HOW GENDER PREFERENCES FOR VEHICLE SIZE/CLASS INFLUENCE FATALITY OUTCOMES

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ABSTRACT

In recent years, the issue of gender equity in real-world crash protection has been the focus of a great deal of research [1, 2, 3, 4]. Concerns that females may be subject to elevated risks of injury relative to their male counterparts under similar circumstances have prompted a debate over the need for a 50th percentile female dummy.

Early automotive testing concentrated on crash test dummies with 50th percentile male characteristics. By the mid 1990s there was general recognition of a need to expand the family of dummies to address a wider range of the population. Initially, the use of a smaller female dummy was prompted by the introduction of frontal airbags and the need to put design controls in place to address proximity issues to the airbags. However, this was quickly followed by an appreciation of the benefits and the need for the "family of dummies" approach in side impact testing as well as in frontal testing.

More recently, the possibility has been raised that some of the risk disparity between males and females may not be physiological, but may be related to vehicle preferences between males and females [5].

The present study is one in a series of investigations which seek to determine the extent to which injury outcome differences by gender are driven by different male and female preferences for vehicle size and class.

METHODS AND DATA COLLECTION

The current work is based on an analysis of Fatality Analysis Reporting System (FARS) data for calendar years 1993 to 2020. The dataset was restricted to well-defined fatal two-vehicle crashes between 1994 model year and later light duty vehicles (cars, light trucks, and vans).

To be included in the sample, the gender, the age, and the seating position of all occupants involved in the collision had to be reported. This was done to facilitate the definition of injury outcome metrics for the collision as a whole, the vehicle occupied, as well as for the partner vehicle in the collision. A further requirement was that vehicle identification numbers (VINs) for both vehicles had to be reported so that the size and class of each vehicle could be categorized. This, in turn, allowed the analysis to examine driver survival rates as a function of gender and age, in fatal two-vehicle crashes of both similar and different classes of vehicles.

Parallel well-defined single vehicle and two-vehicle datasets with the same restrictions were constructed using the Collision Reporting Sampling System (CRSS). The CRSS single vehicle subset consisted of 34,780 drivers (4,864,877 weighted). The CRSS two-vehicle subset consisted of 183,810 drivers (25,208,458 weighted). The FARS two-vehicle subset consisted of 136,612 drivers.

RESULTS

The representation of females among drivers involved in well-defined single vehicle and two-vehicle collisions in the CRSS dataset as a function of vehicle type/size is depicted in Figure 1. In the case of the larger dataset for two-vehicle collisions, a complimentary analysis was performed to explore vehicle preferences considering driver gender and age. For this expanded analysis, two age groups were considered, drivers under 50 years of age and drivers 50 years of age or older. The results from the expanded analysis are summarized in Table 1.

