Studying Passenger Vehicle Fires with Existing Databases

by

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First Analysis of FARS Data[1]

Data Used in the Analysis: To assess the reliability of the fire-related data in FARS, NHTSA was asked to provide several years of FARS data that had been matched by the Agency to the Multiple Cause of Death (MCOD) file maintained by the National Center for Health Statistics of the Department of Health and Human Services.[2] The MCOD file is derived from state death certificate information and contains "nature of injury" codes (N-codes) for many of the decedents contained in the file. Nature of injury codes are defined in the International Classification of Diseases (9th revision).

The FARS/MCOD files for 1987-1989 contained information on 83,568 fatal crashes involving 185,409 vehicles and 334,291 persons. The 185,409 vehicles that were available were subset to include only passenger vehicles (passenger cars and light trucks). Of the 185,409 vehicles that were available, 147,253 were passenger vehicles, as defined in Table 1. 96,301 vehicle occupant fatalities were recorded in these 147,253 passenger vehicles.

3,963 (2.7 percent) of the 147,253 vehicles in this study were coded as having experienced a fire ("fire occurred in vehicle during accident"). The remaining 143,290 (97.3 percent) were coded as having not experienced a fire ("no fire").

For 1,207 (30.5 percent) of the 3,963 vehicles that experienced a fire, "fire or explosion" was the "most harmful event" for the occupants of that vehicle. For the remaining 2,756 vehicles that experienced fire (69.5 percent), "fire or explosion" was not the most harmful event. The FARS 1988 Coding and Validation Manual defines "most harmful event" as follows:

> Most harmful event is "the major event for this vehicle, even if different from the first harmful event (in the crash)."
>
> "If this vehicle is involved in more than one event which causes fatality to its own occupants or to non-motorists, choose the event which causes the greatest number of fatalities to occupants of this vehicle or to non-motorists (not occupants of other vehicles)."

Of the 96,301 passenger vehicle occupants who were fatally injured, one or more N-codes were available for 90,598 (94.1 percent). [Up to 14 N-codes were recorded per case. Most cases had only two, three, or four codes, however, six of the 90,598 cases had 14 N-codes.] For the remaining 5,703 fatalities (5.9 percent), N-codes were not available. The various N-codes that were assumed to be indicators of fire-related trauma are shown in Table 2.

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[1]For more detail on the data, methods, and statistics employed see Griffin, 1997.

[2]NHTSA was able to provide three years of matched data (FARS/MCOD) extending from 1987 to1989. More recent matched data were available, but the Agency was unable to make these data available to the project.

Table 1: Passenger Vehicles (Cars and Light Trucks) Involved in Fatal Crashes between 1987 and 1989 (Table 2, Griffin, 1997)		
Body Type	Frequency	Percent
Convertible	729	0.5
2dr Sedan/HT/Coupe	54,153	36.8
3dr/2dr Hatchback	3,896	2.6
4dr Sedan/HT	37,124	25.2
5dr/4dr Hatchback	1,000	0.7
Station Wagon	6,750	4.6
Hatchback/# doors unk	214	0.1
Other auto	11	0.0
Unk auto type	4,495	3.1
Auto Pickup	568	0.4
Auto Panel	22	0.0
Short Util/not Trk Based	1,399	1.0
Pickup	29,831	20.3
Pickup w/Slide-in Camper	92	0.1
Cab chassis Based	305	0.2
Truck Based Panel	13	0.0
Truck Based SW	647	0.4
Truck Based Utility	3,677	2.5
Other Lt Conventional Trk	46	0.0
Unknown Lt Convent Trk	1,130	0.8
SW, Base Body Unknown	5	0.0
Utility, Base Body Unk	47	0.0
Unknown Light Truck	195	0.1
Unknown Trk Type	904	0.6
Total	147,253	100.0

Of the 96,301 fatally-injured passenger vehicle occupants included in this data set, N-codes were available for 90,598 (94.1 percent). And, of the 90,598 fatally-injured passenger vehicle occupants for whom N-codes were available, 1,785 (2.0 percent) sustained fire-related or burn-related injuries, as defined by the N-codes shown in Table 2.

A Comparison of Passenger Vehicle Fires to Fire-Related Injuries: The data in Table 3 indicate that 201 (11.3 percent) of the 1,785 decedents who sustained fire-related or burn-related injuries were riding in passenger vehicles that did not experience fires. Conversely, 1,584 (88.7 percent) of the 1,785 decedents who sustained fire-related or burn-related injuries were riding in passenger vehicles that experienced fires.

It should be acknowledged that it is possible for decedents to sustain fire-related or burn-related injuries while riding in vehicles that did not experience fires. One case was found during the course of this study, for example, of a fatally-injured, passenger vehicle occupant who was ejected from his vehicle and subsequently burned by the exhaust system of the vehicle in which he had been riding when it came to rest on top of him. Nevertheless, the finding that a relatively large percent (i.e., 11.3 percent) of fatally-injured, passenger vehicle occupants with fire-related or burn-related injuries were riding in vehicles that did not experience fires is surprising. The most parsimonious explanation

Table 2: N-Codes Selected as Indicators of Fire-Related Injuries and the Frequencies with which these N-Codes were Actually Used (ICD-9-CM) (Table 3, Griffin, 1997)

Freq	Code	Summary
	940	Burn confined to eye & adnexa
	940.0	Chemical burn of eyelids & periocular area
	940.1	Other burns of eyelids & periocular area
	940.2	Alkaline chemical burn of cornea & conjunctival sac
	940.3	Acid chemical burn of cornea & conjunctival sac
	940.4	Other burn of cornea & conjunctival sac
	940.5	Burn with resulting rupture & destruction of eyeball
	940.9	Unspecified burn of eye & adnexa
	941	Burn of face, head, & neck
9	941.0	Burn of face, head, & neck, unspecified degree
	941.1	Erythema due to burn [first degree] of face, head, & neck
	941.2	Blisters with epidermal loss due to burn [second degree] of face, head, & neck
3	941.3	Full-thickness skin loss due to burn [third degree NOS] of face, head, & neck
2	941.4	Deep necrosis of underlying tissues due to burn [deep third degree] of face, head, & neck without mention of loss of a body part
	941.5	Deep necrosis of underlying tissues due to burn [deep third degree] of face, head, & neck with loss of a body part
	942	Burn of trunk
130	942.0	Burn of trunk, unspecified degree
1	942.1	Erythema due to burn [first degree] of trunk
4	942.2	Blisters with epidermal loss due to burn [second degree] of trunk
22	942.3	Full-thickness skin loss due to burn [third degree NOS] of trunk
15	942.4	Deep necrosis of underlying tissues due to burn [deep third degree] of trunk without mention of loss of body part
	942.5	Deep necrosis of underlying tissues due to burn [deep third degree] of trunk with loss of a body part
	943	Burn of upper limb, except wrist & hand
5	943.0	Burn of upper limb, except wrist & hand, unspecified degree
	943.1	Erythema due to burn [first degree] of upper limb, except wrist & hand
1	943.2	Blisters with epidermal loss due to burn [second degree] of upper limb, except wrist & hand
2	943.3	Full-thickness skin loss due to burn [third degree NOS] of upper limb, except wrist & hand
3	943.4	Deep necrosis of underlying tissues due to burn [deep third degree] of upper limb, except wrist & hand, without mention of loss of a body part
	943.5	Deep necrosis of underlying tissues due to burn [deep third degree] of upper limb, except wrist & hand, with loss of a body part
	944	Burn of wrist(s) & hand(s)
2	944.0	Burn of wrist(s) & hand(s), unspecified degree
1	944.1	Erythema due to burn [first degree] of wrist(s) & hand(s)
	944.2	Blisters with epidermal loss due to burn [second degree] of wrist(s) & hand(s)
1	944.3	Full-thickness skin loss due to burn [third degree NOS] of wrist(s) & hand(s)
	944.4	Deep necrosis of underlying tissues due to burn [deep third degree] of wrist(s) & hand(s), without mention of loss of a body part
	944.5	Deep necrosis of underlying tissues due to burn [deep third degree] of wrist(s) & hand(s), with loss of a body part
	945	Burn of lower limb(s)
4	945.0	Burn of lower limb(s), unspecified degree
	945.1	Erythema due to burn [first degree] of lower limb(s)
4	945.2	Blisters with epidermal loss due to burn [second degree] of lower limb(s)
7	945.3	Full-thickness skin loss due to burn [third degree NOS] of lower limb(s)

Table 2 (continued): N-Codes that were Selected as Potential Indicators of Fire-Related Injuries and the Frequencies with which these N-Codes were Actually Used (ICD-9-CM)

Freq	Code	Summary
4	945.4	Deep necrosis of underlying tissues due to burn [deep third degree] of lower limb(s) without mention of loss of a body part
	945.5	Deep necrosis of underlying tissues due to burn [deep third degree] of lower limb(s) with loss of a body part
	946	Burns of multiple specified sites
	946.0	Burns of multiple specified sites, unspecified degree
	946.1	Erythema due to burn [first degree] of multiple specified sites
	946.2	Blisters with epidermal loss due to burn [second degree] of multiple specified sites
	946.3	Full-thickness skin loss due to burn [third degree NOS] of multiple specified sites
	946.4	Deep necrosis of underlying tissues due to burn [deep third degree] of multiple specified sites, without mention of loss of a body part
	946.5	Deep necrosis of underlying tissues due to burn [deep third degree] of multiple specified sites, with loss of a body part
	947	Burn of internal organs
1	947.0	Burn of mouth & pharynx
14	947.1	Burn of larynx, trachea, & lung
	947.2	Burn of esophagus
	947.3	Burn of gastrointestinal tract
	947.4	Burn of vagina & uterus
3	947.8	Burn of other specified sites of internal organs
2	947.9	Burn of internal organs, unspecified site
	948	Burns classified according to extent of body surface involved
4	948.0	Burn [any degree] involving less than 10 percent of body surface
3	948.1	Burn [any degree] involving 10-19 percent of body surface
1	948.2	Burn [any degree] involving 20-29 percent of body surface
9	948.3	Burn [any degree] involving 30-39 percent of body surface
12	948.4	Burn [any degree] involving 40-49 percent of body surface
5	948.5	Burn [any degree] involving 50-59 percent of body surface
8	948.6	Burn [any degree] involving 60-69 percent of body surface
12	948.7	Burn [any degree] involving 70-79 percent of body surface
12	948.8	Burn [any degree] involving 80-89 percent of body surface
458	948.9	Burn [any degree] involving 90 percent or more of body surface
	949	Burn, unspecified site
899	949.0	Burn of unspecified site, unspecified degree
1	949.1	Erythema due to burn [first degree], unspecified site
1	949.2	Blisters with epidermal loss due to burn [second degree], unspecified site
69	949.3	Full-thickness skin loss due to burn [third degree NOS], unspecified site
25	949.4	Deep necrosis of underlying tissues due to burn [deep third degree], unspecified site without mention of loss of a body part
	949.5	Deep necrosis of underlying tissues due to burn [deep third degree], unspecified site with loss of a body part
154	986	Toxic effect of carbon monoxide
	987	Toxic effect of other gases, fumes, or vapors
317	987.8	Toxic effect of other specified gases, fumes, or vapors
95	987.9	Toxic effect of unspecified gas, fume, or vapor

Table 3: The Number of Passenger Vehicles, Vehicle Occupant Fatalities, Fatalities with N-Codes, and Fatalities with Fire-Related N-Codes, by Fire Experience (1987-1989)

	Fire Experience				
	No Fire		Fire		Total
Category	Frequency	Comment	Frequency	Comment	Frequency
Vehicles	143,290		3,963		147,253
Fatalities	92,116	(0.6 Fatalities/Vehicle)	4,185	(1.1 Fatalities/Vehicle)	96,301
Total N-Codes	86,662	(94.1% of Fatalities)	3,936	(94.1% of Fatalities)	90,598
Fire N-Codes	201	(0.2% of Total N-Codes)	1,584	(40.2% of Total N-Codes)	1,785

for these 201 cases is that many if not most of these vehicles did experience fires, but were not coded as having experienced fires in FARS.

Note also that a minority of fatally-injured passenger vehicle occupants (40.2 percent) who were riding in vehicles that experienced fires (and for whom N-codes were available) were found to have sustained fire-related or burn-related injuries. That is to say, 58.8 percent of the decedents riding in passenger vehicles that experienced fires (and for whom N-codes were available) were not found to have suffered thermal trauma, smoke inhalation, or asphyxiation.

A Comparison of Passenger Vehicle Fires by State: From Table 3 we see that 3,963 (2.7 percent) of the 147,253 passenger vehicles in the current data set experienced fires. If the likelihood of passenger vehicles experiencing fires is reasonably comparable from state to state, and if the investigating officers reporting this information to the FARS coders in the individual states are reliably reporting passenger vehicle fires, then we might expect that each state would report that about 2.7 percent of the passenger vehicles involved in fatal crashes within their jurisdiction experienced fires, plus or minus some random fluctuation. But, such is not the case.

For 16 states (HI, MN, IA, AR, OK, OR, CT, KY, MA, WI, MO, LA, CA, IN, IL, and GA), the reported percentages of passenger vehicles experiencing fires are significantly above the national average; for 12 states (AZ, MD, NY, NC, NJ, NM, VA, SC, FL, ID, MS, and UT), the reported percentages are significantly below the national average (at $\alpha = 0.05$). In Utah only one passenger vehicle in 888 involved in fatal crashes (i.e., 0.1 percent) experienced a fire; at the other extreme, in Hawaii, 23 of 434 passenger vehicles involved in fatal crashes (i.e., 5.3 percent) experienced fires.

Figure 1 shows the rank ordering of states by "percent of vehicles experiencing fires." The vertical line in this figure represents the 2.7 percent of all passenger vehicles that experienced fires nationwide. The horizontal lines around the data points represent the 95 percent confidence intervals about individual state estimates.

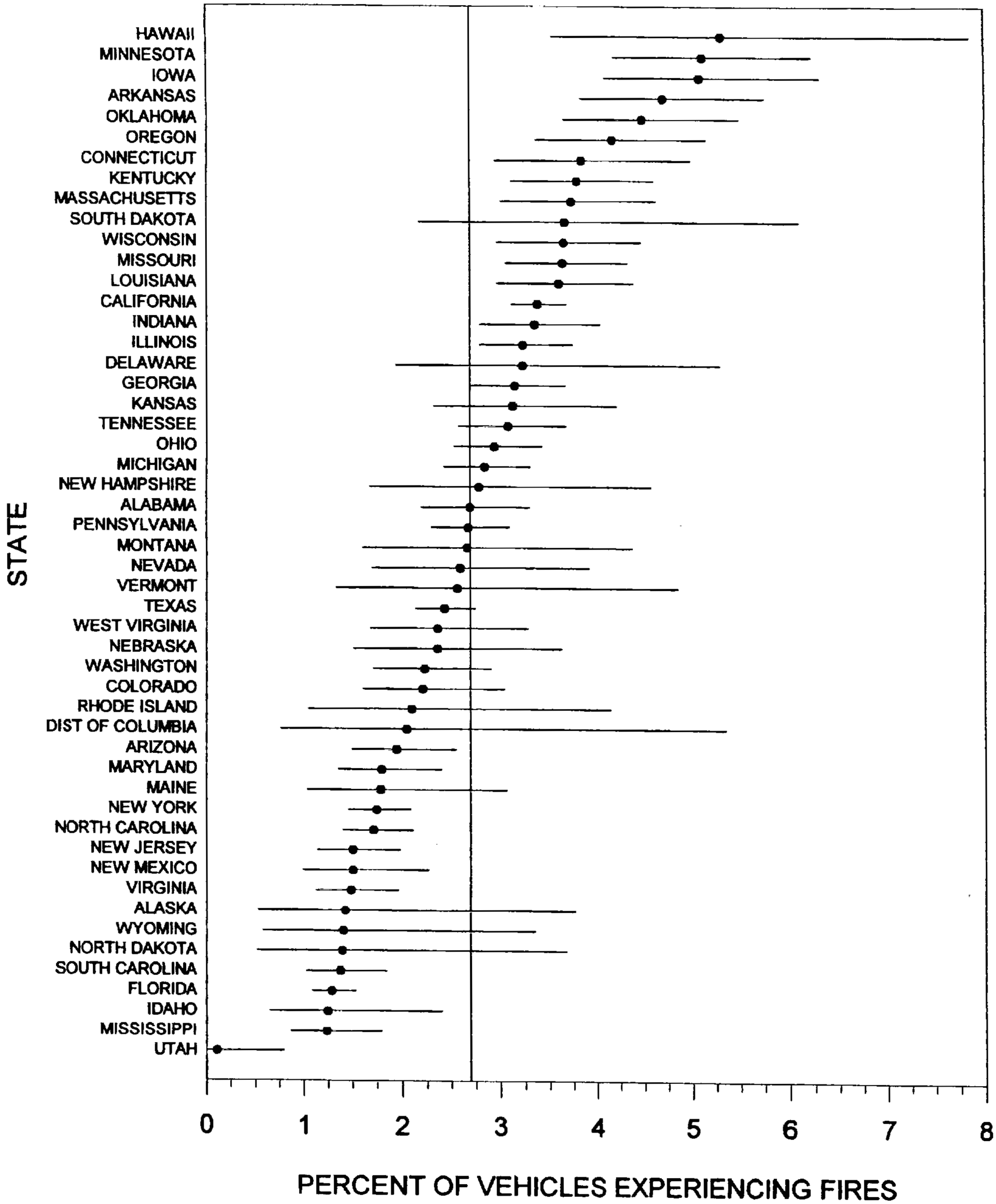

Figure 1: Percent of Vehicles Experiencing Fires, by State (FARS: 1987-1989)

Visual inspection of the data in Figure 1 suggests that there is great variability in reported percentages of passenger vehicles experiencing fires across the states (and the District of Columbia). This suggestion can be confirmed statistically through a chi-square (χ^2) analysis. The calculated χ^2 (referred to as χ^2 homogeneity) for these data (with 50 df) is 484.6 (pr < 0.000), indicating that the 51 estimates depicted in Figure 1 are so variable that it is extremely unlikely that all states (and the District of Columbia) are reporting or estimating the same phenomenon. This analysis suggests that it is extremely unlikely that the 50 states and the District of Columbia are all consistently reporting the same phenomenon.

