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Differences Between Male and Female Involvement in Motor Vehicle Collisions in Hawaii, 1986-1993

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DIFFERENCES BETWEEN MALE AND FEMALE INVOLVEMENT IN MOTOR VEHICLE COLLISIONS IN HAWAII, 1986-1993

ABSTRACT

The purpose of this study is to examine the experiences of male and female drivers involved in two vehicle collisions in the State of Hawaii, over the period 1986-1993. Using comprehensive police crash data, characteristics of male and female drivers are compared in terms of seat belt use, human factors involved in collisions, risky behaviors (such as speeding and alcohol), and patterns in terms of collision involvement. Using odds ratios, we demonstrate that male drivers are 1.4 times more likely than female drivers to be unbelted, 3.6 times more likely to be involved in alcohol related collisions, two times more likely to be involved in speed related collisions, and 1.3 times more likely to be involved in head-on collisions. In addition to examining the general differences between male and female involvement in collisions, relationship between age, gender, and collision involvement is also examined. A logit model, explaining driver fault as a function of age, gender, and other variables is constructed. A U-shaped distribution between the odds of fault and age categories is found to exist, with young males (15-24 years old) and old females (65+) most likely to be classified at fault in collisions in Hawaii.

It has been established that changes in women's travel behavior have increased both travel by women and their exposure to the risks of collision involvement. As pointed out in the NPTS (National Personal Transportation Survey) Demographic Special Reports (U.S. Department of Transportation, 1995), "women are traveling longer and making more trips—and doing more of that in a car." Moreover, FARS (Fatal Accident Reporting System) data, collected by the U.S. Department of Transportation (1991), has shown, for example, a steady increase in the rate of female involvement in fatal crashes over the period 1975 to 1990, while the fatal crash rate among males over the same period has steadily declined (FARS, 1991). The purpose of this paper is to examine data for one state (Hawaii), over the period 1986-1993, in order to gain a deeper understanding of the relationships between gender and crash involvement. Following some background on collision research in Hawaii and discussion of data and methods used in this study, the results and implications of the analysis will be presented.

BACKGROUND

To many, Hawaii conjures images of swaying palm trees and a tropical paradise. But with a population of more than one million people, and more than six million tourists per year, there are associated problems of urbanization, traffic congestion and motor vehicle collisions. For more than a decade, the University of Hawaii, Department of Urban and Regional Planning has been doing research on traffic collisions—not just because it is a major health risk for many age groups, but also because of special circumstances in Hawaii which enhance collision research. As an island location, away from the U.S.

mainland, it is not possible for commuters or others to simply drive across the borders. Moreover, government is highly centralized in the State of Hawaii. There are only four counties each with its own police department, and one state government which together constitutes the entire state-local sector. Collision data is perhaps the most centralized, the most uniform, and the most complete of any state in the nation. In 1992, the University of Hawaii was selected as a site to develop a CODES (Crash Outcome Data Evaluation System) Cooperative Agreement, with the U.S. Department of Transportation. The CODES Project involved the development of linked database comprised of police crash reports, ambulance run reports, hospital data, and insurance claims (see Kim and Nitz, 1994, for further discussion). In addition, there were numerous analyses which were prepared including a *Report to Congress* (1996) on the effectiveness of seat belts and motorcycle helmets. An augmented CODES database was utilized in conducting the analysis for this study.

Previous research in Hawaii (Kim, et. al. 1994), utilizing loglinear modeling techniques, established a relationship between crash types and injury levels: the most serious injury producing collisions involve head-on and rollover collisions. In another paper using a two stage structural modeling technique, (Kim, et. al, 1995), females were found to be slightly more likely to be involved in head-on collisions while less likely to be involved in rollover collisions. The model showed, that while overall females were more likely than males to be injured than males, the stronger effects related to injury in the model were due to alcohol involvement or not wearing seat belts as opposed to gender.

