving safety measures such as the relative accident involvement ratio (RAIR, the likelihood of being at-fault divided by the likelihood of being not-at-fault) were examined as a function of driver age, driver sex, accident location (intersection or non-intersection), and light conditions (day vs night). Data analysis yielded cross-sectional gradients (covering ages from 16 to 80+) of RAIRs in 1978, 1983, and 1988 separately for men and women. In addition, time-lag comparisons (e. g., 30 year-old drivers in 1978 vs 30 year-old drivers in 1983 vs 30 year-old drivers in 1988) were reported.

RAIRs followed a U-shaped age function for men and women in 1978, 1983, and 1988. Women overall had a lower RAIR than men, but "the gender effect is complex and intimately related to driver age. For the best drivers, those of middle age, gender has little influence on accident propensity. The relative advantage of female drivers reverses between younger and older drivers" (p. 449). In considering why younger women had lower RAIRs than younger men but older women had higher RAIRs than older men, Stamatiadis and Deacon (1995) suggested that younger women are advantaged by attitudinal factors and when and where they drive, while in older age men are advantaged through more extensive driving experience. Among older drivers, but not among younger drivers, sex differences in RAIRs were greater at intersections than at nonintersections.

Wylie (1995)

The article is primarily a commentary, and it provides limited data. Fatalities in New Zealand annually from 1981 to 1991 are reported separately for women under 25, men under 25, women over 25, and men over 25. Values are expressed per 100,000 population, and not with reference to licensed drivers. Fatality rates increased from 1989 to 1991 for younger women, but decreased for other groups. A number of possible reasons for this trend (including changes in exposure) are discussed, but data cited in support of the claims are at best suggestive.

Richardson et al. (1996)

The analysis is based on crash statistics (police reports) for Hawaii for 1991-1992. Driver responsibility was taken into account in classifying crashes by type. The main objective was to identify age and sex as a function of crash type (headoned, headoner, broadsided, broadsider, rearended, rearender, sideswiped, sideswiper, roller). Since data are not reported comprehensively, it is difficult to gain a clear understanding of findings. The limited commentary Richardson et al. provide on sex differences indicated that, "Most of the main effects of driver sex on crash type are not significant. Males are somewhat less likely than females to be broadsiders (17% less) or to be rearended (14% less), and somewhat more likely to be rearenders (18% more)...A small number of age and sex interactions with crash type are significant. Notable among them are that older females are 60% more frequently involved in headoners than older males, and older males are 22% more often involved in rearendeds. Senior females are 26% more frequently involved in sideswipers than senior males" (p. 114).

Stamatiadis (1996)

This analysis, which was based on all multi-vehicle crashes in Kentucky reported to the police in 1990-1992, uses the data set employed by Stamatiadis and Deacon (1997). Induced exposure methodology was employed, with Relative Accident Involvement Ratio (RAIR) being expressed for age groups and driver sex as the number of collisions with the driver at fault divided by the number of collision with the driver not at fault. Although the driver at fault was identified on the basis of "citations received and contributing human errors coded in the accident database" (p. 10), the validity and reliability of the classification is not uncertain. Across all age groups the RAIR was 1.07 for men and 0.91 for women. In these terms men were overall more likely than women to be at fault in a multivehicle collision. RAIR varied with age (with younger and older drivers having higher RAIRs than drivers 35-65), and there was an interactive effect of sex and age (beyond 55 RAIRs were higher for women than men).

Data across sex and age of driver were analysed by hour of occurrence (nonrush day vs rush vs nonrush night), location (rural vs urban, intersection vs nonintersection), type of collision (head-on, rightangle, rear end, angle turning, head-on left turn), and driver violation (speeding, failure to yield right of way, following too closely, improper lane use, improper turn, alcohol, inattention). Trends noted by Stamatiadis include: "for female elderly drivers a significant decline is noted in exposure during the rush periods" (p. 11), the sex difference in collisions for younger drivers came about through a higher crash rate for men than women at night (values were similar in rush and non-rush day driving), location differences between older men and women were consistent with elderly women undertaking most of their driving in urban areas (short-distance-and-time-trips), and there was no overall difference between men and women in the likelihood of the collision being at an intersection Older drivers, men and women, were more likely than younger drivers to experience accidents at an intersection.

In terms of type of accident, there were systematic age trends and, in some cases, age by sex of driver interactions. A focus on sex differences alone indicates that among drivers classified as being at fault, men were more likely than women to have experienced a frontal head-on collision or a rear-end collision, whereas women were more likely than men to have experienced a side-impact collision (head-on left turn, right angle, or angle turning). The most frequent violations and errors committed by the at-fault driver were (in turn) inattention, failure to yield right of way, improper turn, following too closely, speeding, alcohol, and improper lane use. There were age differences, and a sex by age interaction, for some of these measures. The primary sex differences related to a higher likelihood that more male than female drivers were speeding or were intoxicated, and a higher likelihood that more female than male drivers failed to yield right-of-way.