A Comparison of "Most Harmful Events" (MHE) in Passenger Vehicles Experiencing Fires, by State: Table 3 indicates that almost 60 percent of passenger vehicle occupants who were riding in vehicles that experienced fires suffered no fire-related or burn-related injuries. Clearly then, "fire or explosion" is not the "most harmful event" for many passenger vehicles that experience fires.

Of the 3,963 passenger vehicles in Table 3 that experienced fires, the "most harmful event" for the occupants of 1,207 vehicles (i.e., 30.5 percent of the vehicles) was "fire or explosion." Collectively, four states [AK (4), RI (4), VT (9), and WY (5)] and the District of Columbia (8) indicated that 30 passenger vehicles in their jurisdictions experienced fires. For none of these 30 vehicles was "fire or explosion" cited as the MHE. Utah (UT) recorded one vehicle fire. "Fire or explosion" was cited as the MHE for this vehicle. Data from these five states and the District of Columbia were not included in the present analysis in order to avoid dividing by zero or taking the natural logarithm of zero. Data from the remaining 45 states (which recorded 99.22 percent of all passenger vehicle fires in the United States) form the basis of the analysis described in this section.

Of the 180 passenger vehicles that experienced fires in Illinois, only one (0.6 percent) had fire or explosion listed as the MHE. At the other extreme, in Virginia, 47 (95.92 percent) of 49 passenger vehicles that experienced fire had fire or explosion listed as the MHE.

In Figure 2 the rank ordering of the 45 states by "percent fire/explosion as the most harmful event" is depicted. The 45 data points in this figure are scattered around the national average of 30.7 percent—the percent of vehicles for which "fire or explosion" was cited as the MHE. The 95 percent confidence intervals about the individual state estimates were derived as before.

For ten states (VA, SC, MO, MT, TX, TN, MD, AR, AZ, and CA), the estimates of "fire or explosion" as the MHE are significantly above the national average (at $\alpha = 0.05$). For fifteen states (OR, FL, IA, MA, GA, CT, MN, KY, MI, MS, NJ, KS, OK, OH, and IL), the estimates are significantly below the national average (at $\alpha = 0.05$).

These data suggest that it is extremely unlikely that the 45 states included in this analysis are estimating (i.e., measuring) the same phenomenon: χ^2 (with 44 df) equals 498.6 (pr < 0.000). This χ^2 was calculated as before.

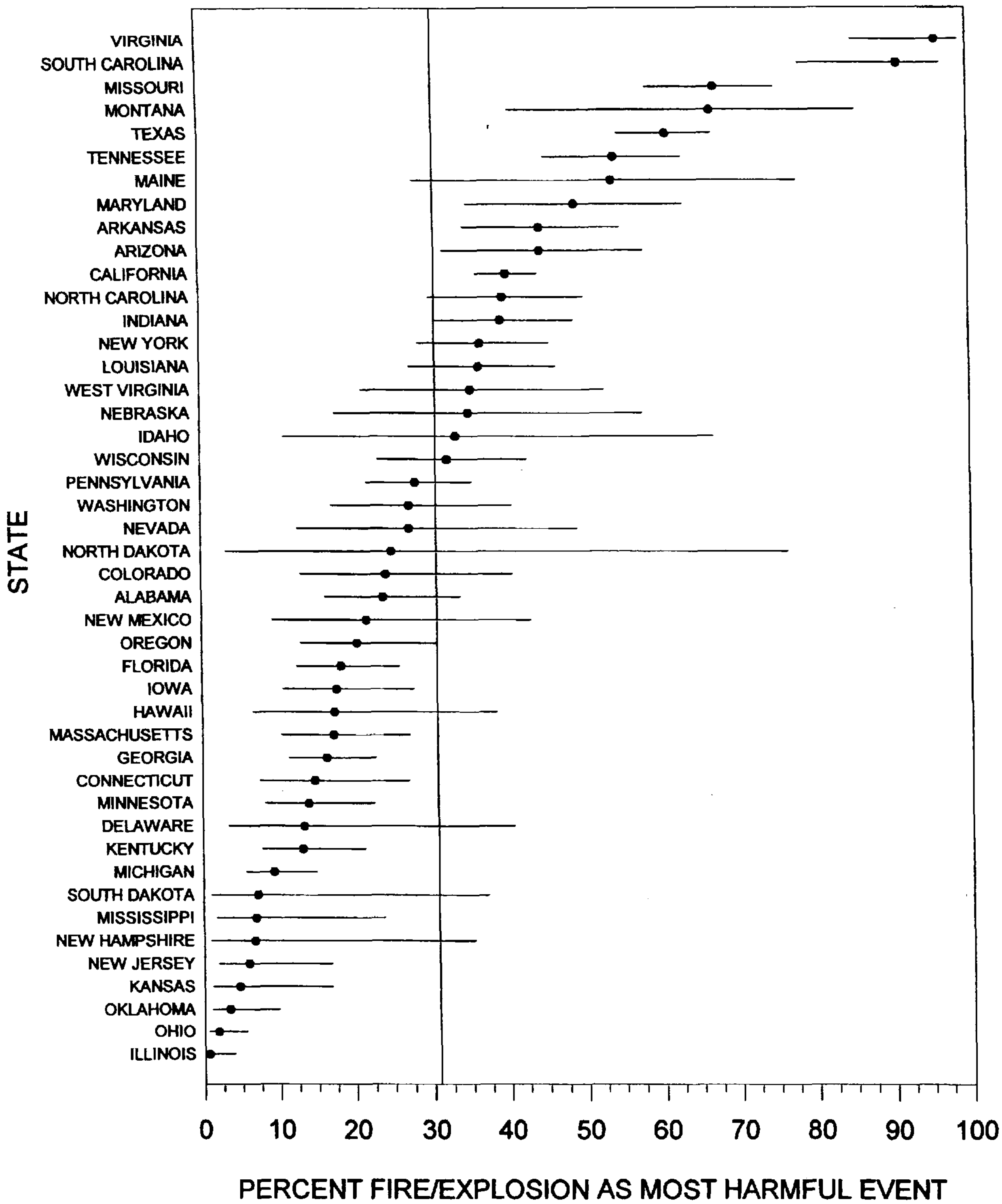

Figure 2: Percent Fire or Explosion Coded as the Most Harmful Event, by State (FARS: 1987-1989)

Second Analysis of FARS Data[3]

Data Used in the Analysis: Three additional years of FARS data (1994 to 1996) were selected for this analysis and compared to the FARS data from 1987 to 1989. There were 147,253 passenger vehicles involved in fatal crashes in the United States between 1987 and 1989 (see Table 3). Between 1994 and 1996 some 133,928 passenger vehicles were found to have been involved in fatal crashes. In 1987-1989, passenger vehicles comprised 79.4 percent of all vehicles contained in the FARS; in 1994-1996, passenger vehicles comprised 79.5 percent of all vehicles contained in FARS. The specific vehicle "body types" that were included under "passenger vehicle" in 1987-1989 and 1994-1996 are shown in Table 4.

A Comparison of Passenger Vehicle Fires by State: Figure 3 is a replication of Figure 1 with 1994-1996 data used instead of 1987-1989 data. In 1994-1996, some 3,552 of 133,928 passenger vehicles (i.e., 2.7 percent) experienced fires; in 1987-1989, some 3,963 of 147,253 passenger vehicles (i.e., 2.7 percent) experienced fires.

Figure 3 depicts the percentages of passenger vehicles that experienced fires in 1994-1996 in each of the 50 states and the District of Columbia, with 95 percent confidence intervals placed around each estimated percentage. The vertical line in this figure again represents the national average "fire experience" for passenger vehicles in fatal crashes: 2.7 percent. Fifteen states had "fire experiences" that were significantly below the national average (UT, MS, NM, ID, MT, FL, MD, VA, SC, CO, NJ, NY, MI, AL, and TX) and 12 states had "fire experiences" that were significantly above the national average (OR, IN, ND, OH, AR, OK, MO, WI, IL, NC, AZ, and CA).

The variability in the individual state expressions of vehicles experiencing fires is great. A chi-square (χ^2) analysis of these data suggests that it is highly unlikely that all of the states and the District of Columbia are consistently measuring the same phenomenon, i.e., a common 2.7 percent of vehicles experiencing fires [$\chi^2 = 473.77$ (with 50 df); $pr < 0.000$].

A Comparison of "Most Harmful Events" (MHE) in Passenger Vehicles Experiencing Fires, by State: Figure 4 is a replication of Figure 2 using 1994-1996 data instead of 1987-1989 data. Some 26.1 percent of all passenger vehicles experiencing fires between 1994 and 1996 were also classified with "fire or explosion" as the MHE, as depicted by the vertical line in Figure 4. The horizontal lines around the state estimates (i.e., the dots) represent the 95th percentile confidence intervals around the state estimates.

Nine states were significantly above the national average (NE, LA, MD, ME, NY, FL, MO, AL, CA); 12 states were significantly below the national average (IN, WS, OR, MN, VA, MA, IL, NC, GA, OH, KS, and OK). Ten states were omitted from Figure 4 to avoid dividing by zero or taking the natural logarithm of zero when calculating the confidence intervals. For nine of the states that were omitted from Figure 4, no vehicles were coded with "fire or explosion" as the MHE. For

[3]For more detail on the data, methods, and statistics employed see Griffin, 1998.

Table 4: Passenger Cars and Light Trucks Selected from FARS by Passenger Vehicle Type, 1987-1989 vs. 1994-1996

	[1987-1989]		[1994-1996]	
Passenger Vehicle Type	Frequency	Percent	Frequency	Percent
Convertible	729	0.5	807	0.6
2dr Sedan/HT/Coupe	54153	36.8	31453	23.5
3dr/2dr Hatchback	3896	2.6	6051	4.5
4dr Sedan/HT	37124	25.2	44122	32.9
5dr/4dr Hatchback	1000	0.7	1592	1.2
Station Wagon	6750	4.6	4103	3.1
Hatchback/unk drs	214	0.1	171	0.1
Other auto	11	0.0	714	0.5
Unk auto type	4495	3.1	2380	1.8
Auto Pickup	568	0.4	309	0.2
Auto Panel	22	0.0	7	0.0
Short Util/not Trk Based	1399	1.0	.	.
Truck Based Utility	3677	2.5	.	.
Compact Utility	.	.	7536	5.6
Large Utility	.	.	1577	1.2
Utility Station Wagon	.	.	877	0.7
Utility Unk Body	.	.	38	0.0
Unknown Van type	.	.	193	0.1
Pickup	29831	20.3	.	.
Compact Pickup	.	.	12701	9.5
Standard Pickup	.	.	18253	13.6
Pickup w/Camper	92	0.1	266	0.2
Convertible Pickup	.	.	4	0.0
Unknown Pickup	.	.	303	0.2
Cab Chassis Based	305	0.2	412	0.3
Truck Based Panel	13	0.0	1	0.0
Truck Based SW	647	0.4	.	.
Other Lt Conventional	46	0.0	3	0.0
Unk Lt Conventional	1130	0.8	34	0.0
SW, Base Body Unk	5	0.0	.	.
Utility, Base Body Unk	47	0.0	.	.
Unknown Light Truck	195	0.1	.	.
Unk Trk Type	904	0.6	.	.
Unknown Truck	.	.	21	0.0
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	147253	100.0	133928	100.0

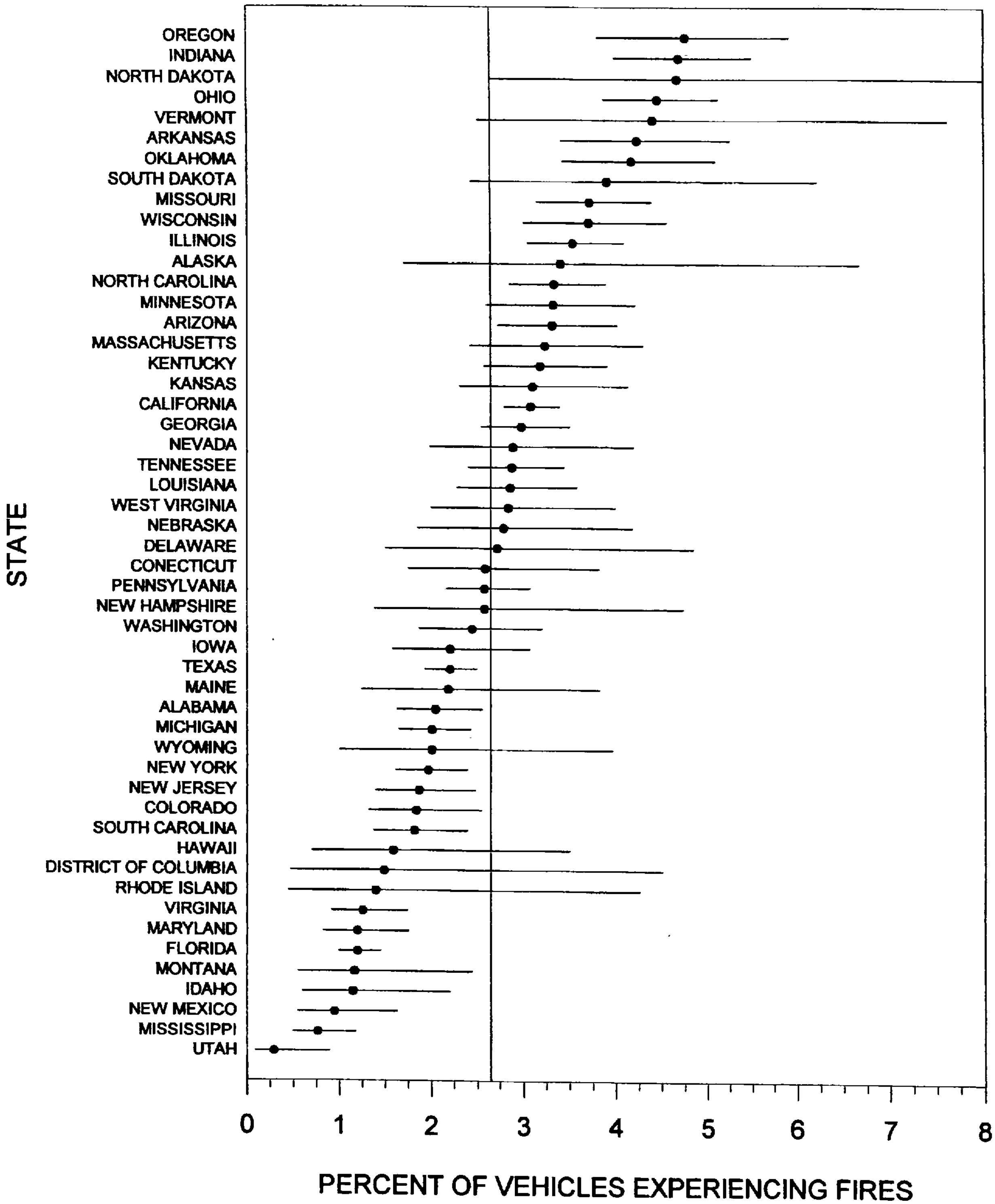


Figure 3: Percent of Vehicles Experiencing Fires, by State (FARS: 1994-1996)