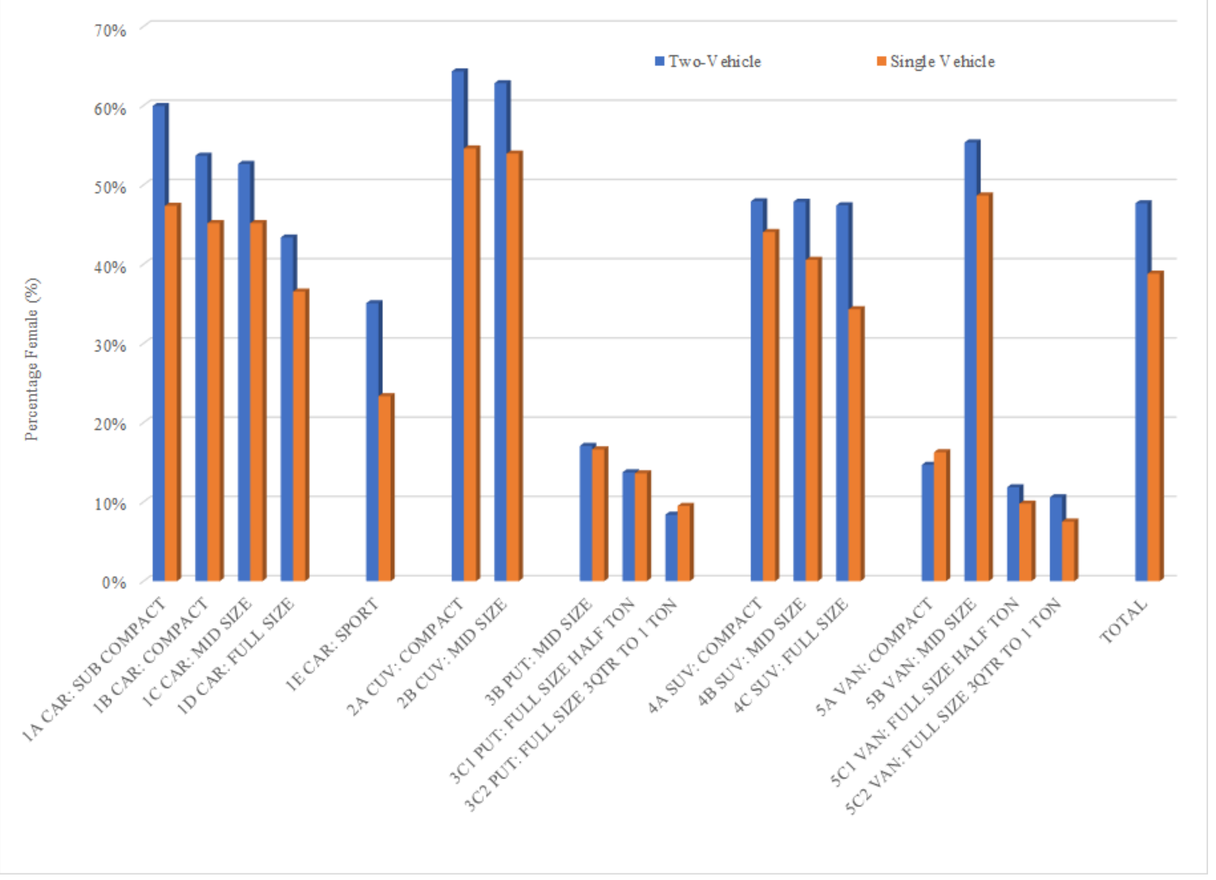

Figure 1. Female Representation Among Drivers as a Function of Vehicle Type/Size Class and Collision Configuration (CRSS).

The female driver representations reflected in Figure 1 highlight the strong preference of females to favor smaller/lighter vehicles. The findings also highlight the extremely low representation of females in the case of pickups (< 15%) and larger vans (<14%). In the case of vans, we can see that the representation of females as drivers is high, but it is highly concentrated in mid-sized vans. When we further consider driver age, we can observe in Table 1 a bias towards sub-compact cars in the case of younger females. On the other hand, older males reflect a bias towards full-size cars. Consequently, any gender-risk analysis must consider these vehicle choice preferences. This necessity can be easily appreciated if we examine the driver survival (rates by gender in pickup-to-car collisions (Figure 2).

From the results presented in Figure 2, we can see the survival rates in these collisions are strongly influenced by vehicle occupied and the age of the occupant. When we control for these factors, there are minimal “gender” influences on the driver survival rates.

Table 1.
Representation of Drivers Collision Exposures by Gender and Age Grouping as a Function of Vehicle Type and Class/Size (CRSS 2017-2020, Two-Vehicle Collisions, All Collision Severities)