DATA AND METHODS

The data utilized in this study come from police crash reports. Although there have been concerns expressed about the quality of police data (O'Day, 1993), there is reason to believe that crash data in Hawaii is superior to other states. Police crash reports are required for all collisions involving an injury or $1,000 property damage. Training for police crash reporting is standardized throughout the state. All crash report forms are sent to the state Department of Transportation for entry into a centralized computer system. Tapes were acquired and a comprehensive database was constructed on dedicated Sun workstation equipment housed within the Department of Urban and Regional Planning, at the University of Hawaii. Analysis was performed using the Unix version of SAS.

A database comprised of 121,315 male and 67,986 female drivers involved in two-car collisions in Hawaii over the period 1986-1993 was constructed. In addition to analysis of frequencies, the odds ratios related the police reported frequencies of crash involvement by gender for various variables such as seat belt use, human factors, crash types, and so on were calculated. Odds ratios provide a useful tool by which to compare crash involvement of males and females. Used in this context, they provide a superior measure than standard statistical testing because of the large population sizes (which would make even small differences statistically significant) and because of the ease of interpretation.

In order to examine the interactions between age, gender, and other variables and collision involvement, a logit regression model was constructed. Fault is treated as a binary response term (fault versus not at fault).[1] In this model, the relationship between "fault" and various independent variables is examined more closely. In Hawaii, the determination of fault is made by police officers at the scene of the collision and reported on the crash report. According to the police, the determination of fault is one of the most important tasks that they carry out in collision reporting. Internal validity of the fault designation has been tested by examining vehicle maneuvers and driver actions. More than 90% of those committing the dangerous action just prior to the collision were attributed with fault on the crash form.

RESULTS

Over the period, 1986-1993, there were 67,986 females and 121,315 males involved in two-car collisions in Hawaii. There were 39 females and 94 males who died as a result of injuries suffered in collisions over this period. In addition, 500 females and 756 males received incapacitating injuries and more than 11,000 persons received non-incapacitating injuries over the period. Figure 1, Age Distribution of Drivers Involved in Two Vehicle Collisions By Gender in Hawaii, 1986-1993 shows the age distribution of drivers involved in two car collisions over the eight year period. The two youngest age groups, 15-24 and 25-34 account for more than half of the total number of drivers involved in collisions. It is interesting to note that there are more females involved in collisions in both the youngest age group, 15-24, and in the two oldest age groups, 55-64 and 65+. There are likely to be different reasons explaining this U-shaped distribution in terms of collision involvement. Overall, young drivers (both males and females) have a tendency to be more involved in collisions than older age drivers (Evans, 1991). Since the life expectancy for women is longer than that for men, there are more older women involved in collisions. It is apparent the effects of youth and old age need to be studied more.

Figure 1
Age Distribution of Drivers Involved in Two Vehicle
Collisions By Gender in Hawaii, 1986-93