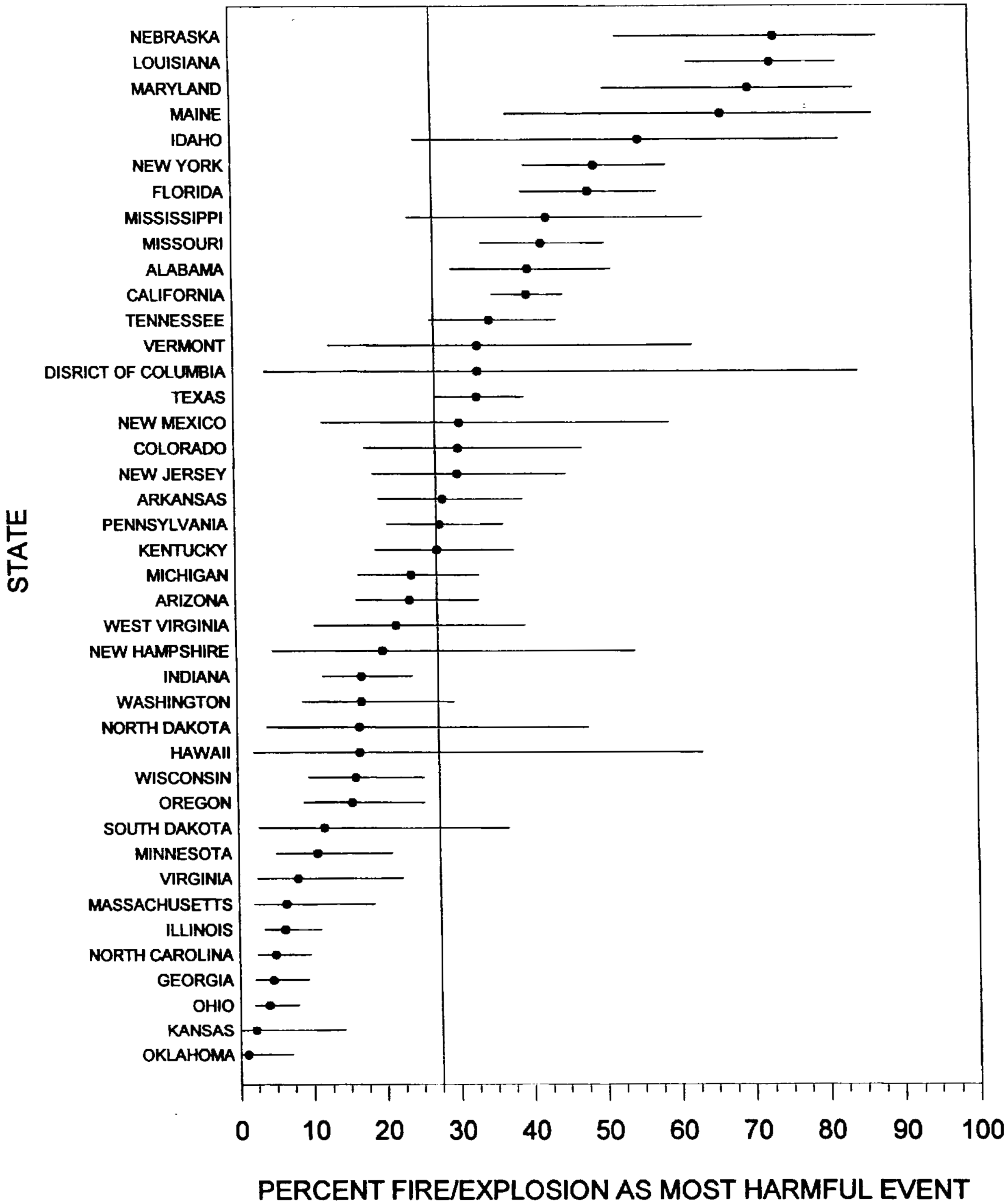


Figure 4: Percent Fire or Explosion Coded as the Most Harmful Event, by State (FARS: 1994-1996)

one state (SC), all 50 vehicles that experienced a fire were coded with "fire or explosion" as the MHE.

	MOST HARMFUL EVENT	
STATE	FIRE	OTHER
AK	0	8
CT	0	25
DE	0	11
IA	0	35
MT	0	7
NV	0	27
RI	0	3
SC	50	0
UT	0	3
WY	0	8
	50	127

The variability in the individual state codings of "fire or explosion" as the MHE depicted in Figure 4 is great. A chi-square (χ^2) analysis of these data suggests that it is highly unlikely that all of these states and the District of Columbia are consistently measuring the same phenomenon, i.e., a common 26.10 percent of vehicles coded with "fire or explosion" as MHE [$\chi^2 = 391.00$ (with 40 df); $pr < 0.000$].

Passenger Vehicle Fires in 1987-1989 vs. 1994-1996: Figures 1 and 3 indicate that individual states did not consistently report passenger vehicle fires during 1987-1989 and during 1994-1996. These state-to-state differences may have been due to variations in the reporting procedures and protocols used by investigating officers and FARS coders in different states. Or, these differences might have resulted from some unknown, extraneous factors operating in different states to promote or inhibit the likelihood that passenger vehicles involved in fatal crashes experienced fires. Whatever these extraneous factors might have been, if they were consistent from the late 1980's to the mid 1990's, then the percentage of fires experienced in a given state in 1987-1989 should be comparable to the percentage of fires experienced in the same state in 1994-1996.

Table 5 shows the percentages (PCTs) of passenger vehicles that experienced fires in 1987-1989 and 1994-1996, by state. The last column in this table provides the results of Z tests to determine if there were significant changes in fires experienced between 1987-1989 and 1994-1996 in individual states. Using Arizona as an example, note that the percentage of vehicles experiencing fires in Arizona in 1994-1996 is greater than the percentage of vehicles experiencing fires in Arizona in 1987-1989. This increase in the percentage of vehicles experiencing fires is significant at $\alpha = 0.05$ ($Z = 3.21$) (▲). For Hawaii, the percentage of vehicles experiencing fires in 1994-1996 is smaller than the percentage experiencing fires in 1987-1989. This reduction is significant at $\alpha = 0.05$ ($Z = -2.84$) (▼).

Table 5: Passenger Vehicle Fires, by State (1987-1989 vs. 1994-1996)

STATE	[1987-1989] FIRE	NO FIRE	PCT	TOTAL	[1994-1996] FIRE	NO FIRE	PCT	TOTAL	Z
ALABAMA	92	3331	2.69	3423	77	3688	2.05	3765	-1.0
ALASKA	4	275	1.43	279	8	227	3.40	235	1.47
ARIZONA	54	2710	1.95	2764	101	2949	3.31	3050	3.21 ▲
ARKANSAS	90	1825	4.70	1915	81	1831	4.24	1912	-0.69
CALIFORNIA	575	16413	3.38	16988	409	12889	3.08	13298	-1.51
COLORADO	37	1636	2.21	1673	36	1920	1.84	1956	-0.79
CONNECTICUT	54	1353	3.84	1407	25	940	2.59	965	-1.66
DELAWARE	15	450	3.23	465	11	394	2.72	405	-0.44
DIST OF COLUMBIA	4	191	2.05	195	3	199	1.49	202	-0.43
FLORIDA	131	10027	1.29	10158	111	9123	1.20	9234	-0.55
GEORGIA	165	5075	3.15	5240	151	4916	2.98	5067	-0.50
HAWAII	23	411	5.30	434	6	372	1.59	378	-2.84 ▼
IDAHO	9	709	1.25	718	9	772	1.15	781	-0.18
ILLINOIS	180	5397	3.23	5577	174	4752	3.53	4926	0.86
INDIANA	112	3232	3.35	3344	147	2986	4.69	3133	2.76 ▲
IOWA	79	1477	5.08	1556	35	1548	2.21	1583	-4.29 ▼
KANSAS	43	1329	3.13	1372	45	1405	3.10	1450	-0.05
KENTUCKY	99	2516	3.79	2615	87	2652	3.18	2739	-1.22
LOUISIANA	99	2650	3.60	2749	75	2546	2.86	2621	-1.53
MAINE	13	713	1.79	726	12	537	2.19	549	0.50
MARYLAND	47	2559	1.80	2606	27	2216	1.20	2243	-1.70
MASSACHUSETTS	81	2088	3.73	2169	46	1378	3.23	1424	-0.80
MICHIGAN	161	5516	2.84	5677	104	5072	2.01	5176	-2.79 ▼
MINNESOTA	93	1727	5.11	1820	65	1893	3.32	1958	-2.75 ▼
MISSISSIPPI	29	2301	1.24	2330	21	2713	0.77	2734	-1.71
MISSOURI	125	3310	3.64	3435	133	3443	3.72	3576	0.18
MONTANA	15	549	2.66	564	7	590	1.17	597	-1.86
NEBRASKA	20	829	2.36	849	23	800	2.79	823	0.57
NEVADA	22	826	2.59	848	27	906	2.89	933	0.39
NEW HAMPSHIRE	15	525	2.78	540	10	378	2.58	388	-0.19
NEW JERSEY	51	3325	1.51	3376	46	2419	1.87	2465	1.05
NEW MEXICO	23	1504	1.51	1527	13	1362	0.95	1375	-1.36
NEW YORK	123	6897	1.75	7020	101	5024	1.97	5125	0.88
NORTH CAROLINA	91	5187	1.72	5278	160	4641	3.33	4801	5.18 ▲
NORTH DAKOTA	4	282	1.40	286	12	245	4.67	257	2.25 ▲
OHIO	164	5411	2.94	5575	196	4203	4.46	4399	4.02 ▲
OKLAHOMA	90	1917	4.48	2007	96	2202	4.18	2298	-0.49
OREGON	83	1908	4.17	1991	77	1541	4.76	1618	0.86
PENNSYLVANIA	171	6244	2.67	6415	125	4725	2.58	4850	-0.29
RHODE ISLAND	8	373	2.10	381	3	211	1.40	214	-0.61
SOUTH CAROLINA	44	3153	1.38	3197	50	2697	1.82	2747	1.37
SOUTH DAKOTA	14	368	3.66	382	17	418	3.91	435	0.18
TENNESSEE	120	3779	3.08	3899	120	4052	2.88	4172	-0.53
TEXAS	248	9976	2.43	10224	238	10555	2.21	10793	-1.06
UTAH	1	887	0.11	888	3	1035	0.29	1038	0.85
VERMONT	9	342	2.56	351	12	260	4.41	272	1.27
VIRGINIA	49	3243	1.49	3292	37	2894	1.26	2931	-0.76
WASHINGTON	55	2408	2.23	2463	53	2110	2.45	2163	0.49
WEST VIRGINIA	34	1407	2.36	1441	32	1095	2.84	1127	0.76
WISCONSIN	90	2379	3.65	2469	87	2261	3.71	2348	0.11
WYOMING	5	350	1.41	355	8	391	2.01	399	0.63
	3963	143290		147253	3552	130376		133928	

Figure 5 plots the data provided in Table 5 in the form of odds. The odds of a passenger vehicle experiencing a fire in the i^{th} state in 1994-1996 are shown in the first equation, where F_i represents the number of passenger vehicles that experienced fires in the i^{th} state and N_i represents the number of passenger vehicles that did not experience fires in the i^{th} state.

$$\textbf{(1994-1996) Odds}_i = \frac{F_i}{N_i} \qquad \text{(Eq 1)}$$

The second equation is the same as the first, but represents the data from 1987 to 1989.

$$\textbf{(1987-1989) Odds}_i = \frac{F_i}{N_i} \qquad \text{(Eq 2)}$$

Had the passenger vehicle fire experience of individual states been consistent from 1987-1989 to 1994-1996, the data points would have fallen on the diagonal (plus or minus chance fluctuation). If there had been a uniform, nationwide reduction in passenger vehicles experiencing fires between 1987-1989 and 1994-1996, and had the states reliably reported fire experience, the data points would have fallen on a straight line going through the origin and with a slope of less than 1.0 (plus or minus chance fluctuation). If there had been a uniform, nationwide increase in passenger vehicles experiencing fires between 1987-1989 and 1994-1996, and had the states reliably reported fire experience, the data points would have fallen on a straight line going through the origin and with a slope greater than 1.0 (plus or minus chance fluctuation).

These data points cannot reasonably be approximated (i.e., modeled) by a straight line. The "best" straight line that can be defined to approximate the data in Figure 5 is a dashed line falling just below the diagonal. This dashed line (with a slope of 0.986) represents an apparent nationwide, 1.4 percent reduction in the odds of a passenger vehicle experiencing a fire in 1994-1996, compared to 1987-1989. The dashed line does not fall significantly below the diagonal, $\chi^2 = 0.35$ (with 1 df); pr = 0.554)] and is not a reasonable approximation to the data [$\chi^2_{(50)} = 149.66$; pr < 0.000].

"Most Harmful Events" (MHEs) in Passenger Vehicles Experiencing Fires in 1987-1989 vs. 1994-1996: Figures 2 and 4 have shown that individual states did not consistently report MHE in passenger vehicles that experienced fires during 1987-1989 and during 1994-1996. These state-to-state differences may have been due to variations in the reporting procedures and protocols used by investigating officers and FARS coders in different states. Or, these differences might have resulted from some unknown, extraneous factors operating in different states to promote or inhibit the likelihood that passenger vehicles that experienced fires were also coded with "fire or explosion" as the MHE.