WEIGHTED DATA		GENDER/ AGE GROUP				
VEHICLE TYPE	VEHICLE CLASS/SIZE	F, 15 TO 49 YRS	F, 50 TO 120 YRS	M, 15 TO 49 YRS	M, 50 TO 120 YRS	Grand Total
CAR	CAR: SUB COMPACT	44.5%	15.4%	29.6%	10.5%	100.0%
	CAR: COMPACT	41.3%	12.4%	36.2%	10.1%	100.0%
	CAR: MID SIZE	38.3%	14.3%	35.0%	12.3%	100.0%
	CAR: FULL SIZE	28.3%	15.0%	39.1%	17.6%	100.0%
	CAR: SPORT	26.5%	8.4%	51.7%	13.3%	100.0%
CAR TOTAL		**37.9%**	**13.5%**	**36.6%**	**12.1%**	**100.0%**
CUV	CUV: COMPACT	40.7%	23.6%	21.8%	13.8%	100.0%
	CUV: MID SIZE	40.6%	22.2%	21.8%	15.4%	100.0%
CUV TOTAL		**40.7%**	**23.1%**	**21.8%**	**14.4%**	**100.0%**
3 PUT	3A PUT: COMPACT	9.0%	5.8%	56.0%	29.1%	100.0%
PUT	PUT: MID SIZE	10.4%	6.6%	49.5%	33.6%	100.0%
	PUT: FULL SIZE HALF TON	9.4%	4.4%	53.8%	32.5%	100.0%
	PUT: FULL SIZE ¾ TO 1 TON	5.8%	2.5%	59.6%	32.1%	100.0%
PUT TOTAL		**9.1%**	**4.6%**	**53.6%**	**32.7%**	**100.0%**
SUV	SUV: COMPACT	36.6%	11.2%	36.0%	16.3%	100.0%
	SUV: MID SIZE	35.0%	12.8%	36.0%	16.2%	100.0%
	SUV: FULL SIZE	36.8%	10.6%	36.2%	16.4%	100.0%
SUV TOTAL		**35.8%**	**11.9%**	**36.0%**	**16.3%**	**100.0%**
VAN	VAN: COMPACT	8.5%	6.2%	56.1%	29.2%	100.0%
	VAN: MID SIZE	38.4%	17.0%	24.8%	19.8%	100.0%
	VAN: FULL SIZE HALF TON	6.8%	4.8%	56.3%	32.2%	100.0%
	VAN: FULL SIZE ¾ TO 1 TON	7.4%	3.2%	59.3%	30.1%	100.0%
VAN TOTAL		**28.6%**	**12.9%**	**35.3%**	**23.2%**	**100.0%**
ALL TOTAL		**33.8%**	**13.9%**	**36.0%**	**16.4%**	**100.0%**

Further appreciation of the need to carefully consider the specific vehicle pairings in two-vehicle collisions when calculating gender-risk metrics can be gained from the three vehicle pairing scenarios depicted in Table 2. First, let us consider the baseline car-to-pickup scenario (C1). Here we can see the overall driver survival rate is 56.9% and is made up by unadjusted (no control for vehicle occupied) survival rates of 39.8% and 63.4% for female drivers and male drivers, respectively. When we control for vehicle class, the survival rates differ greatly as a function of vehicle occupied, 29.4 % for car drivers and 84.5% for pickup truck drivers. However, we see little difference in the adjusted survival rates as a function of gender.

Next, let us consider how survival rates change when we reduce the size/mass of the car and increase the size/mass of the pickup. This scenario (C2) can be assumed to be approximated by pairing compact cars with full-size pickups. With this pairing, the car driver survival rate decreases to 23.4% while the pickup driver survival rate increases to 90.5%. However, we again see little difference in the adjusted survival rates as a function of gender.