In interpreting the above findings, Stamatiadis focussed on sex by age interactions. He concluded: "elderly female drivers have higher accident rates than elderly males, although younger drivers do not show gender differences in gender patterns", but suggested that "these differences between genders may disappear in the future as current younger cohorts move into retirement. This postulation is based on the fact that younger females today demonstrate driving experiences that are identical to males in the same age cohorts" (p. 21).

Lang, Waller, and Shope (1996)

The analysis was based on police records for 1660 adolescents who had been driving for two years and while in high school had completed self-report measures covering topics such as parental attitudes and control, drug and alcohol use, and peer involvement. The objective in data analysis was to identify for males and females the extent to which the self-report measures taken in high school predicted involvement in a single-vehicle crash or a crash resulting in injury. Different predictors were found for males and females. Single-vehicle crashes by women were predicted by cigarette use, and for men by substance availability, alcohol misuse, and propensity for marijuana use. Injury crashes by women were predicted by race, alcohol misuse, and friends' involvement with alcohol and marijuana, and for men by living circumstance, substance availability, and marijuana use.

6. CONCLUSION

The studies described above do not provide a strong or consistent basis for reaching conclusions about the relative safety of men and women as drivers. Many have relied on police reports of collisions and injury without addressing validity and reliability issues relating to this outcome measure. Crash fatalities are more likely to be comprehensively and consistently documented, and potentially offer a more reliable basis for analysis. Although fatality level is the reference point by which road safety typically is indexed, the validity of studying sex differences in driving through fatality analysis needs to be questioned. Trauma, and hence the likelihood of death, differs as a function of crash type. Further, men and women involved in a collision of the same severity experience different trauma levels. The studies reviewed above suggest that women are more likely than men to suffer side-impact collision, and hence be more vulnerable to trauma and death. If so, there will be inflated representation (relative to driving competence and overall collision rate) of women among driver fatalities.

The studies described above typically made reference to potential confounds, but addressed the issue directly to only a limited degree. There seems general recognition that instead of comparing men and women in general, sex differences need to be examined in the context of driver age. Confounds (variables that potentially mediate driving outcomes) thus need to be identified and evaluated in the context of sex in relation to age. For example, instead of correcting for sex differences in exposure by taking into account average miles driven by men and women, consideration needs to be given to the manner in which exposure differs between men and women as a function of age. Taking age into account in conjunction with sex complicates the issue of confounds, as is clearly recognised in several of the studies cited above.

Instead of yielding definitive evidence, the studies described above provide no more than suggestive perspectives on the relative safety of men and women as drivers. Since most analyses were limited to a single time period, the extent to which changes are occurring over time is poorly documented. It would seem unwise to conclude solely from data such as that reported by Wylie (1995) that women now are at greater risk as drivers than they were in the past. Allowance must instead be made for concurrent changes in risk opportunity (as Wylie in fact noted). The paucity of longitudinal data on driving (and particularly data established within cohort/sequential designs) is disappointing, since measures at a single point in time can never capture the impact that the increased representation of women among drivers is having. A further advantage of longitudinal data is that continuities and discontinuities over time in driving measures and their correlates can be examined within a lifespan developmental perspective. A longitudinal data base also allows future trends to be predicted. Brude (1995) sought to forecast driving fatalities up to the year 2000 on the basis of a time series analysis covering 1977-1991 statistics, but, in common with other forecasts, his analysis did not include driver age or sex as variables. One difficulty in attempting prediction over an extended period is that substantial changes can be anticipated in car design and in the road and traffic environments, and hence in driving requirements (see, for example, Parkes et al., 1995; Pauzie, 1995). Sex differences in driver safety are particularly difficult to forecast, since factors that potentially mediate sex differences in driver safety (such as the confounds identified above) have changed over time and are unlikely to remain static in the future.

As noted consistently in the literature, the sex ratio of drivers in Western countries will shift cumulatively over the next 20-40 years. In contrast to the past, young women are now almost as likely as young men to gain a driving licence. Licensing soon after eligibility has become almost universal, and as currently younger cohorts age there will be a similar sex ratio among drivers in all age ranges. Over time there has been a cumulative increase not only in motor vehicle registrations, but in distance per year of travel. As well as increasing their representation as drivers, women have more closely come to match men in terms of distance driven per year. Such trends are consistent with substantial changes that have occurred in Western societies in sex roles and stereotypes, family structure, the education and employment of women, income levels, reasons for driving, and the availability of alternative transport. The involvement of women in driving over time is probably paralleled by changes across a range of sociocultural and socioeconomic indicators, and future analyses of sex differences in driving should seek to relate driving outcome trends to changes over time in these indicators.