Table 6 shows the percentages (PCTs) of passenger vehicles that experienced fires and were also coded with "fire or explosion" as the MHE in 1987-1989 and 1994-1996, by state. Between

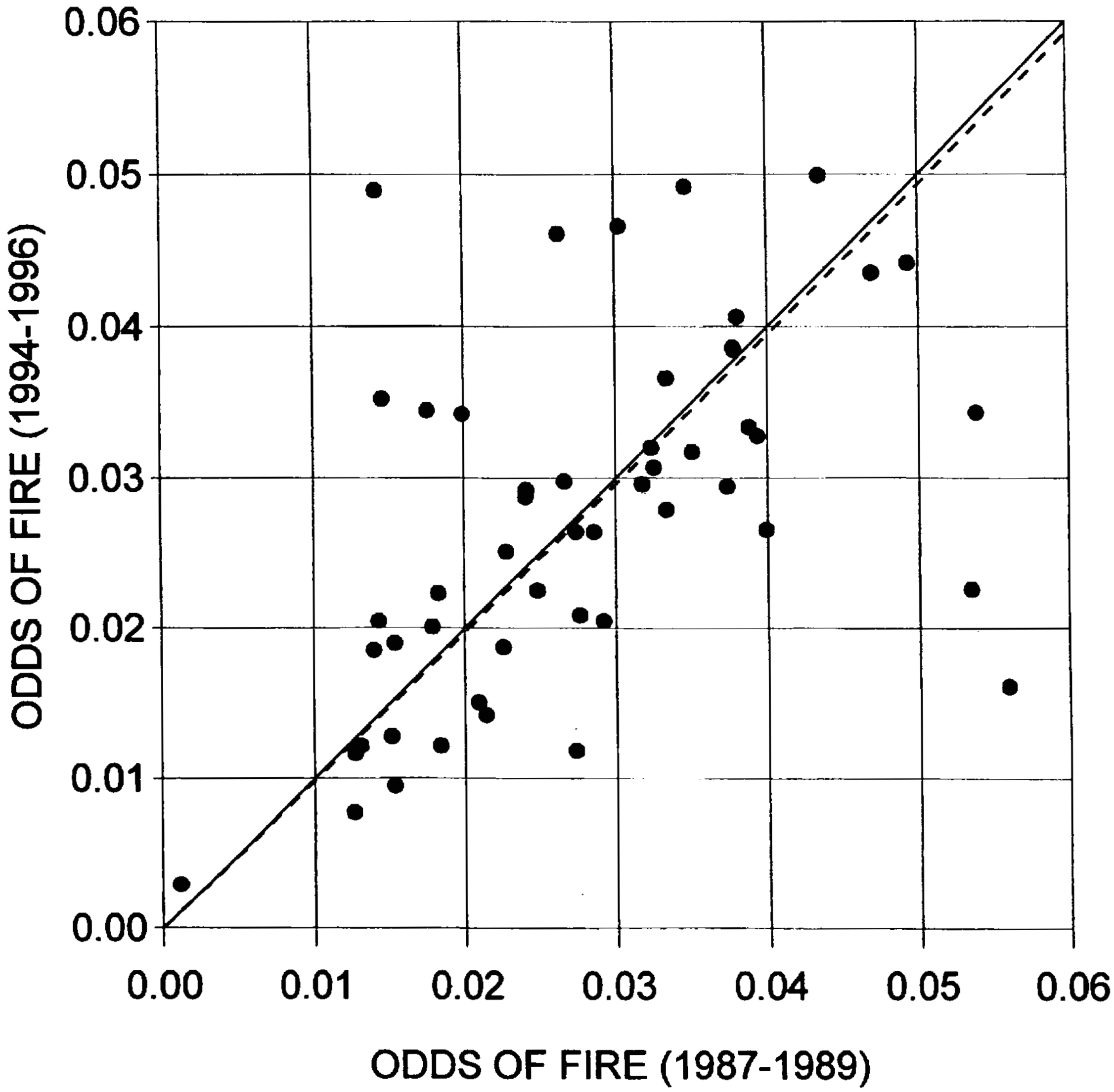


Figure 5: Odds of a Passenger Vehicle Fire (1987-1989 vs. 1994-1996), by State

Table 6: Fires or Explosions as MHEs, by State (1987-1989 vs. 1994-1996)

	[1987-1989]				[1994-1996]				
STATE	FIRE	NO FIRE	PCT	TOTAL	FIRE	NO FIRE	PCT	TOTAL	Z
ALABAMA	22	70	23.91	92	31	46	40.26	77	2.28 ▲
ALASKA	0	4	0.00	4	0	8	0.00	8	.
ARIZONA	24	30	44.44	54	24	77	23.76	101	-2.65 ▼
ARKANSAS	40	50	44.44	90	23	58	28.40	81	-2.17 ▼
CALIFORNIA	230	345	40.00	575	164	245	40.10	409	0.03
COLORADO	9	28	24.32	37	11	25	30.56	36	0.60
CONNECTICUT	8	46	14.81	54	0	25	0.00	25	-2.03 ▼
DELAWARE	2	13	13.33	15	0	11	0.00	11	-1.26
DIST OF COLUMBIA	0	4	0.00	4	1	2	33.33	3	1.25
FLORIDA	24	107	18.32	131	54	57	48.65	111	5.03 ▲
GEORGIA	27	138	16.36	165	7	144	4.64	151	-3.36 ▼
HAWAII	4	19	17.39	23	1	5	16.67	6	-0.04
IDAHO	3	6	33.33	9	5	4	55.56	9	0.95
ILLINOIS	1	179	0.56	180	11	163	6.32	174	3.00 ▲
INDIANA	44	68	39.29	112	25	122	17.01	147	-4.02 ▼
IOWA	14	65	17.72	79	0	35	0.00	35	-2.66 ▼
KANSAS	2	41	4.65	43	1	44	2.22	45	-0.63
KENTUCKY	13	86	13.13	99	24	63	27.59	87	2.46 ▲
LOUISIANA	36	63	36.36	99	55	20	73.33	75	4.84 ▲
MAINE	7	6	53.85	13	8	4	66.67	12	0.65
MARYLAND	23	24	48.94	47	19	8	70.37	27	1.79
MASSACHUSETTS	14	67	17.28	81	3	43	6.52	46	-1.71
MICHIGAN	15	146	9.32	161	25	79	24.04	104	3.27 ▲
MINNESOTA	13	80	13.98	93	7	58	10.77	65	-0.60
MISSISSIPPI	2	27	6.90	29	9	12	42.86	21	3.03 ▲
MISSOURI	84	41	67.20	125	56	77	42.11	133	-4.04 ▼
MONTANA	10	5	66.67	15	0	7	0.00	7	-2.92 ▼
NEBRASKA	7	13	35.00	20	17	6	73.91	23	2.56 ▲
NEVADA	6	16	27.27	22	0	27	0.00	27	-2.90 ▼
NEW HAMPSHIRE	1	14	6.67	15	2	8	20.00	10	1.01
NEW JERSEY	3	48	5.88	51	14	32	30.43	46	3.18 ▲
NEW MEXICO	5	18	21.74	23	4	9	30.77	13	0.60
NEW YORK	45	78	36.59	123	50	51	49.50	101	1.95
NORTH CAROLINA	36	55	39.56	91	8	152	5.00	160	-6.92 ▼
NORTH DAKOTA	1	3	25.00	4	2	10	16.67	12	-0.37
OHIO	3	161	1.83	164	8	188	4.08	196	1.24
OKLAHOMA	3	87	3.33	90	1	95	1.04	96	-1.08
OREGON	17	66	20.48	83	12	65	15.58	77	-0.80
PENNSYLVANIA	48	123	28.07	171	35	90	28.00	125	-0.01
RHODE ISLAND	0	8	0.00	8	0	3	0.00	3	.
SOUTH CAROLINA	40	4	90.91	44	50	0	100.00	50	2.18 ▲
SOUTH DAKOTA	1	13	7.14	14	2	15	11.76	17	0.43
TENNESSEE	65	55	54.17	120	42	78	35.00	120	-2.99 ▼
TEXAS	151	97	60.89	248	79	159	33.19	238	-6.11 ▼
UTAH	1	0	100.00	1	0	3	0.00	3	-2.00 ▼
VERMONT	0	9	0.00	9	4	8	33.33	12	1.93
VIRGINIA	47	2	95.92	49	3	34	8.11	37	-8.17 ▼
WASHINGTON	15	40	27.27	55	9	44	16.98	53	-1.29
WEST VIRGINIA	12	22	35.29	34	7	25	21.88	32	-1.20
WISCONSIN	29	61	32.22	90	14	73	16.09	87	-2.50 ▼
WYOMING	0	5	0.00	5	0	8	0.00	8	.
	1207	2756		3963	927	2625		3552	

1987-1989 and 1994-1996 some 25 states showed a significant gain or loss in the reporting of "fire or explosion" as the MHE.

Figure 6 (which is logically analogous to Figure 5) depicts the odds of a vehicle being coded with "fire or explosion" as MHE in 1994-1996 relative to 1987-1989, by state.[4] The dashed line in Figure 6 is the "best" estimate of the overall change in the odds of a vehicle being coded with "fire or explosion" as MHE. The slope of the dashed line is 0.79. Or, generally speaking, the odds of a vehicle being coded with "fire or explosion" as the MHE in 1994-1996 are 0.79 times as large as the odds of a vehicle being coded with "fire or explosion" as the MHE in 1987-1989. This 21.0 percent reduction in the odds of MHE being a "fire or explosion" between 1987-1989 and 1994-1996 is significant, [χ^2 = 17.34. (with 1 df); pr < 0.000].

It should be quickly pointed out, however, that the apparent 21.0 percent reduction in the odds of a vehicle being coded with "fire or explosion" as the MHE is not consistent across the states. That is to say, the data points in Figure 6 are widely scattered about the dashed line. Different states are showing significantly different "rates of change" in the odds of a vehicle being coded with "fire or explosion" as the MHE between 1987-1989 and 1994-1996, [$\chi^2_{(47)}$ = 408.40; pr < 0.000].[5]

Synopsis of Findings Regarding the Reliability of Fire-Related Data in FARS

When FARS data are compared to injury data derived from death certificates, it is clear that many fatally-injured passenger vehicle occupants who sustained thermal trauma, smoke inhalation, or asphyxiation were riding in vehicles that did not experience fires, i.e., were riding in vehicles that were not coded as having experienced fires in the FARS database. See Table 3.

During two different reporting periods, 1987-1989 and 1994-1996, large inconsistencies in the states' reporting of passenger vehicle fires were observed (Figures 1 and 3). During those same two reporting periods, 1987-1989 and 1994-1996, even larger inconsistencies were seen in the states' reporting of "most harmful event" (Figures 2 and 4).

Finally, between 1987-1989 and 1994-1996, inconsistencies were seen within states in the reporting of passenger vehicle fires (Figure 5) and "fire of explosion" as the MHE (Figure 6).

---

[4] Three states were omitted from Figure 6:

- SC: the odds of "fire or explosion" in 1994-1996 were infinite
- UT: the odds of "fire or explosion" in 1987-1989 were infinite
- VA: the odds of "fire or explosion" in 1987-1989 were 23.5, off the scale used in Figure 6

[5] Three states were omitted from this analysis (AK, RI, and WY). None of these states coded any vehicles in 1987-1989 or 1994-1996 with "fire or explosion" as the MHE. Thus the degrees of freedom in this analysis were reduced from 50 to 47.

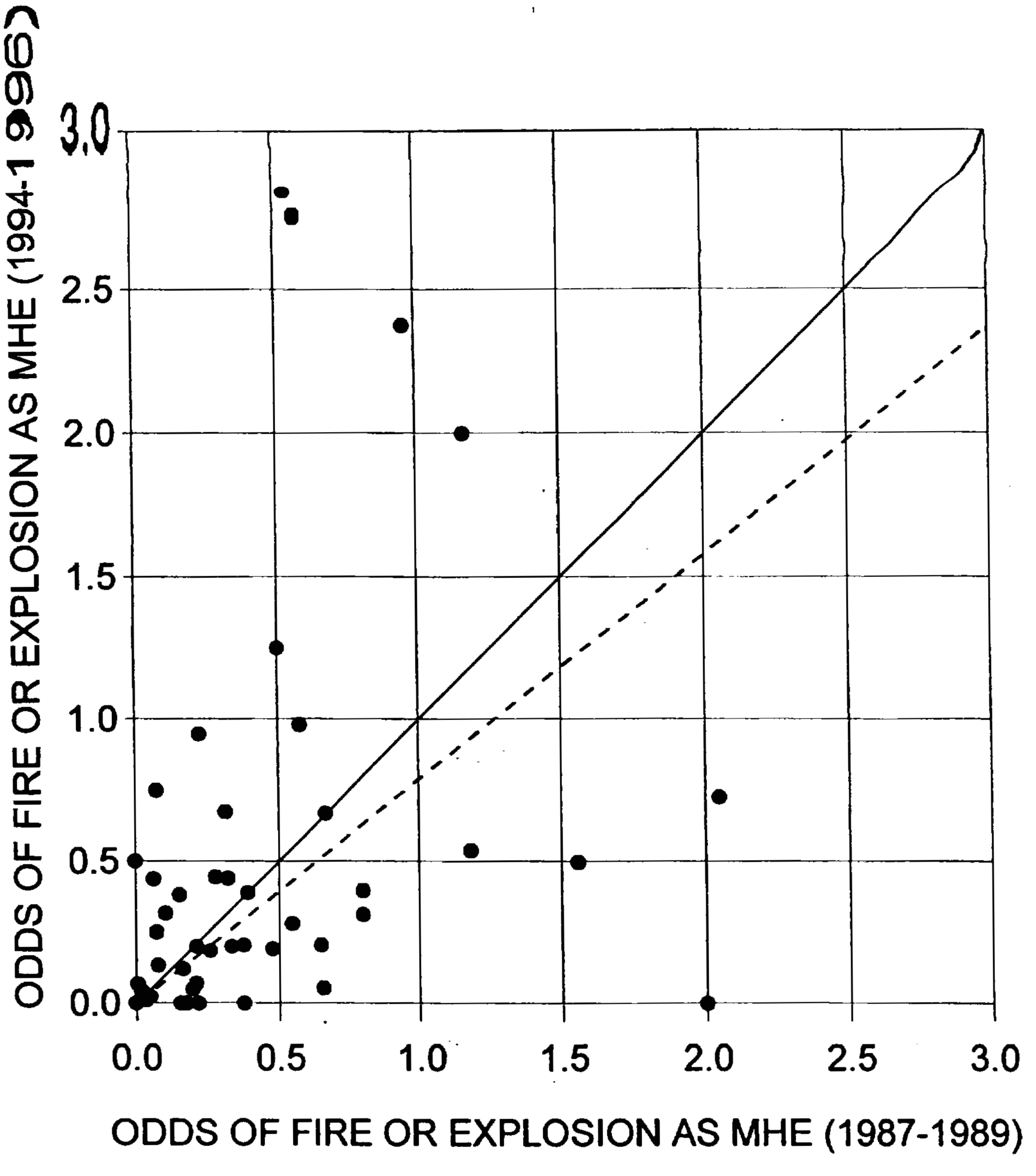


Figure 6: Odds of Fire or Explosion as MHE (1987-1989 vs. 1994-1996), by State

PASSENGER VEHICLES (CONTAINING ONE OR MORE FATALLY-INJURED OCCUPANTS) THAT DID OR DID NOT EXPERIENCE FIRES (FARS 1994-1996)

Between 1994 and 1996 some 84,876 passenger vehicles were involved in fatal crashes in the United States in which one or more occupants were fatally injured. Of those 84,876 passenger vehicles, 3,269 (3.85 percent) experienced fires (Figure 7).

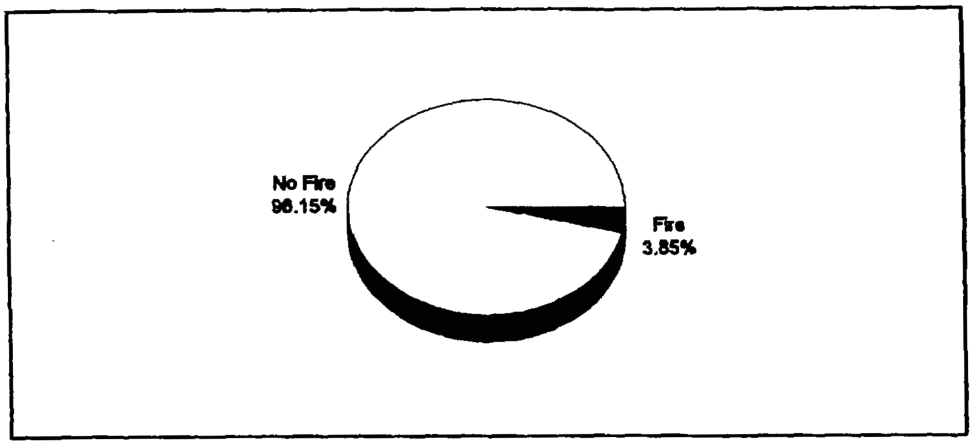


Figure 7: Passenger Vehicles Containing One or More Fatally-Injured Occupants (N = 84,876) that Did or Did Not Experience Fires (FARS 1994-1996)

The purpose of the discussion in this section is (a) to describe the circumstances and conditions surrounding those passenger vehicles (that contained one or more fatally-injured occupants) and that experienced fires, and (b) to compare and contrast the circumstances and conditions surrounding vehicles experiencing fires to the circumstances and conditions surrounding other passenger vehicles (that contained one or more fatally-injured occupants), but that did not experience fires.

This analysis was carried out with the knowledge that the "fire experience" information contained in FARS is highly inconsistent from state to state. It is likely that some of the 81,607 passenger vehicles represented in Figure 7 that were not coded as having experienced fires had, in fact, experienced fires. Such miscodes are referred to as false negatives. Conversely, some of the 3,269 passenger vehicles that were coded as having experienced fires may, in fact, not have experienced fires. These miscodes are referred to as false positives. There is no obvious way to determine whether false negative cases or false positive cases were more frequent in the present data set (i.e., in the 84,876 passenger vehicles in which one or more occupants were fatally-injured), but it seems reasonable to speculate that false negatives were probably more common than false positives.

If a FARS coder did not indicate that a given passenger vehicle experienced a fire, either (a) the vehicle did not experience a fire or (b) the coder and/or the investigating officer failed to indicate or assert that the vehicle experienced a fire. In the absence of any specific or definitive information on the police accident report (PAR) indicating that a given passenger vehicle experienced a fire, the likely default response of the FARS coder is that the vehicle did not experience a fire. On the other hand, if a FARS coder has indicated that a given passenger vehicle experienced a fire, there was likely some information available to the coder that the vehicle did indeed experience a fire.