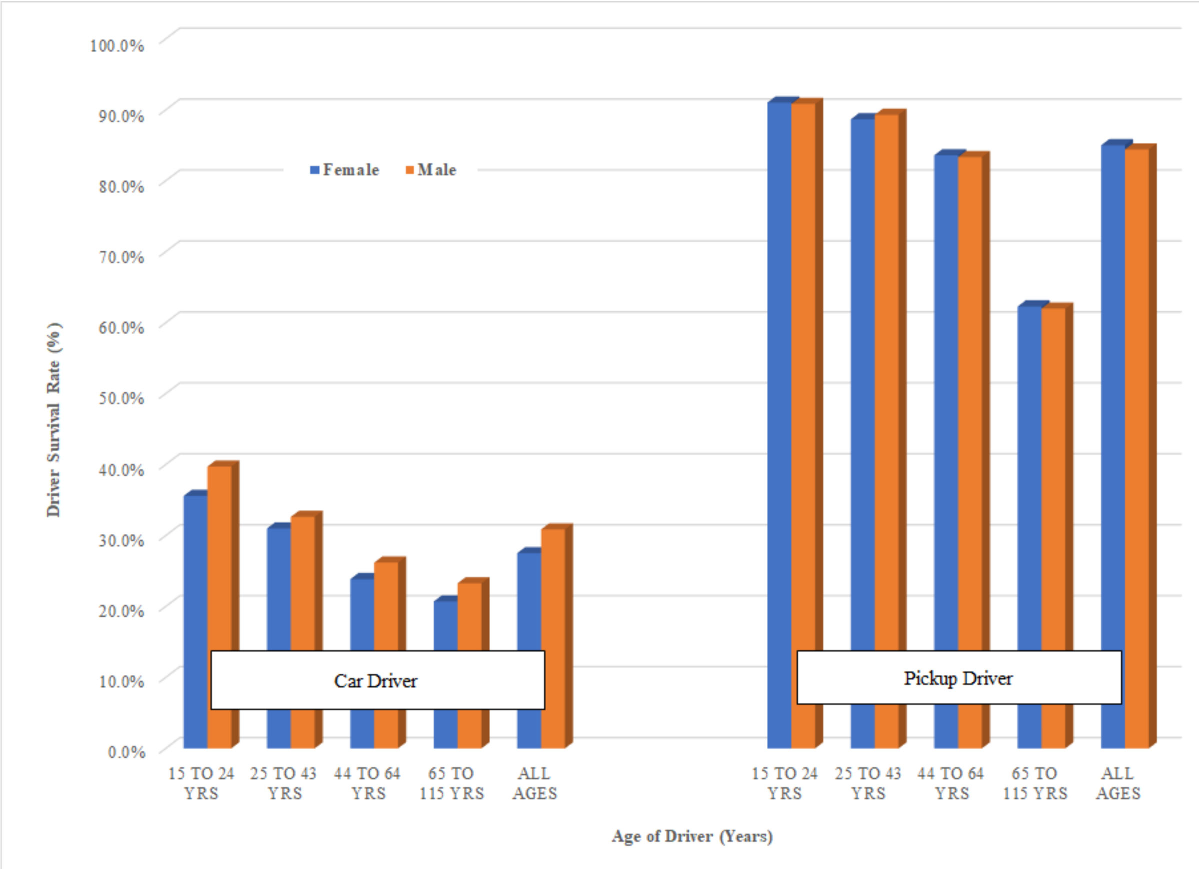

Figure 2. Driver Survival Rates in Car collisions-to-Pickup by Gender as a Function of Vehicle Occupied and Occupant Age Grouping (FARS).

In the final car-to-pickup scenario (C3), we increase the class/size of the car to mid-size while maintaining class/size of the pickup (full-size pickup). With this pairing, the car driver survival rate increases to 25.9% while the pickup driver survival rate decreases to 88.4%. As in the previous two scenarios, we see little difference in the adjusted survival rates as a function of gender.

In all three of the above scenarios, we see a negligible change in the overall driver survival rate for the collision (~ 57%). The changes in survival rates at the vehicle level appear to reflect the traditional trade-off between self-protection and partner protection when mass changes are introduced. In the case of two of the above scenarios (C1 and C3), the female pickup survival rate exceeded the male rate. In all three scenarios, the female car survival rate was marginally lower than that of their male counterparts. The magnitude of the differences could easily be explained due to the trend for females to select lighter/smaller vehicles.

Driver survival rates as a function of gender were also investigated for additional collision scenarios. The first of these (C4) focused on car-to-car collisions between compact and mid-sized cars. The second (C5) focused on collisions between vehicles of the same size class. These results are depicted in Tables 3 and 4, respectively. As expected, in Scenario C4 , the vehicle pairing resulted in the mid-sized car showing a higher driver survival rate than the compact car for both genders. In the two car-to-car vehicle pairings depicted in Scenario C5, the female and male survival rates were identical, while in the pickup-to-pickup vehicle pairing the female survival rate was only slightly lower than the male rate.

Table 2.
Driver Survival Rates for Selected Car-to-Pickup Collisions by Gender of Driver