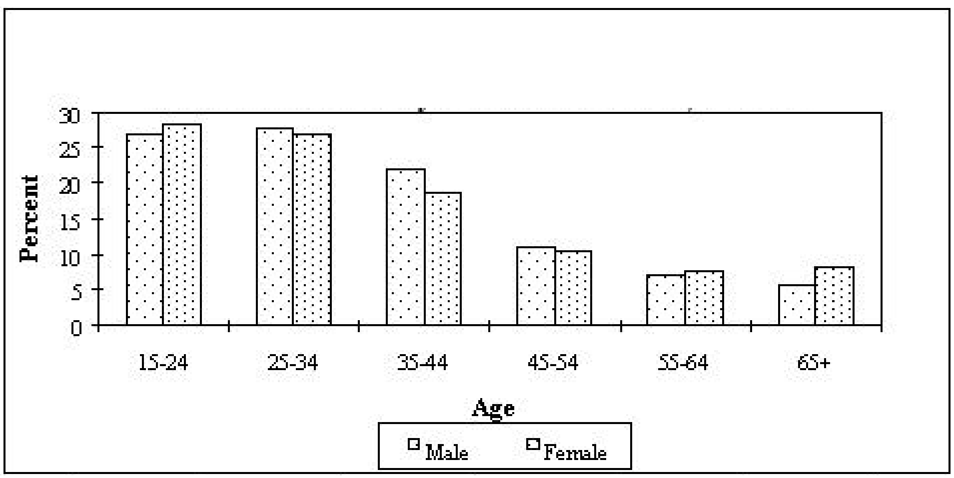


Table 1, Characteristics of Drivers Involved in Two Vehicle Collisions in Hawaii, 1986-93, contains a summary of the key differences between males and females and their pattern of collision involvement. In terms of percentage distributions, a higher proportion of females involved in collisions are: 1) more likely to use their seat belts; 2) have no human factors (e.g., inattention, misjudgment, etc.) involved in collision; 3) have no other factors (e.g., speeding, etc.); 4) more likely to drive automobiles than vans or pickup trucks, 5) more likely to have vehicle maneuvers prior to a collision; 6) less likely to be in the serious collision types (head-ons); 7) slightly more likely to be involved in urban collisions; 8) more likely to be involved in intersection collisions, and more likely to be involved in daytime collisions than their male counterparts. Moreover, while a higher proportion of males involved in collisions (0.1%) are killed compared to females (.07%); females are more likely to be reported injured, at levels of injury from possible, to non-incapacitating, to incapacitating levels. It is interesting to note that there is almost double rate of "possible" injuries among females compared to males.

Table 1
Characteristics of Drivers Involved in Two Vehicle Collisions in Hawaii, 1986-93

	Male		Female		Odds Ratio
	Frequency	Percent	Frequency	Percent	(M/F)
Seatbelt Use					
Yes	108,580	97.51	63,132	98.26	
No	2,770	2.49	1,120	1.74	1.44
Human Factors					
None	59,496	50.74	35,690	53.66	
Inattention	33,791	28.82	18,171	27.32	1.12
Misjudgment	16,888	14.40	9,825	14.77	1.03
Alcohol/Drug	2,272	1.94	383	0.58	3.56
Other Factors					
None	67,535	57.15	40,318	60.48	
Speeding	3,961	3.35	1,138	1.71	2.08
Failure to Yield	17,446	14.76	11,164	16.75	0.93
Disregard Control	3,002	2.54	1,601	2.40	1.12
Injury Severity					
None	78,956	84.42	41,460	75.62	
Possible Injury	7,439	7.95	7,730	14.10	0.51
Nonincapacitating	6,283	6.72	5,099	9.30	0.65
Incapacitating	756	0.81	500	0.91	0.79
Fatal	94	0.10	39	0.07	1.27
Vehicle Type					
Automobile	91,510	75.60	57,805	85.19	
Van	8,333	6.88	3,780	5.57	1.39
Pickup Truck	21,203	17.52	6,272	9.24	2.14
Vehicle Maneuver					
Straight Ahead	64,603	53.55	33,779	49.90	
Changing Lanes/Merging	5,016	4.16	2,553	3.77	1.03
Slowing/Stopping	8,418	6.98	4,903	7.24	0.90
Stop in Traffic	12,767	10.58	8,238	12.17	0.81
Left Turn	14,548	12.06	9,587	14.16	0.79
Crash Types					
Head-on	3,634	3.04	1,667	2.48	1.34
Rear-end	48,830	40.79	26,957	40.08	1.12
Sideswipe	38,192	31.91	20,749	30.85	1.13
Broadside	29,043	24.26	17,890	26.60	
Area					
Urban	104,147	85.85	59,120	86.96	
Rural	17,167	14.15	8,864	13.04	1.10
Location					
Intersection	57,364	47.29	33,243	48.90	0.94
Non-intersection	63,951	52.71	34,743	51.10	
Time					
Daytime	90,077	74.25	55,226	81.23	
Nighttime	31,238	25.75	12,760	18.77	1.50
Total	121,315		67,986		

The last column in Table 1 also contains the raw odds ratios of males to females of various categories. For example, to calculate the odds ratio for belt use by gender, the frequency of unbelted males to belted males over unbelted females to belted females has been tabulated. The resultant odds ratio can be interpreted that among crash involved drivers, males are 1.44 times more likely to be unbelted than their female counterparts. Odds ratios of close to one signify "neutral" gender effects, while those greater than one signify increased male effects, while those smaller than one correspond with increased odds for female effects. The results suggest that strongest gender effects include the following, that compared to females involved in collisions, males are:

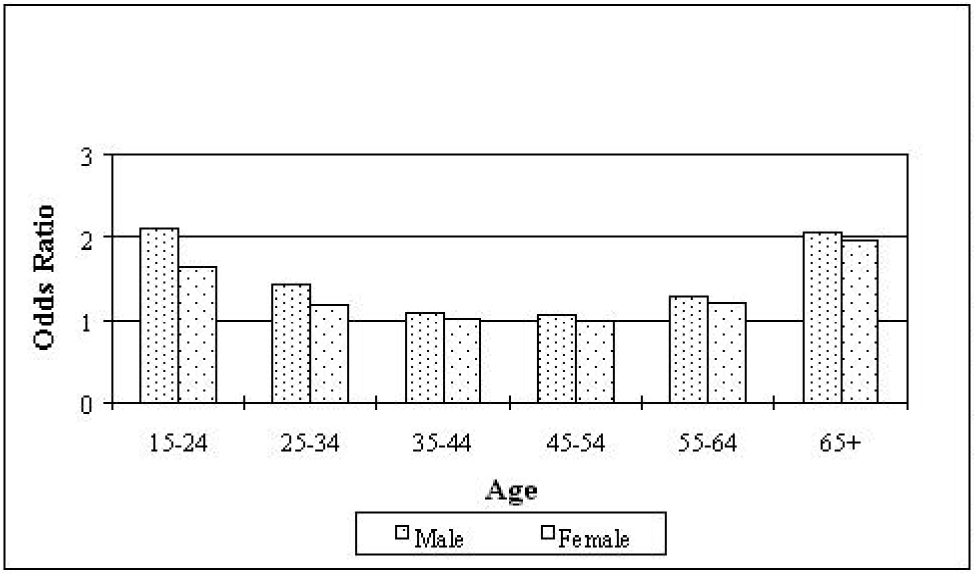
- 3.56 times more likely to be involved in alcohol or drug related crashes;
- 2.08 times more likely to be involved in speed related collisions;
- 1.44 times more likely to be unbelted;
- 1.34 times more likely to be involved in head-on collisions;
- 1.5 times more likely to be involved in night collisions;
- 2.14 times more likely to be driving pickup trucks, and
- 1.27 times more likely to be killed.

These results also show that females are slightly more likely than males to be involved in collisions which involve "failure to yield," as well as being more likely to be involved in collisions which involve left turns, being stopped in traffic, or slowing or stopping. Females are also more likely than males to be involved in collisions in urban areas and at intersections.

In order to test for the relationships between age, gender, and other variables, three different models were run and tested. The variables in addition to fault, which were included in the analysis include: age, area (urban or rural), intersection, and day time versus night time. Based on the first model, variables such as daytime, urban, and intersection, which had weak and insignificant effects, were dropped from the model. Three different forms of the model were developed and tested. The first involved explaining fault as a function of age, gender, and other variables; the second explained fault as function of age, gender, and other variables, but restricted the analysis to include only males who hit females and females who hit males. The reason for the second form, was to better isolate the gender effects. Both models produced similar in terms of the direction and magnitude of effects. The final model includes interaction terms between age and gender and was run on the unrestricted dataset. Stepwise regression and backwards elimination procedures were used to build the final model. The model results are displayed in Table 2, Logit Model Parameter Estimates for Likelihood of Fault. There were significant interactions between gender and age, particularly for the two young age groups (15-24, 25-34). Other terms were eliminated from the model because they were not significant.