In view of the discussion in the last two paragraphs, it is likely that any differences observed between passenger vehicles that experienced fires, and passenger vehicles that did not experience fires, will tend to err in a conservative direction, i.e., false negative codes should have been more common that false positive codes.

Data used in the Analysis[6]

Table 7 summarizes the data used in these analyses.

Table 7: The Numbers of Passenger Vehicles that Contained One or More Fatally-Injured Occupants, by Type of Crash (Single-Vehicle vs. Multi- Vehicle), Vehicle Class, and Fire Experience

Type of Crash and Vehicle Class		Fire Experience		Total
		No Fire (%)	Fire (%)	
Single-Vehicle Crashes	Passenger Cars	24,149 (95.50)	1,138 (4.50)	25,287
	Pickups	9,350 (96.27)	362 (3.73)	9,712
	Utility Vehicles	3,453 (96.80)	114 (3.20)	3,567
	Vans	1,887 (96.03)	78 (3.97)	1,965
	Other Passenger Vehicles	80 (94.12)	5 (5.88)	85
Multi-Vehicle Crashes	Passenger Cars	32,848 (97.01)	1,012 (2.99)	33,860
	Pickups	6,043 (94.07)	381 (5.93)	6,424
	Utility Vehicles	1,621 (94.57)	93 (5.43)	1,714
	Vans	2,110 (96.39)	79 (3.61)	2,189
	Other Passenger Vehicles	66 (90.41)	7 (9.59)	73
Total		81,607 (96.15)	3,269 (3.85)	84,876

[6]For more detail on the data, methods, and statistics employed see Griffin, 1999.

Passenger Vehicles Involved in Single Vehicle Crashes[7]

Within vehicle class, vehicles that did and did not experience fires were quite comparable in terms of location (urban/rural) (Figure 8) and highway class (route signing)(Figure 9).

Of the 45 categories in FARS that describe the "first harmful event" in a crash, the two categories that were most often used for the 40,616 passenger vehicles represented in Figure 10 were "overturn" and "collision with a tree." For those vehicles that did not experience fires, "overturn" was a relatively more common outcome. For 16.6 percent of the passenger cars, 29.01 percent of the pickups, 46.5 percent of the utility vehicles, and 34 percent of the vans, "overturn" was coded as the "first harmful event" in the crash. By contrast, the percentages for those vehicles that did experience fires were 5.4, 10.2, 12.3, and 10.3 for passenger cars, pickups, utility vehicles, and vans.

When "rollover" was used in Figure 11 to compare passenger vehicles that did and did not experience fires, the same phenomenon that was seen with "first harmful event" is repeated. Rollovers as "first events" in the crash were relatively more common for vehicles that did not experience fires. Secondary or "subsequent" rollover was comparable for vehicles that did and did not experience fires.

Crashes in which passenger vehicles experienced fires were relatively more common after dark (Figure 12). For passenger cars that experienced fires, 75.0 percent were recorded after dark. For pickups, utility vehicles, and vans, the percentages were, 68.8, 71.9, and 64.1 percent, respectively. For those vehicles that did not experience fires, the figures for passenger cars, pickups, utility vehicles, and vans were, respectively, 60.94, 61.84, 56.68, and 45.15 percent.

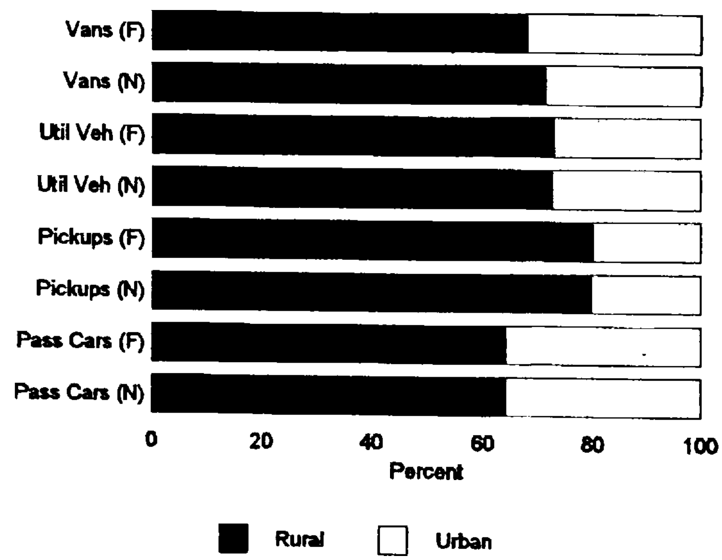
The great majority of drivers in these single-vehicle crashes (those that experienced fires and those that did not) were male. However, vehicles that experienced fires were somewhat more likely to have been driven by males (Figure 13).[8]

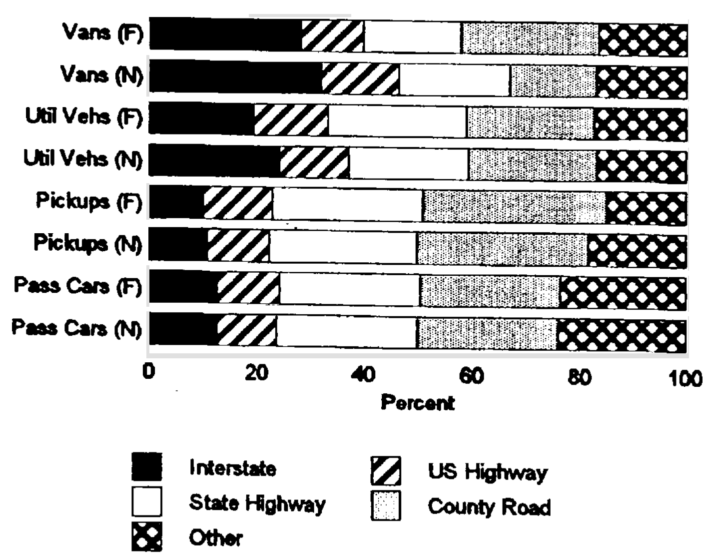
The initial points of impact for passenger vehicles that did and did not experience fires in single-vehicle crashes are shown in Figures 14 through 17 (for passenger cars, pickups, utility vehicles, and vans, respectively). The most conspicuous difference between the vehicles that did and did not experience fires in these figures was "non-collision." The initial points of impact for non-fire vehicles are much more apt to be coded as "non-collision," which is in keeping with Figures 10 and 11. For all four classes of vehicles that experienced fires, 12 o'clock was the most common point of impact. For vehicles that did not experience fires, 12 o'clock was also the most common point of impact, except for utility vehicles which were more apt to overturn (i.e., non-collision, 42.1 percent) than strike an object head-on (i.e., 12 o'clock, 25.5 percent).

---

[7]Note that relatively few utility vehicles and vans involved in single-vehicle crashes experienced fires, 114 and 78, respectively (Table 7).

[8]The percentages of pickup drivers who were male were not significantly different (at $\alpha = 0.05$) with regard to fire experience.


Vans (F)
Vans (N)
Util Veh (F)
Util Veh (N)
Pickups (F)
Pickups (N)
Pass Cars (F)
Pass Cars (N)
0
20
40
60
80
100
Percent
Rural
Urban


Vans (F)
Vans (N)
Util Vehs (F)
Util Vehs (N)
Pickups (F)
Pickups (N)
Pass Cars (F)
Pass Cars (N)
0
20
40
60
80
100
Percent
Interstate
US Highway
State Highway
County Road
Other

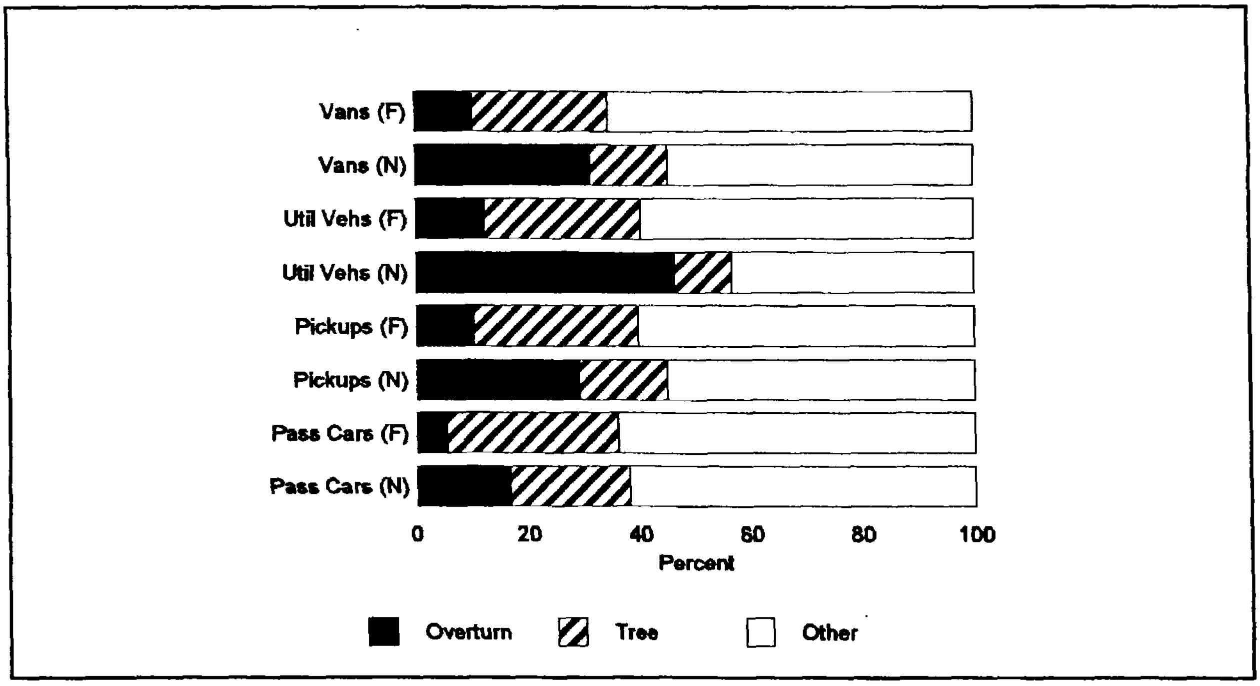


Figure 10: Vehicles Involved in Single-Vehicle Crashes by First Harmful Event, Vehicle Class, and Fire Experience [No Fire (N); Fire (F)]

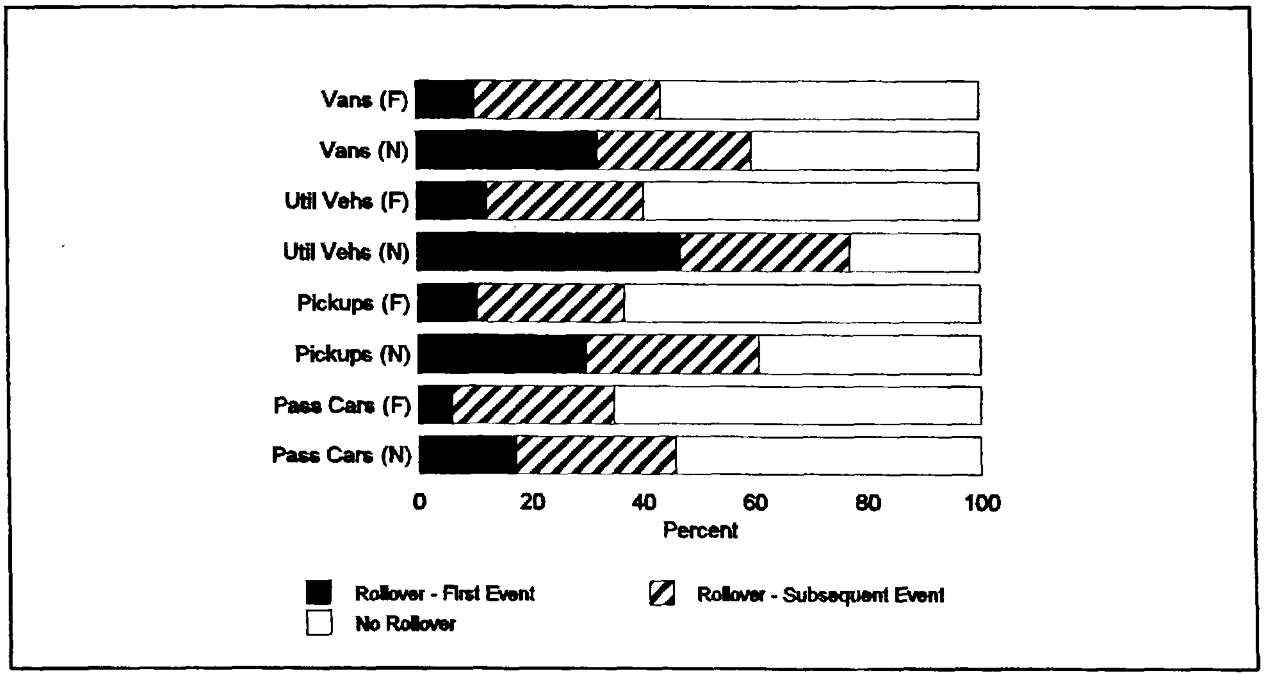
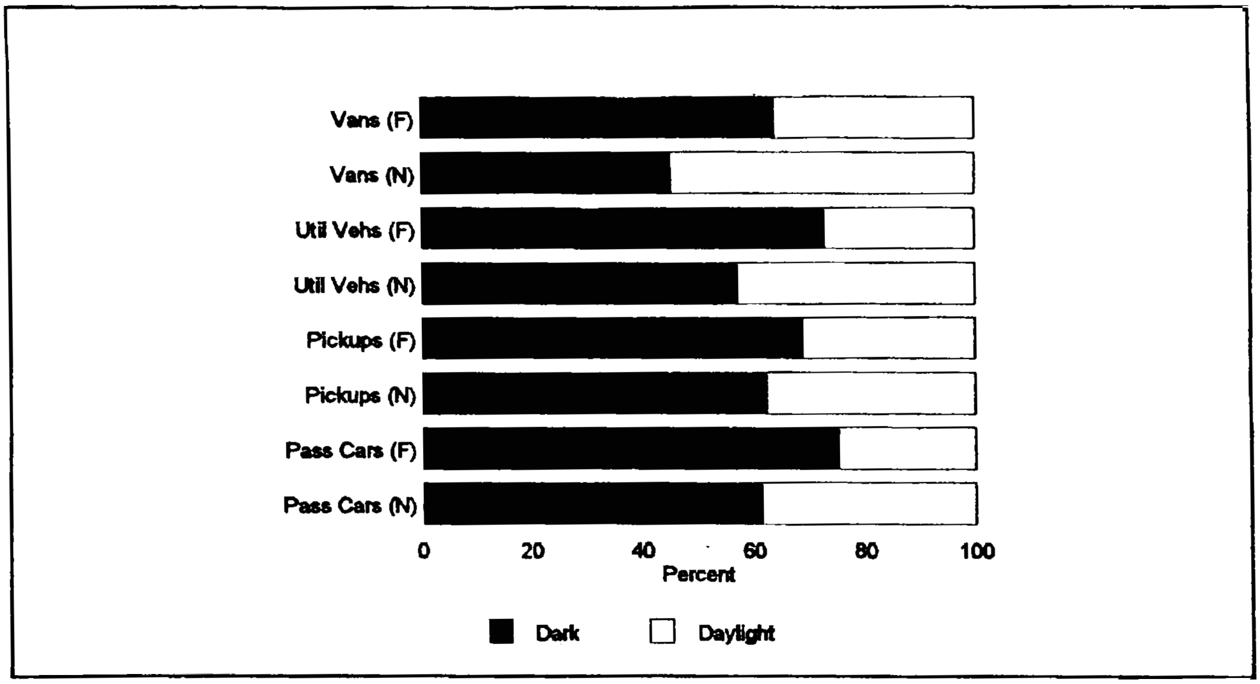
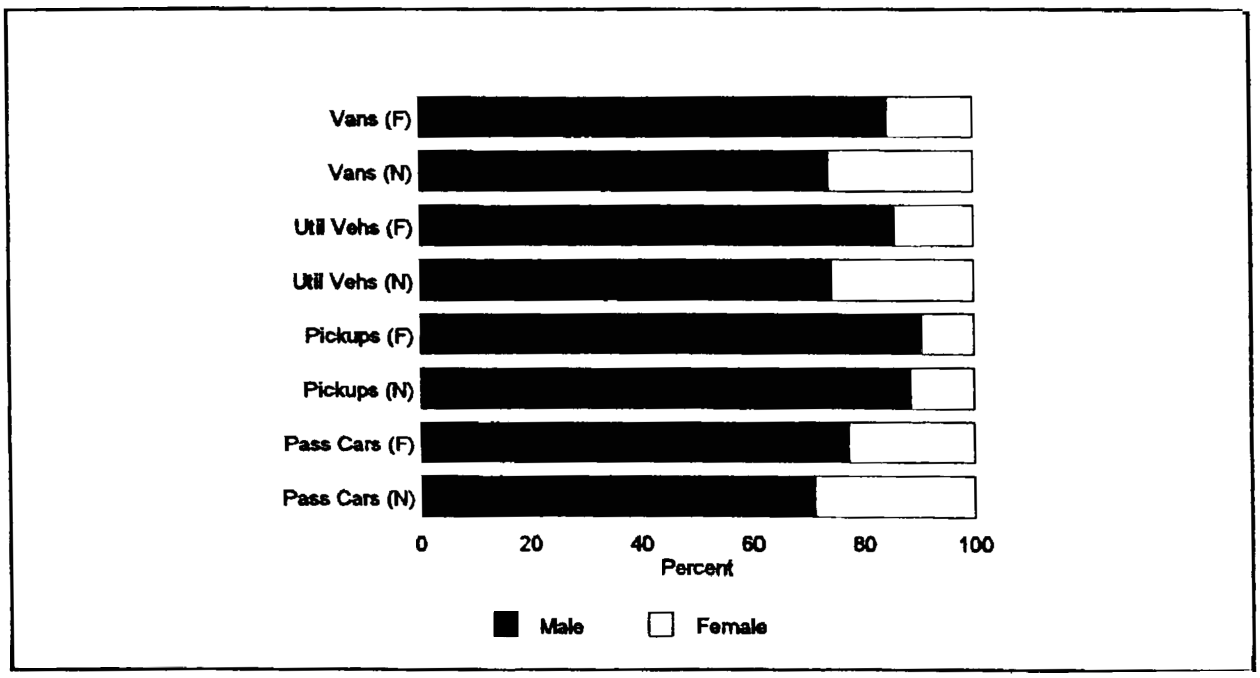


