



PII: S0001-4575(96)00085-1

MOTOR-VEHICLE CRASH-INJURY RISK FACTORS AMONG AMERICAN INDIANS

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(Received 4 June 1996; in revised form 26 October 1996)

Abstract—The rates of motor-vehicle crash mortality are highest among American Indians and Alaska Natives, compared to other ethnic groups. The aim of this study was to compare risk factors for motor-vehicle crashes and occupant injuries between rural and urban American-Indian (AI) drivers, and between rural AI and non-AI rural drivers. A statewide traffic-accident database was linked to the Indian Health Service patient-registration database to identify crashes that involved American-Indian drivers. Using a cross-sectional design, crashes occurring in a two-county region during 1989 and 1990 were studied. A total of 9329 motor-vehicle crashes involving 16,234 drivers and 6431 passengers were studied. Two percent of drivers were American Indian. Compared to American-Indian drivers in urban crashes, rural crashes involving American-Indian drivers were more likely to result in injury or death (38% vs 64%, $p < 0.001$). The difference in risk for crashes between urban and rural non-AI drivers was not as high (42% vs 33%). Only 44 percent of rural American-Indian motor-vehicle occupants reported wearing seat belts, compared to 70 percent of urban American-Indian occupants ($p < 0.05$). Rates of driver alcohol impairment, as assessed by the police, were much higher among AI drivers and highest among rural AI drivers. We conclude that, compared to non-American-Indian drivers, AI drivers are less likely to be restrained and more likely to be alcohol-impaired at the time of the crash. These risks are higher among rural AI drivers than urban AI drivers. Published by Elsevier Science Ltd

Keywords—Indians—North American, Accidents—traffic, Epidemiologic factors, Rural population

INTRODUCTION

Motor-vehicle injuries are a leading cause of death among American Indians and Alaska Natives (referred to in this paper as American Indians) in the U.S. These deaths occur at two-and-a-half times the rate for all U.S. residents (Indian Health Service, 1994a) and account for 40 percent of all injury deaths among American Indians (Indian Health Service, 1990). Although motor-vehicle (MV) injury death rates among American Indians vary considerably by geographic region and tribe, the overall disparity of death rates between whites and American Indians is well recognized (Baker et al., 1992). In some areas of the U.S., the age-adjusted motor-vehicle-injury mortality rate among American Indians is five times

higher than for the entire U.S. population (Indian Health Service, 1994b). For this reason, the reduction of motor-vehicle fatalities is targeted as a special objective (Objective 4.1a and 9.3d) for American Indians in the Healthy People 2000 objectives (Public Health Service, 1990).

There is little published information regarding factors that explain the higher risk of motor-vehicle-injury mortality among American Indians compared to other populations. The excess crash-mortality rate among American Indians could be partly attributable to the high proportion of American Indians that live in rural and remote rural locations (Baker et al., 1987). The association of rurality and high crash-injury mortality has been thought to be partly related to greater vehicle crash forces associated with higher vehicle speed on rural, compared to urban, roads. Previous reports have also suggested that rural drivers may be less likely to use restraints and more likely to drive while intoxicated (Ryan et al., 1992; Goldberg

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et al., 1991; Landen and LaFontaine, 1993). The physical environment is markedly different in rural areas. Rural roads are often more challenging to drive, may be poorly lit or marked, and may be more distant from the emergency medical services (Centers for Disease Control and Prevention, 1989). Finally, exposure to driving risk, measured by the number of vehicle miles travelled, may differ between populations.

Few studies have compared crash-injury risk factors between rural American Indians and non-Indians living in the same geographic area. These types of studies have been hampered by the lack of ethnic identifiers in crash-records data. For example, national crash databases, such as the Fatal Accident Reporting System and General Estimates System, do not have any information about the ethnicity of the occupants. We conducted this study to compare known risk factors for motor-vehicle crash injury between American Indian and non-Indian drivers involved in rural and urban crashes occurring in a two-county area of the Pacific Northwest. We also sought to compare risk factors for rural and urban crash injuries involving American-Indian drivers involved in crashes.