	VEHICLE PAIRING	VEHICLE OCCUPIED	GENDER OF DRIVER	SURVIVAL RATE (%)	EXPOSURES
C1	1 CAR; 3 PUT		Female	39.8%	9,204
			Male	63.4%	24,454
	1 CAR; 3 PUT Total		ALL	56.9%	33,658
	1 CAR; 3 PUT	1 CAR	Female	27.5%	7,230
			Male	30.9%	9,599
		1 CAR Total		29.4%	16,829
		3 PUT	Female	85.0%	1,974
			Male	84.4%	14,855
		3 PUT Total		84.5%	16,829
	1 CAR; 3 PUT Total		ALL	56.9%	33,658
C2	VEHICLE PAIRING	VEHICLE OCCUPIED	GENDER OF DRIVER	SURVIVAL RATE (%)	EXPOSURES
	1B CAR: COMPACT; 3C PUT: FULL SIZE		Female	34.6%	2,550
			Male	66.1%	6,270
	1B CAR: COMPACT; 3C PUT: FULL SIZE Total			57.0%	8,820
	1B CAR: COMPACT; 3C PUT: FULL SIZE	1B CAR: COMPACT	Female	21.7%	2,072
			Male	24.9%	2,338
		1B CAR: COMPACT Total		23.4%	4,410
		3C PUT: FULL SIZE	Female	90.4%	478
			Male	90.6%	3,932
		3C PUT: FULL SIZE Total		90.5%	4,410
	1B CAR: COMPACT; 3C PUT: FULL SIZE Total			57.0%	8,820
C3	VEHICLE PAIRING	VEHICLE OCCUPIED	GENDER OF DRIVER	SURVIVAL RATE (%)	EXPOSURES
	1C CAR: MID SIZE; 3C PUT: FULL SIZE		Female	36.8%	2,055
			Male	64.8%	5,629
	1C CAR: MID SIZE; 3C PUT: FULL SIZE Total			57.3%	7,684
	1C CAR: MID SIZE; 3C PUT: FULL SIZE	1C CAR: MID SIZE	Female	24.4%	1,676
			Male	27.1%	2,166
		1C CAR: MID SIZE Total		25.9%	3,842
		3C PUT: FULL SIZE	Female	91.8%	379
			Male	88.4%	3,463
		3C PUT: FULL SIZE Total		88.8%	3,842
	1C CAR: MID SIZE; 3C PUT: FULL SIZE Total			57.3%	7,684

Table 3.
Driver Survival Rates Observed in Compact Car-to-Mid-Sized Car Collisions by Gender of Driver

	VEHICLE PAIRING	VEHICLE OCCUPIED	GENDER OF DRIVER	SURVIVAL RATE (%)	EXPOSURES
C4	1B CAR: COMPACT; 1C CAR: MID SIZE		Female	57.0%	3,064
			Male	57.4%	4,244
	1B CAR: COMPACT; 1C CAR: MID SIZE Total			57.2%	7,308
	1B CAR: COMPACT; 1C CAR: MID SIZE	1B CAR: COMPACT	Female	45.4%	1,570
			Male	47.2%	2,084
		1B CAR: COMPACT Total		46.4%	3,654
		1C CAR: MID SIZE	Female	69.3%	1,494
			Male	67.2%	2,160
		1C CAR: MID SIZE Total		68.0%	3,654
	1B CAR: COMPACT; 1C CAR: MID SIZE Total			57.2%	7,308

Table 4.
Driver Survival Rates by Gender Observed in Collisions between Vehicles of Identical Size Class

	VEHICLE PAIRING	VEHICLE OCCUPIED	GENDER OF DRIVER	SURVIVAL RATE (%)	EXPOSURES
C5	3C PUT: FULL SIZE; 3C PUT: FULL SIZE	3C PUT: FULL SIZE	Female	49.45%	362
			Male	52.69%	3,122
		3C PUT: FULL SIZE Total		52.35%	3,484
	1B CAR: COMPACT; 1B CAR: COMPACT	1B CAR: COMPACT	Female	56.33%	1,573
			Male	56.93%	2,185
		1B CAR: COMPACT Total		56.68%	3,758
	1C CAR: MID SIZE; 1C CAR: MID SIZE	1C CAR: MID SIZE	Female	56.2%	1,442
			Male	55.4%	1,940
		1C CAR: MID SIZE Total		55.7%	3,382

DISCUSSION

The present study highlights the need, in any investigation of gender-risk, to consider and control for not only what vehicle is being occupied, but also the characteristics the other involved vehicle in the case of two-vehicle collisions.

The FARS database is confined to very severe crashes which produced at least one fatality. Consequently, what is not clear is the extent to which the present findings can be generalized to less severe crashes. This issue is being addressed through additional analyses of Canadian and US databases.

Historically, establishing the belt use status of individuals, and quantifying crash severity accurately, has proven problematic. With the increasing availability of data from Event Data Recorders (EDR), these problems have been reduced. As EDR databases grow in numbers, the ability to utilize these data to address gender-related risk issues is increasing yearly.

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