Figure 11: Vehicles Involved in Single-Vehicle Crashes by Rollover, Vehicle Class, and Fire Experience [No Fire (N); Fire (F)]


Vans (F)
Vans (N)
Util Vehs (F)
Util Vehs (N)
Pickups (F)
Pickups (N)
Pass Cars (F)
Pass Cars (N)
0
20
40
60
80
100
Percent
Dark
Daylight


Vans (F)
Vans (N)
Util Vehs (F)
Util Vehs (N)
Pickups (F)
Pickups (N)
Pass Cars (F)
Pass Cars (N)
0
20
40
60
80
100
Percent
Male
Female

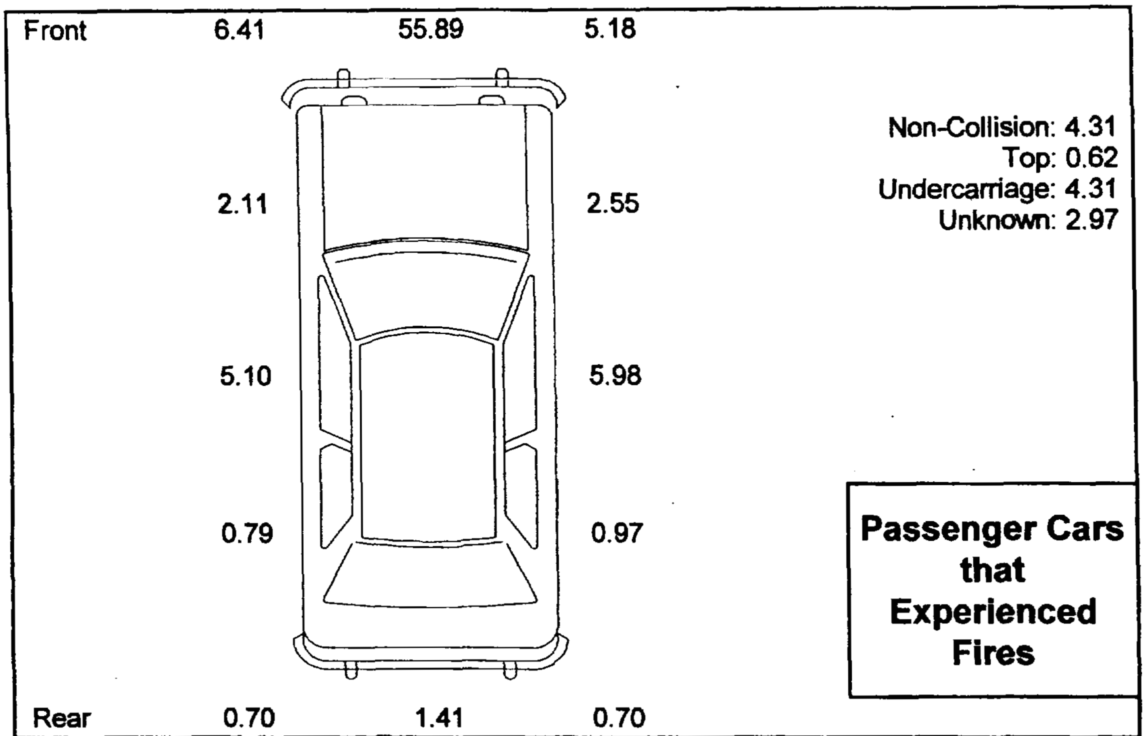


Figure 14(a): Percentage Distribution of <u>Initial</u> Impact Points on Passenger Cars that Experienced Fires in Single-Vehicle Crashes (N=1,138)

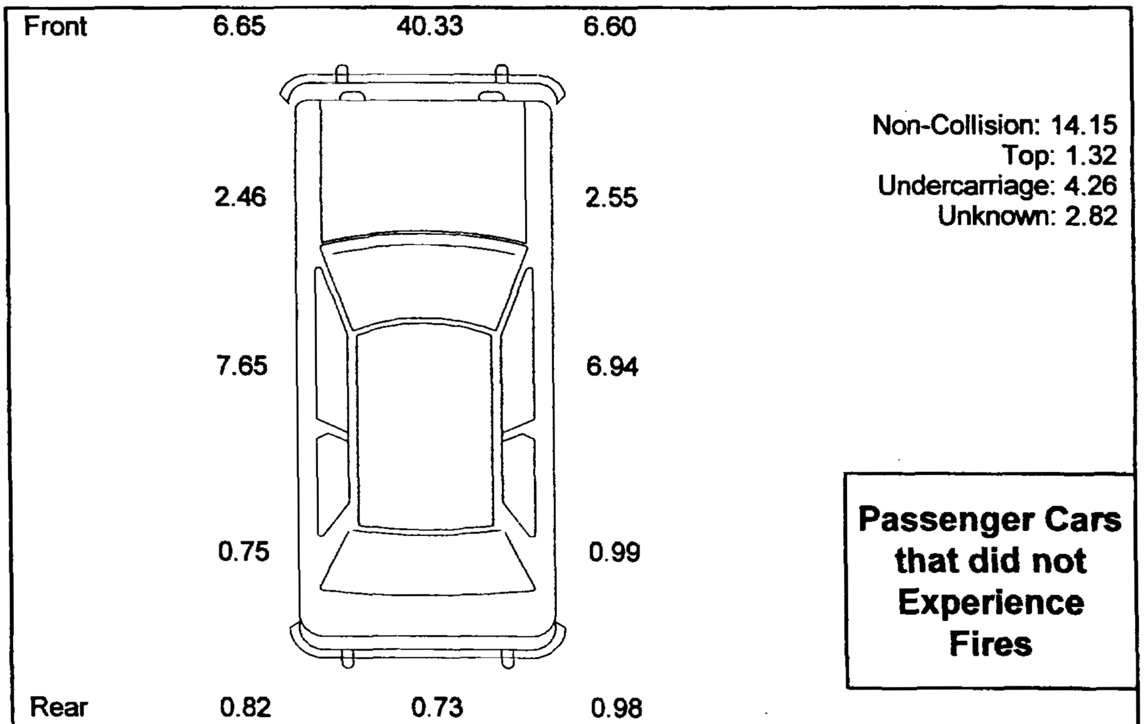


Figure 14(b): Percentage Distribution of <u>Initial</u> Impact Points on Passenger Cars that Did Not Experience Fires in Single-Vehicle Crashes (N=24,149)

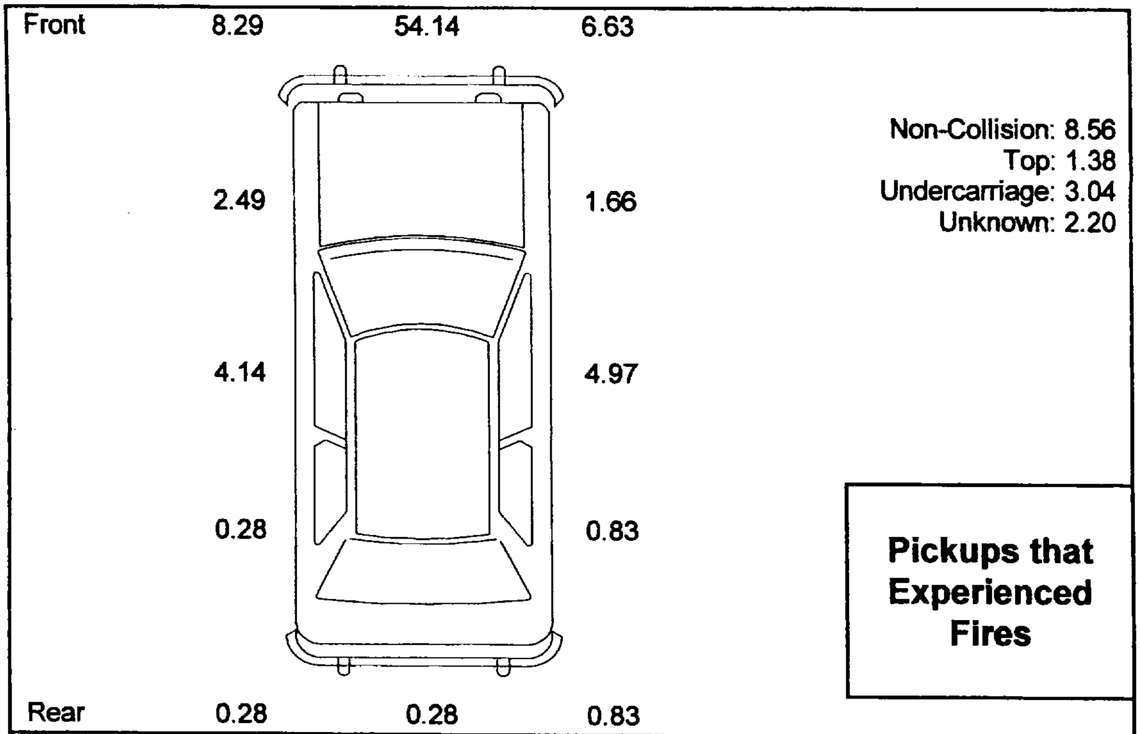


Figure 15(a): Percentage Distribution of <u>Initial</u> Impact Points on Pickups that Experienced Fires in Single-Vehicle Crashes (N=362)

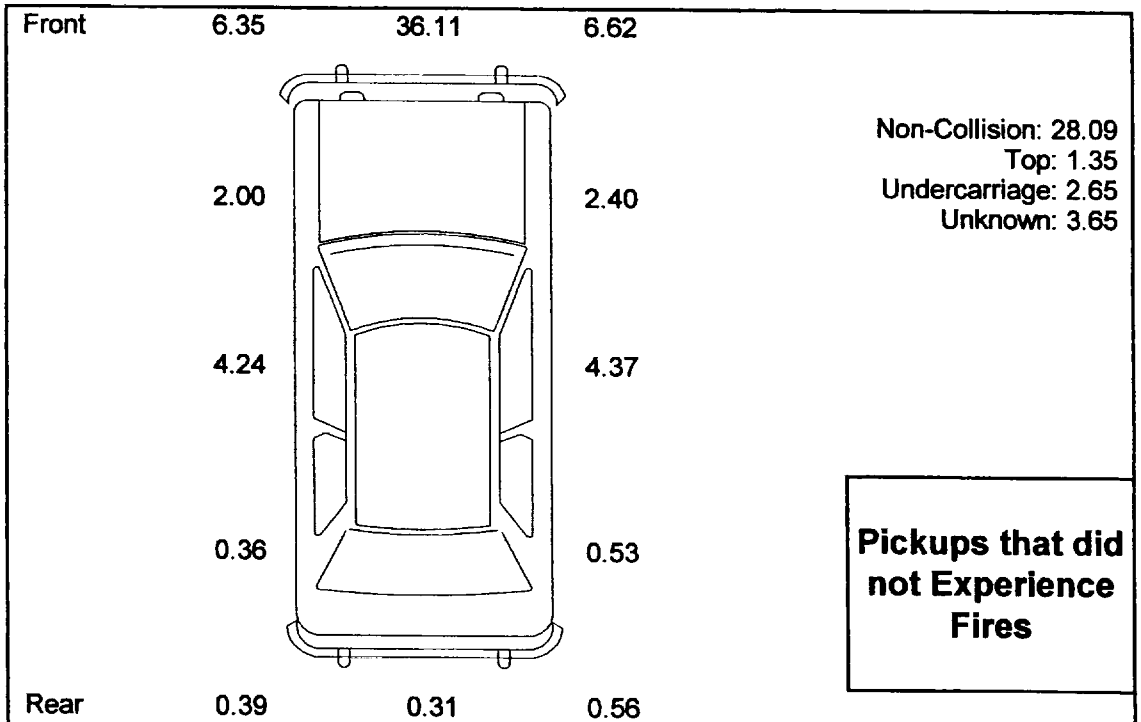


Figure 15(b): Percentage Distribution of <u>Initial</u> Impact Points on Pickups that Did Not Experience Fires in Single-Vehicle Crashes (N=9,350)

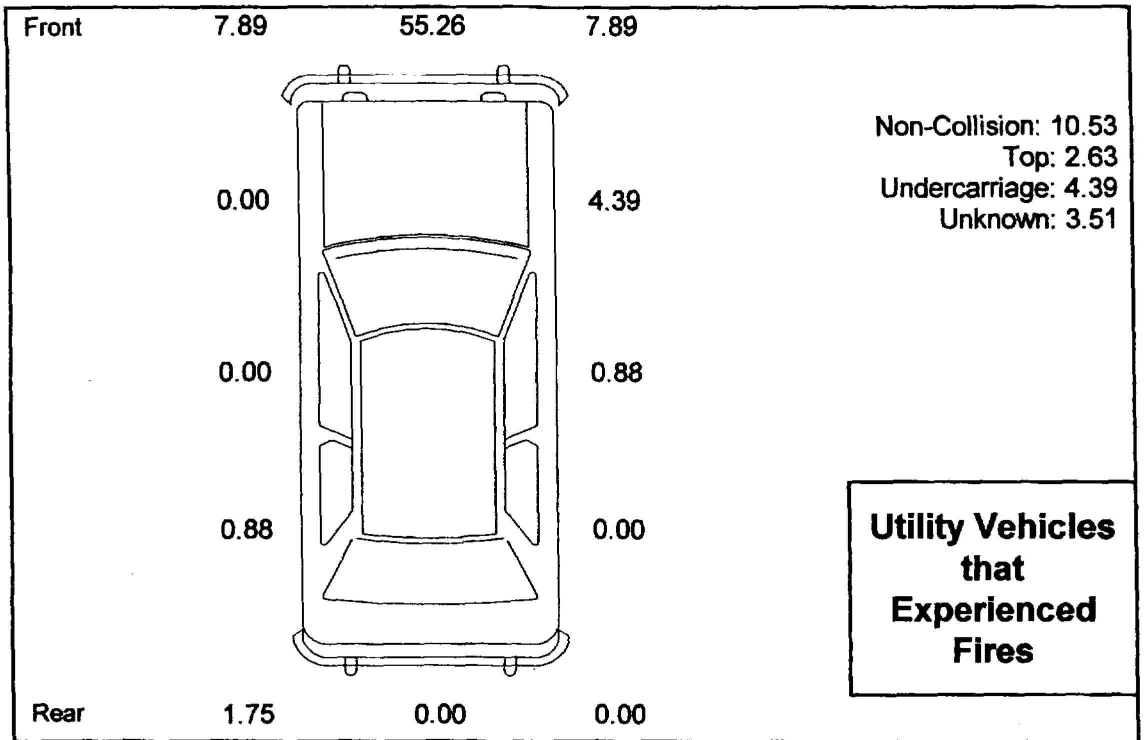


Figure 16(a): Percentage Distribution of Initial Impact Points on Utility Vehicles that Experienced Fires in Single-Vehicle Crashes (N=114)