METHODS

Site

This study was conducted in a region of two contiguous counties in a State in the Pacific Northwestern United States with a total population of 205,439. The study region includes an Indian reservation and several urbanized areas adjacent to the reservation. An earlier study had determined that the five-year (1986–91) average regional motor-vehicle (MV) mortality rate was more than double the rate for all American Indians in the State (133.7 vs 48 per 100,000) and eight times the rate for the State's entire population (15.3 per 100,000) (Grossman et al., 1994). During the 1990 U.S. Census, 4.4 percent of the region's population identified themselves as American Indian or Alaska Native (US Bureau of the Census, 1990). Approximately 69 percent of American Indians and virtually all rural Indian residents of these two counties resided on the reservation during 1990.

Data sources

The State Patrol Traffic Accident Database includes data from every MV collision reported to law-enforcement agencies in the State that resulted in injury, or property damage in excess of 500 dollars. Each collision file contains information regarding driver(s), vehicle(s) and environmental conditions

that may have contributed to the crash. Crashes reported to this tribal law-enforcement agency are routinely included in the database. However, since the State Patrol Traffic Accident Database does not include a field for race or ethnicity, we conducted record linkages with another database to identify American-Indian drivers. Using a personal-identification code for the driver, all selected crash files were linked to a regional patient-registration database of the Indian Health Service (IHS) to identify American-Indian drivers. This database includes all American Indians registered to receive any type of IHS service (including direct care or third-party contract care) in a three-State area (Washington, Oregon and Idaho). To test the assumption that most American Indians residing in the two counties would be registered with the IHS, registration counts ($n=9346$) were compared with 1990 U.S. Census data ($n=8986$) and found to be highly comparable. Linkage of the traffic-accident database to the IHS registration database was facilitated using a unique driver-license code which consists of both a seven-letter name code and number derived from the date of birth. Although this code is not directly present in the IHS database, it was computed for each person in the IHS database. If a driver subject in the State-Patrol database did not have the driver-license code listed, then we composed the code by transforming the name and date-of-birth data recorded in the crash record.

Subjects

The subjects included all drivers and passengers in MV collisions occurring in a two-county area from 1989–90 recorded in the State-Patrol database. Pedestrians and cyclists were excluded from the analysis. Drivers were classified as American Indian if they linked to the IHS registration database and as 'non-Indian' if they did not link. We could not definitively ascertain the ethnicity of passengers since personal identifiers are not recorded for passengers in the database. Since we considered the driver's ethnicity to be a proxy for the ethnicity of the passengers in the driver's vehicle, 'American Indian passengers' in these analyses are passengers in crashes with American-Indian drivers.

Definitions

Rural crashes are defined by the State Patrol as collisions occurring on a roadway in an area or community of less than 2500 people. Using the KABCO (killed; incapacitating injury; non-incapacitating injury; possible injury; no injury; injury, severity unknown) injury classification system employed in most police reports, we considered a crash injury

present if the officer indicated the presence of either a 'non-disabling' or 'disabling' injury among any of the occupants at the scene. Crashes with 'possible' injuries were not counted as injuries. Drivers were categorized as 'intoxicated' if the police accident report indicated that the driver had been drinking alcohol and was impaired. Drivers were categorized as 'not intoxicated' if, in the judgment of the officer, they either had not been drinking or were drinking but ability was not impaired. The validity of these classifications was recently investigated and found to have a high degree of accuracy (Grossman et al., 1996).

Analysis

Univariate and bivariate analyses were used to compare differences between groups. Chi-square analysis was used to detect statistically-significant differences between groups. Logistic regression was used to estimate the magnitude of crash-injury risk to American-Indian drivers, compared to non-Indians, after controlling for potential confounding factors. The outcome variable was presence of crash injury. The main independent variable used was whether the driver was American Indian. This study was approved by the local tribal council and by the institutional review boards of the Indian Health Service and the University of Washington.

RESULTS

There were 9329 motor-vehicle crashes identified during the two-year period in the study region. Of the 16,234 drivers and 6431 passengers identified from these crashes, 2.3 percent of the drivers were linked to the IHS database and thus were classified as American Indian ($n=375$). Two hundred and ninety-four passengers (4.6%) were occupants of vehicles with American-Indian drivers (Table 1).

Two-thirds of crashes occurring among American-Indian drivers were located in rural sections of the study region. In comparison, 40 percent of crashes among non-Indian drivers were rural. Though crash characteristics and consequences differed between American-Indian and non-Indian

drivers, these differences were magnified in the rural areas. About 38 percent of urban crashes among American-Indian drivers resulted in injury or death, compared to 64 percent of rural crashes among American Indians (Table 2). The risk of injury was also higher among non-Indian drivers in rural crashes compared to urban drivers, although the disparity was not as high.