As Wylie (1995) noted, assessment of the relative safety of men and women as drivers has until recently been neglected. In contrast, there has been extensive investigation of the comparative safety of younger and older drivers. Recent studies concerned explicitly with the issue of sex differences have generally adopted strategies and methodologies that have been employed in research on aging effects. Driving outcomes of interest have been crashes, injuries, and fatalities. Within one tradition the primary data have been negative outcome rates (e. g., crashes expressed per population value, per number of licensed drivers, per mile travelled, etc). Another tradition compares level of involvement in at-fault and not-at-fault collisions. As identified in the earlier commentary, there are substantial methodological issues with each approach and considerable problems in achieving valid interpretation of data.

In the case of sex difference analysis, a primary issue is that there are many variables and processes correlated with sex that potentially mediate differences obtained between men and women on driving measures. These potential mediators (confounds) typically are associated with sex of driver, but not inevitably so. The pattern of association is not fixed, but may change over time. The strategic question is whether to seek to control for confounds (compare only men and women who are equivalent on a measure such as exposure) or instead make allowance in data analysis for the influence of confounds on outcome. Sex differences can be studied within maximalist or minimalist perspectives. Investigators committed to a maximalist approach focus on identifying ways men differ from women, highlight these differences, and treat confounds as though they are a genuine rather than artifactual component of sex differences. In contrast, minimalists seek to “explain away” sex differences by assuming that differences in outcome obtained between men and women will reduce, or even disappear entirely, as allowance in data analysis is increasingly made for confounds. Instead of highlighting differences between men and women, minimalists often will draw attention to the fact that differences between men and women on the outcome measure of interest may be statistically significant, but nevertheless slight in magnitude relative to the extent of variability within each sex in scores on the outcome measure.

In maximalist terms men and women can be expected to differ on driving measures through men and women differing on many variables and processes that influence driving outcomes. In minimalist terms sex differences in outcome reflect not whether drivers are men or women, but a wide range of factors and processes where men and women differ (but the differences are not inevitable or invariable). The extreme minimalist position is that finding differences between men and women on driving outcomes indicates that not all potential confounds have been taken into consideration. It is important to consider the orientation and agenda of investigators, since the study of sex differences even when employing already collected statistics (e. g., fatality records) is not a passive descriptive exercise (see Evans, 1993, for an example of how the same database can be represented in different ways).

Crash statistics provide only indirect information about driver behaviors and events that preceded collision. There is at least suggestive evidence from the studies reviewed above that there are differences in crash type patterns between men and women that are likely consequences of differences in driving style. Sex differences on driving measures seem also to be related to age (which, in terms of current data, is confounded with cohort). However, trends so far identified need to be duplicated across data sets, and assessed over time, before definite claims can be made. It would be premature to plan interventions or countermeasures targeted at women as opposed to men on the basis of existing data.

Many published analyses of driving outcomes reported data without classifying drivers by sex. For example, Fergusson et al. (1996) compared driver crash involvement between states in USA with different licensing practices, while Langley et al. (1996) evaluated the New Zealand graduated licensing system. There is potential for these and similar data sets to be re-analysed to examine differences between men and women. Because of changes over time in the driving population and in driving circumstances, the re-analysis will often be primarily of historic interest. In some cases, however, re-analysis will provide data that can constitute the first part of a longitudinal study. What seems required if trends are to be compared between studies (e. g., between countries) is consensus over methodological issues and at least a certain level of consistency in the way data are analysed and reported.

Many writers have noted the changes that have occurred, and will continue in Western countries until 2020-2040, in not only the age distribution but in the sex ratio of drivers. As advocated throughout this commentary, sex of driver must always be studied in the context of age of driver. A substantive practical issue for professionals concerned with driver safety is whether future study of sex differences should focus on older drivers, rather than across the spectrum or younger drivers alone. The question of interest is whether the sex differences noted earlier for older drivers are replicated to an extent that indicates there is a problem in need of solution. An issue to keep in mind is that as well as being elderly on the basis of age, drivers now 70-80 are from a specific birth cohort (1917-1927). Differences in driving between men and women in this cohort may reflect factors unique to the cohort, and not be evident in the case, for example, of drivers who will be 70-80 twenty years from now (the 1937-1947 birth cohort).

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