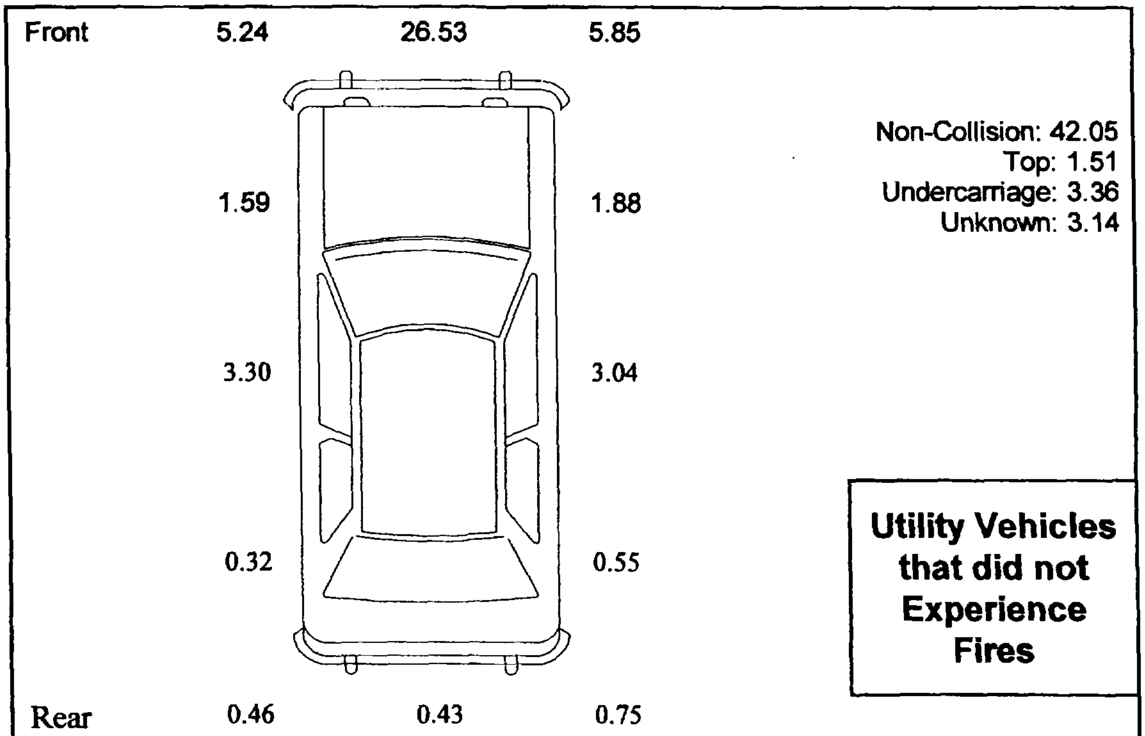


Figure 16(b): Percentage Distribution of Initial Impact Points on Utility Vehicles that Did Not Experience Fires in Single-Vehicle Crashes (N=3,453)

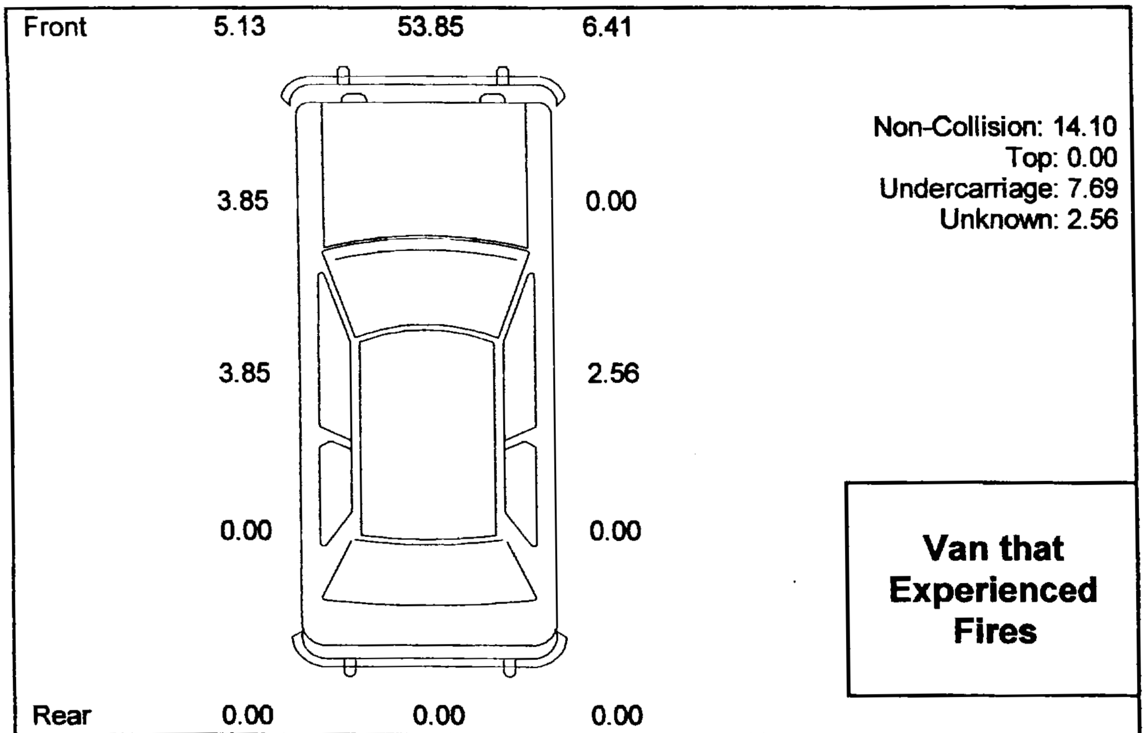


Figure 17(a): Percentage Distribution of <u>Initial</u> Impact Points on Vans that Experienced Fires in Single-Vehicle Crashes (N=78)

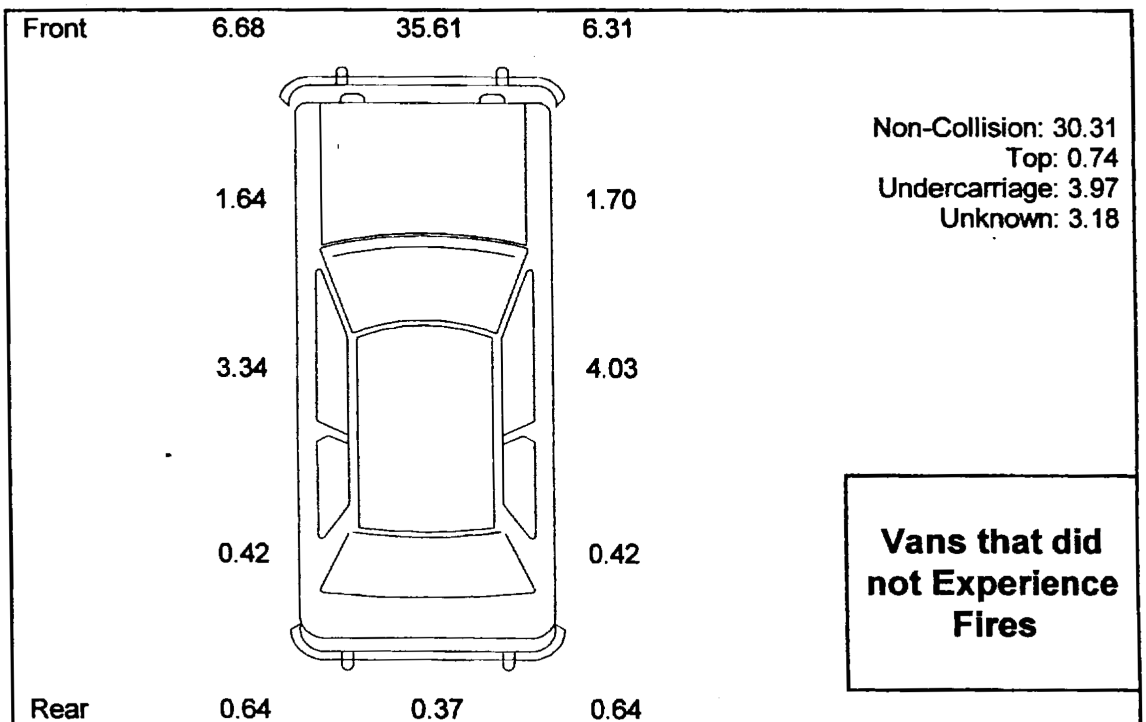


Figure 17(b): Percentage Distribution of <u>Initial</u> Impact Points on Vans that Did Not Experience Fires in Single-Vehicle Crashes (N=1,887)

Passenger Vehicles Involved in Multi-Vehicle Crashes[9]

Between 1994 and 1996 there were 44,260 passenger vehicles involved in fatal, multi-vehicle crashes in this country in which one or more vehicle occupants were killed. These 44,260 vehicles were involved in 41,968 fatal, multi-vehicle crashes. Almost 85 percent of the multi-vehicle crashes in which these vehicles were involved were two-vehicle crashes (Table 8).

Table 8: Multi-Vehicle Crashes Involving at Least One Passenger Vehicle with a Fatally-Injured Occupant (FARS 1994-1996)

Vehicles Involved in Crashes*	Crash Frequency	Cumulative Crashes	Cumulative Percent
2	35,575	35,575	84.77
3	5,067	40,642	96.84
4	928	41,570	99.05
5+	398	41,968	100.00

*The number of vehicle forms submitted was used to define the number of vehicles involved in crashes

Passenger cars and pickups that were involved in multi-vehicle crashes and that experienced fires were relatively more likely to have occurred in rural areas. For utility vehicles and vans, the urban/rural differences were not significant (at $\alpha = 0.05$) with regard to fire (Figure 18).

For three of the four vehicle classes (passenger cars, pickups, and vans), vehicle fires were relatively more common on interstates (Figure 19). For utility vehicles, the difference was not significant (at $\alpha = 0.05$).

Passenger cars, pickups, and utility vehicles that experienced fires in multi-vehicle crashes were relatively more likely to be striking vehicles (as opposed to struck vehicles). Vans that experienced fires in multi-vehicle crashes appeared more likely to be striking vehicles, but this difference was not significant (at $\alpha = 0.05$) (Figure 20).

Passenger cars and pickups that experienced fires in multi-vehicle crashes were also relatively more likely to have occurred during hours of darkness, but for utility vehicles and vans, the differences were not significant (at $\alpha = 0.05$)(Figure 21).

For passenger cars and utility vehicles that experienced fires in multi-vehicle crashes, the drivers were more likely to be males. For pickups and vans, the differences in the percentages of

[9]Note that the numbers of utility vehicles and vans in the data set that experienced fires in multi-vehicle crashes were relatively few, 93 and 79, respectively (Table 7).

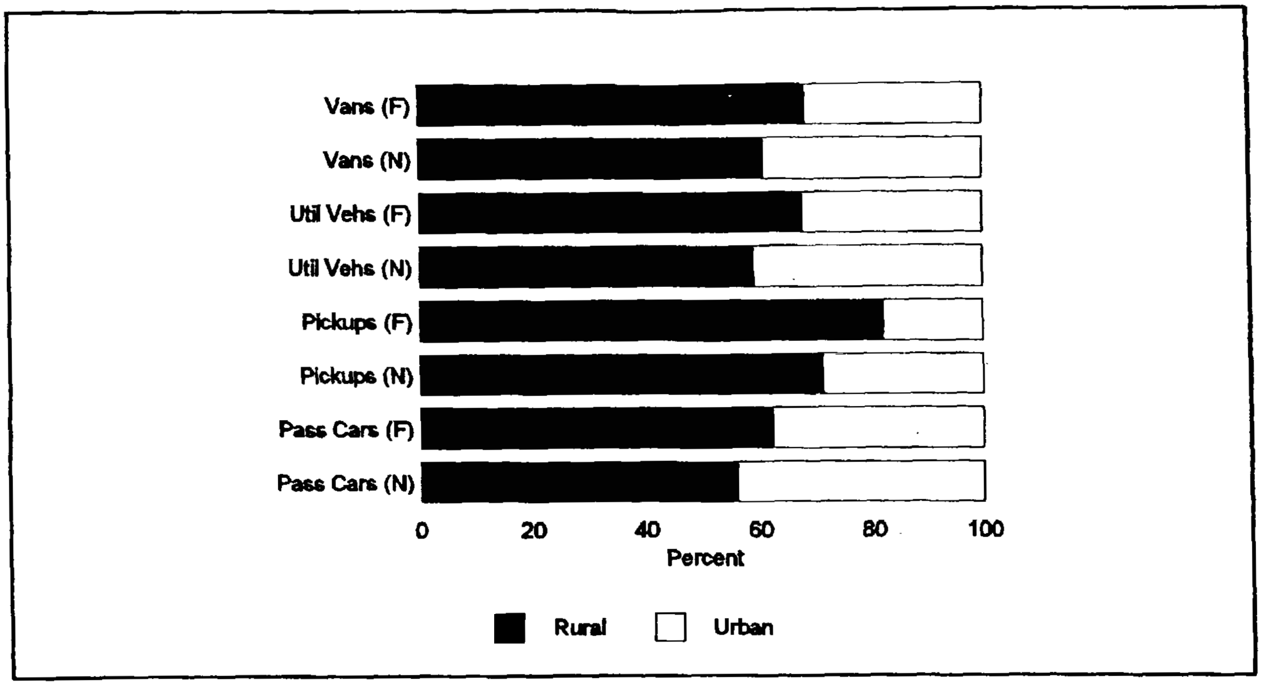


Figure 18: Vehicles Involved in Multi-Vehicle Crashes by Location (Urban/Rural), Vehicle Class, and Fire Experience [No Fire (N); Fire (F)]

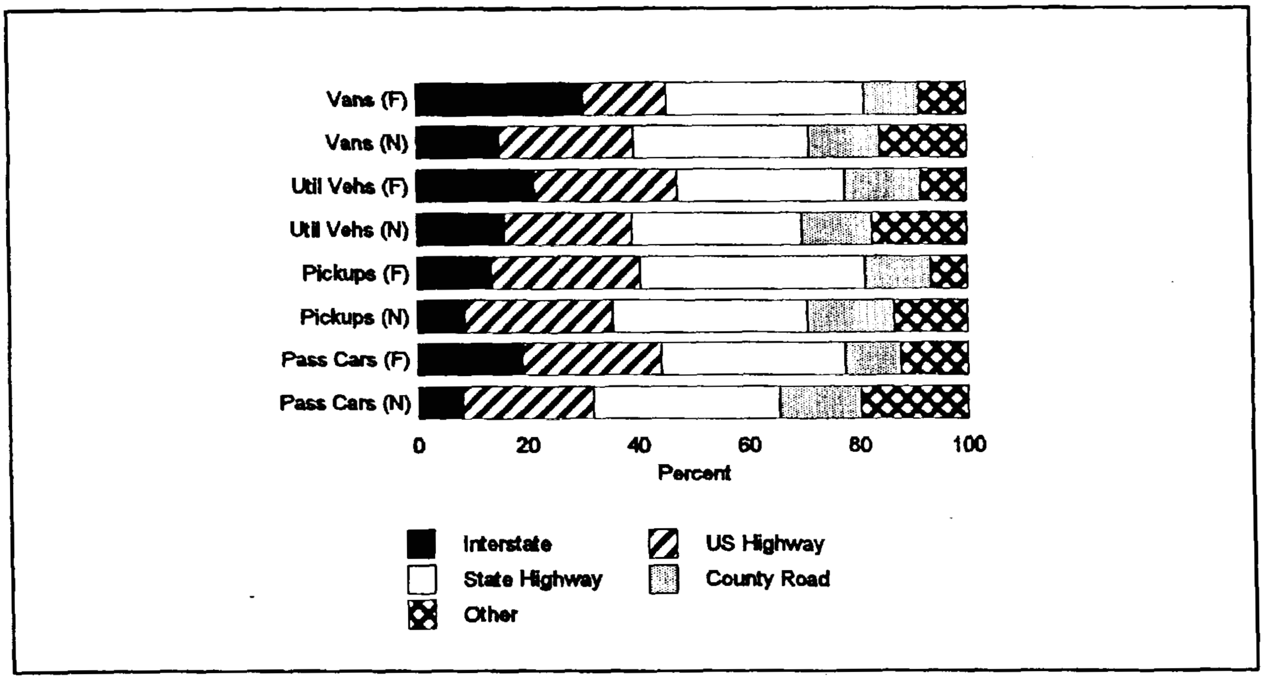


Figure 19: Vehicles Involved in Multi-Vehicle Crashes by Highway Class (Route Signing), Vehicle Class, and Fire Experience [No Fire (N); Fire (F)]