Differences in rates of seat-belt use and alcohol intoxication may partly explain this pronounced disparity between urban and rural crash injuries. Non-Indian drivers in rural crashes were less likely to report using seat belts compared to those in urban crashes (68% vs 76%, $p<0.001$), but American Indians in rural crashes were far less likely to report using seat belts than those in urban crashes (44% vs 70%, $p<0.001$). The proportion of drivers who were thought to be intoxicated also differed by crash location for both American Indian and other drivers. Non-Indian drivers involved in rural crashes were over two times more likely to be impaired by alcohol intoxication (in the judgment of the law enforcement officer) compared to drivers in urban crashes. Rural Indian drivers involved in crashes were also more likely than urban Indian drivers to be impaired but the magnitude of the impairment rate was much higher among both groups of Indian drivers.

Rural crashes may also be more strongly associated with increased rates of injury mortality because of higher vehicle speeds leading to higher rates of deceleration and crash force among vehicle occupants. Although vehicle speed at the time of the crash is not routinely estimated by law enforcement for most collisions, two potential proxy measurements for the degree of force are the severity of vehicle damage and the posted speed limit. In general, rural crashes were much more likely to be associated with a posted speed limit greater than 45 miles per hour compared with urban crashes. The risk of severe vehicle damage was also higher in rural than urban crashes, but differences appeared to be of similar magnitude for both American Indians and others (Table 2). Several other potential crash risk factors did not differ significantly between rural American Indians and other rural drivers. No differences were detected in the scene lighting, roadway condition or the proportion of crashes that occurred at night. Furthermore, the age and type of vehicle did not differ appreciably between the two rural groups.

Higher rates of restraint misuse or failure (perhaps associated with use of older vehicles) could also contribute to an increased rate of injuries. However, there was no difference in the protective effect of occupant restraints for both rural American Indians and others. Occupants of both rural groups not

Table 1. Subjects involved in crashes, 1989-90

	Crash with non-Indian driver		Crash with American-Indian driver	
	<i>n</i>	%	<i>n</i>	%
Drivers	15859	72	375	56
Passengers	6137	28	294	44
Total	21996	100	669	100

Table 2. Rural-urban differences in crash characteristics for American Indian and non-Indians

Unit of analysis	Non-Indian				American Indian				<i>p</i> *	
	All	Rural	Urban	<i>p</i>	All	Rural	Urban	<i>p</i>		
Crash with injury or death	Crash	36.7	42	33	<0.001	55.1	64	38	<0.001	<0.0001
Adverse weather conditions	Crash	10.3	14	8	<0.001	9.9	9	12	0.41	0.69
Nighttime/no light conditions	Crash	17.7	34	6.9	<0.001	23.5	31	9	<0.001	0.006
Wet/snow/icy road conditions	Crash	16.1	23	12	<0.001	14.9	16	14	0.62	0.55
Posted speed ≥45 mph	Crash	35.9	73	7	<0.001	53.6	73	12	<0.001	<0.001
Restraint use at time of crash	Occupant	72.7	68	76	<0.001	50.8	44	70	<0.001	<0.001
Died or injured	Occupant	15.4	25	10	<0.001	32.1	39	16	<0.001	<0.001
Driver impaired	Driver	8.7	13	6	<0.001	36.7	45	19	<0.001	<0.001
Severe vehicle damage	Driver	47.2	66	33	<0.001	57.2	66	37	<0.001	<0.001
Vehicle is pick-up truck	Driver	28.5	32	27	<0.001	36.0	39	29	0.04	0.002

*Significance of difference between all non-Indian and Indian groups.

wearing restraints had over a two-times higher risk of injury or death compared to those with seat belts (Table 3). There was also a strong association between driver intoxication and the use of restraints in the rural and urban areas combined. Intoxicated drivers were more likely to report not using a seat belt than un intoxicated drivers at the time of the crash. Fifty-seven percent of non-Indian drivers who were intoxicated reportedly did not wear seat belts, compared to 64 percent of Indian drivers who were intoxicated. The proportion of non-intoxicated drivers not wearing belts was much lower, although different between groups (Table 4).