The results in terms of the odds ratios of being at fault, by gender and age are summarized in Figure 2, Odds Ratios of Being at Fault By Age and Gender. Female drivers aged 45 to 64 had the lowest likelihood of being at fault and was used as the reference group for calculation of the odds ratios. In general, there is a U-shaped distribution with respect to age: young drivers and old drivers, regardless of gender are likely to be classified at-fault in collisions in Hawaii. Odds ratios of more than one indicate an increased risk of being classified at-fault. This table reveals that males (15-24) and females (65+) are most likely to be classified at-fault. Those with the lowest odds ratios include middle aged males and females (35-44 and 45-54). In fact, the group least likely to be classified at fault is 45-54 year old females. The elevated risks of being classified at fault for both young females (15-24) and older females (65+) are also apparent. But it is important to note that males in both of these groups have higher odds ratios than their female counterparts.

Figure 2
Odds Ratio of Being at Fault By Age and Gender



Logit Model Parameter Estimates for Likelihood of Fault

Variables	Parameter Estimate	Standard Error	Odds Ratio
Intercept	0.318	0.025	
Age Group			
15-24	0.492	0.032	1.635
25-34	0.171	0.031	1.187
35-44	0.0212*	0.028	1.021
45-54	0.000	0.000	1.000
55-64	0.182	0.035	1.200
65+	0.669	0.036	1.951
Gender			
Male	0.058	0.022	1.060
Female	0.000	0.000	1.000
Interaction			
15-24 and Male	0.190	0.035	1.210
25-34 and Male	0.124	0.035	1.132
Likelihood χ^2	1279.048 with 8 d.f.		
"*'not significant at .05.			

DISCUSSION

Similar findings have been found in other states. Stamatiadis (1996), in classifying drivers at fault or not at fault in the State of Kentucky over the period 1990-92, found a similar U-shaped distribution, with younger drivers and older drivers more likely to be classified at fault. However, his study seems to indicate the risk ratios for younger males and females to be quite similar, compared to the differences found in Hawaii. The findings also tend to corroborate our earlier studies (Kim, et. al., 1995), which showed that overall, the gender effects are less pronounced than the age or age-gender effects.

In reviewing the statistical results, certain methodological concerns might be raised. First, there may be concerns about data quality, because, after all, this is based on police-collected data. The data used in this analysis, however, consists of fields which are likely to be among those which are most accurately and reliably reported—gender, age, intersection, lighting, and urban and rural location. A second concern is correlated with the potential problem of bias in reporting fault. It is important to recognize that there is a potential bias—that police may be more inclined to fault one group more than another. In response to this concern, the internal validity of the police crash report was tested. Fault designations were compared to dangerous actions. In more than 90% of the cases, fault was assigned to the vehicle or driver, which committed the dangerous action—passing or overtaking another vehicle, making an illegal turn, rear-ending, sideswiping or “broadsiding” another vehicle. The internal consistency suggests validity in terms of fault classifications. A third concern relates to the selection of appropriate methods for analyzing collision risk. Ideally, a better measure of exposure would be used, such as travel times or travel distances by the various age and gender groups. Unfortunately, such data are not readily available. Moreover, collision research often uses “induced exposure,” similar to this paper. It is important to note, moreover, that the data are population based—that is, they include all persons involved in police-reported collisions over the eight year period. The method of tabulating odds ratios, moreover, is often used in public health research, when exposure to various health risks are not available.

The results of this paper suggest that there is a need for more focused and targeted program of education and enforcement. Because more females than males age 15 to 24 are involved in collisions, even though a smaller proportion of females in this age group are classified at fault, there is need to conduct more research on why younger females are involved in collisions and what can be done to prevent them. Parents and the public may need to be made aware of the increased risks to younger females so that community-based programs of education and traffic safety can be developed. Much of the previous attention is focused on risky behaviors (speeding, failure to yield, alcohol, etc.). On the basis of this analysis, it is apparent that in general, males are more likely than females to be involved in crashes involving these risky behaviors. While more males than females are killed in car crashes, females, overall, have a higher rate of injury.