Multivariate logistic regression was used to estimate the magnitude of the risk of driver crash-injury or fatality among American Indians after controlling for other variables in the model. The results of the regression demonstrate that, after simultaneously controlling for other variables, the magnitude of the estimated relative risk for crash injury or fatality was

not significantly higher among Indians than non-Indians (OR: 1.3, 95% CI 0.94–1.9). Of the variables in the model, severe vehicle damage, as a proxy for speed and crash forces, was most strongly associated with injury or fatality (OR = 11.3, 95% CI 9.5–13.5). Each of the other variables also exerted an independent and significant effect on the outcome. These variables include rural crash location (OR = 1.6, 95% CI 1.4–1.9), driver impairment by alcohol (OR = 1.9, 95% C.I. 1.6–2.3), and use of seat belts (OR = 2.9, 95% C.I. 2.5–3.3).

DISCUSSION

Several important factors appear to be related to the increased risk of crash injury among American Indians and other rural residents. These include the lower rate of restraint used by rural motor-vehicle occupants and the increased prevalence of drunk driving by rural drivers. Higher vehicle speeds on

Table 3. Effect of restraint-use on injury outcome for occupants of rural crashes*

	Non-Indian		American Indian		<i>p</i>
	<i>n</i>	Proportion of occupants injured or killed (%)	<i>n</i>	Proportion of occupants injured of killed	
Restraints used	3507	17.8	142	27.5	0.003
No restraint use	1665	46.4	183	54.6	0.03

*Unit of analysis = person.

Table 4. Effect of driver intoxication on use of restraints*

	Non-Indian		American Indian		<i>p</i>
	<i>n</i>	No restraint use (%)	<i>n</i>	No restraint use (%)	
Intoxicated†	707	57	84	64	0.2
Not intoxicated	8329	21	167	30	0.005

*Unit of analysis is driver in rural or urban crash.†Driver with unknown sobriety status excluded.

rural roads, as indicated by the higher posted speed and greater severity of vehicle damage also plays an important role in the severity of injuries.

At least two risk factors, seat-belt non-use and drunk driving, were much more prevalent among rural American Indians than among other rural drivers involved in crashes. However, agent factors such as vehicle speed or age did not appear to differ. Since the protective effect of seat belts was similar, restraint failure (secondary to misuse or age) was also unlikely to be a significant factor. Some physical environmental factors such as weather, lighting and road surface condition also did not differ appreciably between crashes involving American Indians and non-Indians. Interestingly, many risk factors among urban American Indian drivers were much less prevalent and resembled the prevalence of other urban drivers.

Few other studies of risk factors for non-fatal motor-vehicle crashes and occupant injuries among American Indians have been published. Using data from the 1988 Behavioral Risk Factor Surveillance System, Sugarman and colleagues demonstrated that self-reported seat-belt non-use was highly prevalent among a sample of American Indians and varied between 25 percent in the Western states to 64 percent in Plains States (Sugarman et al., 1992). Similar studies in Montana also demonstrated seat-belt non-use rates of greater than 60 percent on several reservation locations in Plains States (Landen and LaFontaine, 1993; Cheadle et al., 1994).

The apparent 'racial' differences in host factors evident in this study are probably unrelated to race and may be partly explained by the differences in the socio-cultural environment. As with the general population, our study does indicate important differences in the driving behaviors of urban and rural American-Indian motor-vehicle occupants (Maio et al., 1992). Reported seat-belt use among the urban American-Indian drivers in the same county was similar to that of other urban drivers and much more prevalent than among rural American Indians. Similarly, alcohol intoxication among urban American-Indian drivers was much less frequent than among rural American-Indian drivers. Clearly, the rural location of the crash is an important effect modifier for these risk factors. Part of the difference in rates of intoxication may be explained by factors associated with rural location (e.g. poverty), since urban/rural differences in risk factors are also observed among other races. However, the larger magnitude of the difference among the urban and rural American-Indian occupants may be related to the unique legal environment of the Indian reservation.

With some exceptions, American-Indian reservations are sovereign nations in which most State laws

and statutes do not apply (Confederated Tribes of the Colville Reservation v. State of Washington., 1992). With few exceptions, traffic laws of the surrounding state cannot be enforced among American-Indian people on the reservation without the consent of the tribe. However, American Indians driving off the reservation are subject to State traffic laws and can be prosecuted for violations. Although the State in which this study occurred did have a mandatory seat-belt law at the time of this study, the reservation did not have such a law. This unique legal circumstance may have contributed to the large urban/rural differential in the reported use of occupant restraints among American Indians in this region. Similarly, differences in liquor laws and laws regarding driving whilst intoxicated may have been associated with these differences. Although 49 of 50 States currently have mandatory seat-belt laws, the proportion of Indian tribes that have comparable tribal laws in effect is far lower. In a survey co-sponsored by the Indian Health Service and the National Highway Traffic Safety Administration, 59 of 153 responding tribes reported that they did not have either a tribal seat-belt law or adopt the State law; only 14 percent had adopted a tribal law regarding the mandatory use of seat belts (Indian Health Service, 1994a). Success with tribal seat-belt laws in reducing motor-vehicle injuries on Indian reservations has been demonstrated elsewhere (Centers for Disease Control and Prevention, 1992). Currently, the Indian Health Service is attempting to garner support for the enactment and enforcement of model tribal laws regarding occupant restraint and driver intoxication (personal communication, Richard J. Smith, III, Injury Prevention Program, Indian Health Service).

Our study had several potential limitations. We were not able to assess additional potential risk factors that may have contributed to the excess injury morbidity and mortality among American Indians and other rural drivers. One of these is the provision of emergency medical services and trauma care to crash victims. Mortality could be higher because of delays in EMS notification, the lack of pre-hospital advanced life-support services, and the greater distance to trauma centers (Rutledge et al., 1994; Brodsky, 1993; Rutledge et al., 1993). Since rural residents living in other rural parts of the region off the reservation appear to have similar access to basic pre-hospital emergency medical services, it is unlikely that this factor contributed significantly to the higher mortality among American Indians.

Another potential limitation is the possible misclassification of some passengers as American Indian. This would only have affected those variables in which passengers were included (e.g. restraint use and

injury). Other driver and crash level variables would not have been included since passenger data are not included. Stratification of restraint use and injury by driver/passenger among American-Indian occupants did not reveal important differences (data not shown). A final potential source of misclassification is the linkage procedure. Because we used a unique identification code, it is highly unlikely that people of other races were classified as American Indian. Furthermore, the numbers of IHS-registered American Indians in the two-county region compares very similarly to Census data and likely reflects the vast majority of American Indians living in the region.

Another potential limitation relates to the use of police data for information related to restraint use and driver intoxication. Much of the seat-belt data is self-reported and there is good evidence that rates of self-reported restraint use are higher compared to objective data obtained from observations of occupants (Robertson, 1992). Despite the possibility that belt-use rates may be overestimated, it is unlikely to differ between American Indians and non-Indians or between rural and urban areas. Finally, a recent analysis of the validity of the classification of driver intoxication in the State-Patrol database revealed an overall sensitivity and specificity of over 90 percent (Grossman et al., 1996).

We conclude that rural American-Indian drivers and passengers in this region are at greater risk of motor-vehicle injury compared to urban American-Indian vehicle occupants in the same region. This increased risk is partly explained by the comparatively lower rates of seat-belt use among occupants and higher rates of alcohol intoxication among the rural, compared to urban, American-Indian drivers. One possible important reason for these urban/rural differences may be the lack of tribal laws regarding occupant restraints. Although some tribes have enacted safety-belt legislation, a very large proportion have not yet done so. Greater efforts should be made by tribal governments to enact and enforce tribal laws regarding mandatory use of occupant restraints in motor vehicles. Greater attention is needed by federal agencies to assist in this process and provide incentives to tribes to reduce motor-vehicle injuries and fatalities.

Acknowledgements—We wish to extend our sincere gratitude toward Davis Washines, Phil Salzberg and Tom Koepsell for their guidance and assistance with this project. We also appreciate the help of John Moffat, Richard Smith, III, and Fred Rivara for their reviews of earlier versions of this paper. Expert technical assistance was provided by Robert Soderberg, Michelle Trudeau and Karen J. Karleski.

This research was supported, in part by grant #R49/CCR002570 from the Centers for Disease Control and Prevention. Dr. Sugarman was with the Indian Health Service at

the time of this study was performed but is no longer affiliated. The opinions expressed do not reflect the views of the Indian Health Service or the U.S. government and solely reflect the author's views.

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