There would appear to be support for two different approaches for increasing traffic safety for women. First, one could target certain groups, such as young females or older females and investigate further their crash involvement patterns. Of concern is the higher rates of fault among both of these groups as well as the larger demographic trends which suggest both more younger female drivers as well as more older females on the road. Perhaps more disaggregate models might be constructed to investigate the patterns identified in this paper. There may be need to develop separate models for young male or older female drivers, which build on the findings of this study. The second line of inquiry involves recognizing the apparent temporal and spatial patterns of collision involvement. As shown earlier, when compared to men, women tend to be involved in collisions in urban areas, at intersections, during daylight hours. Efforts to improve safety through engineering, enforcement, and targeted to urban areas might also serve to enhance safety overall and to women in particular. The fact that women are more likely than men to be involved in left-turn collisions, suggests that there may be improvements in traffic control that could lead to enhanced safety. Understanding more about the time and spatial relationships of female collision involvement could also lead to improved safety for children and others, as the vehicle occupancy rate tends to be higher for women drivers. Research conducted by Levine, Kim, and Nitz (1995) has shown that zonal characteristics can be correlated with collision risk; in particular, retail trade is strongly correlated with increased collision involvement at the block group level in Hawaii.

CONCLUSIONS

There is need for more state-level analysis of gender differences in traffic safety. The reason is that first, national databases are often confounded by problems of aggregation. The problems with national crash data include different crash thresholds, different definitions, and widely divergent geographies, climates, environmental, and roadway conditions which affect the likelihood of collisions and the subsequent reporting of crash data. State-level data holds the promise of controlling for many of these differences. Also, it is important to realize that many traffic safety programs are likely to be implemented at the state and local level. Therefore it is useful to have state level data, both for problem identification as well as for program design and evaluation. State level collision data could, conceivably, be tied into other databases to develop further insight into the relationships between demographics, licensure, traffic citations, and collisions. There is more need to integrate data at the state and local level.

At the same time, there is also need for comparative studies which look across states in order to determine if there are consistent trends and patterns which require national level attention and program development. The Hawaii data reveals that in terms of both young women drivers and older women drivers, there is need for more research, problem identification, and program design. In all likelihood, the patterns identified in this paper are likely to intensify, over time, as the population continues to age and as more women start to driver earlier and longer.

A contribution of this paper, in terms of methodology involves both its use of odds ratios and the deployment of a logit model to explain fault. At present, with all age groups, males are more likely than females to be classified at fault in collisions. This suggests that women are “better drivers” than men. If male driving was to improve over time, then the difference in the odds of being classified at fault by gender would narrow. Should this occur, then women, in time, would be no better drivers than men.

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NOTES

[1] For purposes of illustration, consider a three variable model which includes fault (F), age (A), and sex (S). The loglinear approach uses an additive model that incorporates main effects and interactions between variables in the form:

$$\ln(m_{ijk}) = u + u_{F(i)} + u_{A(j)} + u_{S(k)} + u_{FA(ij)} + u_{FS(ik)} + u_{AS(jk)}, \quad (1)$$

where m_{ijk} are the expected cell frequencies and the u's are the parameters to be estimated. The grand mean of the cell frequencies is u. Each of the subscripted u parameters represents a deviation from the grand mean due to that effect. For example, $u_{A(j)}$ are the age effects with a separate parameter estimate for each categorized age group (i.e., teenage, young, middle age, seniors). The term, $u_{FA(ij)}$ represents the interaction effects between fault and age.. From the loglinear model (1), using the category not at fault as the reference group, the logit model for fault over no fault is:

$$\begin{aligned} \ln(m_{ijk} / m_{Ojk}) &= [u + u_{F(i)} + u_{A(j)} + u_{S(k)} + u_{FA(ij)} + u_{FS(ik)} + u_{AS(jk)}] \\ &\quad - [u + u_{F(O)} + u_{A(j)} + u_{S(k)} + u_{FA(Oj)} + u_{FS(Ok)} + u_{AS(jk)}] \\ &= [u_{F(i)} - u_{F(O)}] + [u_{FA(ij)} - u_{FA(Oj)}] + [u_{FS(ik)} - u_{FS(Ok)}] \\ &= w_F + w_{A(j)} + w_{S(k)}. \end{aligned} \quad (2)$$

where the w's are parameters to be estimated.