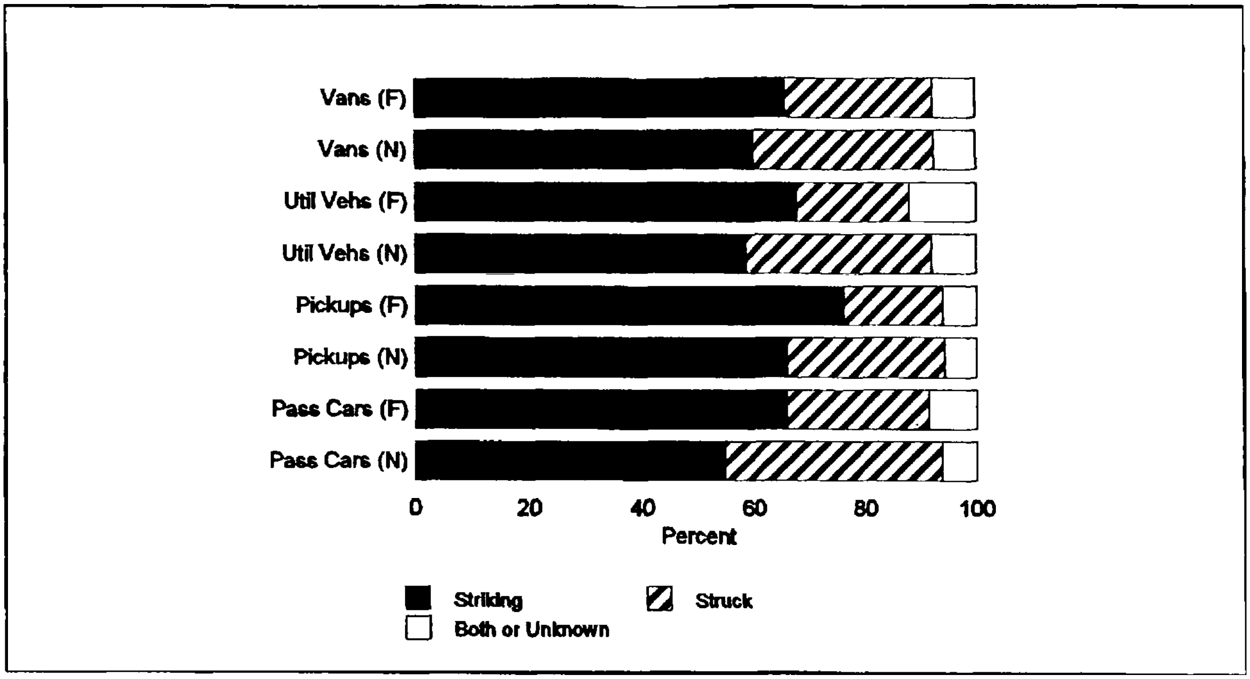


Figure 20: Vehicles Involved in Multi-Vehicle Crashes by Role in Crash, Vehicle Class, and Fire Experience [No Fire (N); Fire (F)]

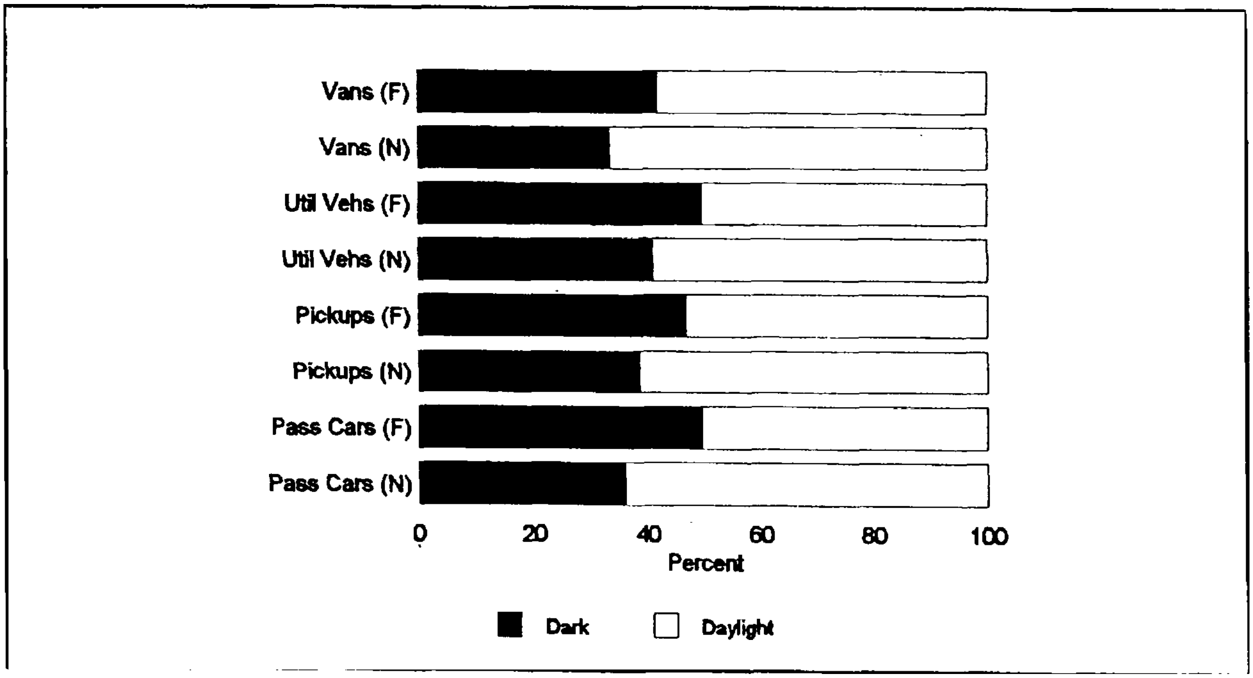


Figure 21: Vehicles Involved in Multi-Vehicle Crashes by Daylight (Dark/Daylight), Vehicle Class, and Fire Experience [No Fire (N); Fire (F)]

males who were driving vehicles that did or did not experience fires were not significant (at $\alpha = 0.05$)(Figure 22).

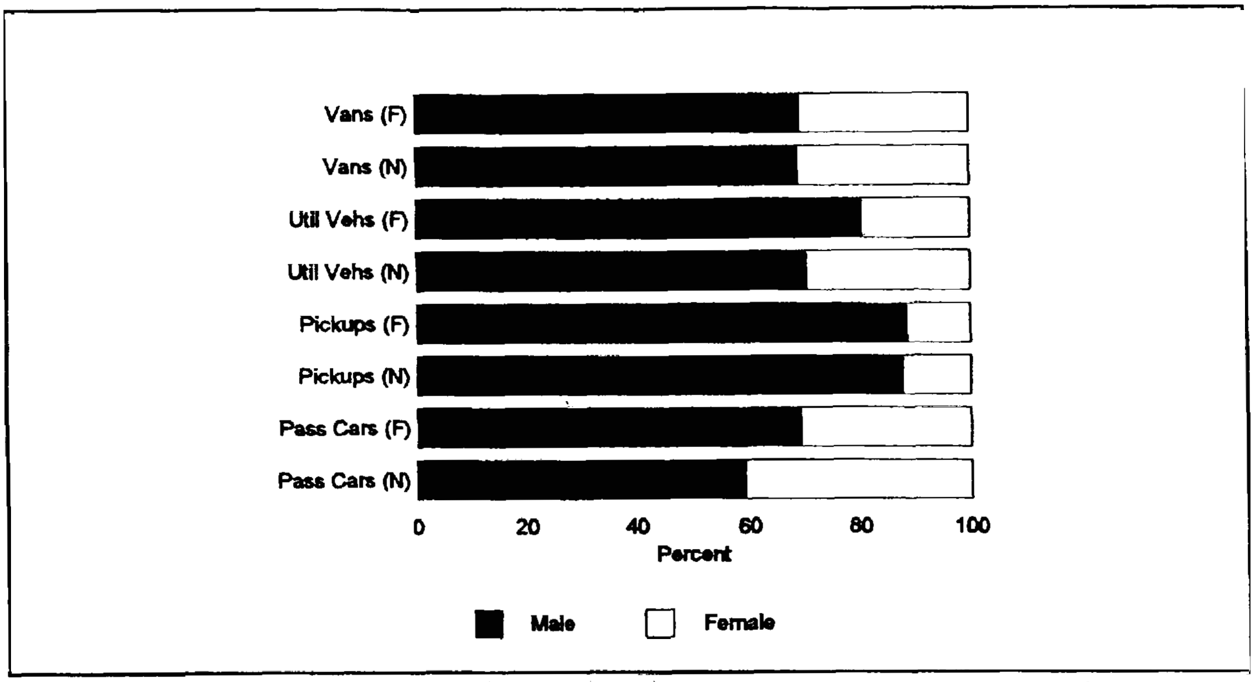


Figure 22: Vehicles Involved in Multi-Vehicle Crashes by Sex of Driver, Vehicle Class, and Fire Experience [No Fire (N); Fire (F)]

Figures 23 through 26 depict, respectively, the initial points of impact for passenger cars, pickups, utility vehicles, and vans involved in multi-vehicle crashes. For passenger cars that experienced fires, impacts at 12 o'clock and 6 o'clock were over represented when compared to vehicles that did not experience fires, while impacts at 3 o'clock and 9 o'clock were under represented (Figure 23). Initial impact points for pickups that did and did not experience fires were fairly comparable (Figure 24). Utility vehicles and vans that experienced fires were somewhat more apt to have initial points of impact at 6 o'clock (Figures 25 and 26).

Summary Comments

It seems reasonable to assert that the great majority of the 84,876 passenger vehicles considered in this study were involved in severe crashes since all of the crash-involved, passenger vehicles in the data set contained at least one fatally-injured occupant. Granted that most of the passenger vehicles studied were involved in severe crashes, the differences found between those vehicles that experienced fires and those that did not are all the more interesting.

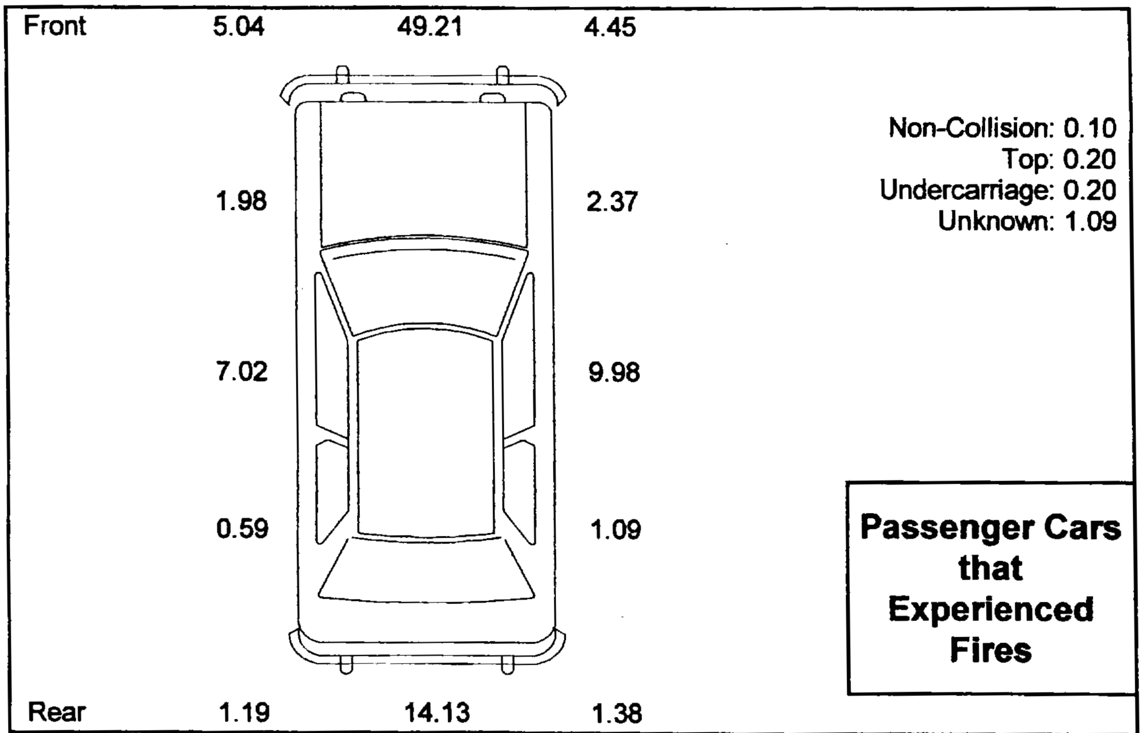


Figure 23(a): Percentage Distribution of <u>Initial</u> Impact Points on Passenger Cars that Experienced Fires in Multi-Vehicle Crashes (N=1,012)

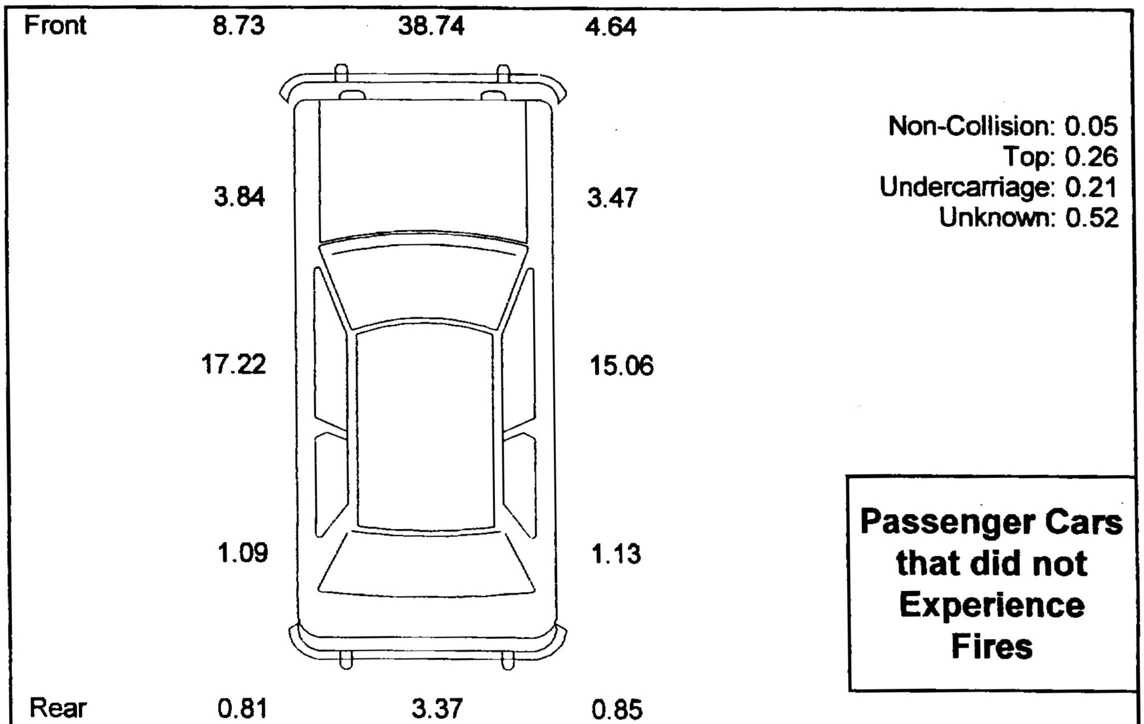


Figure 23(b): Percentage Distribution of <u>Initial</u> Impact Points on Passenger Cars that Did Not Experience Fires in Multi-Vehicle Crashes (N=32,848)

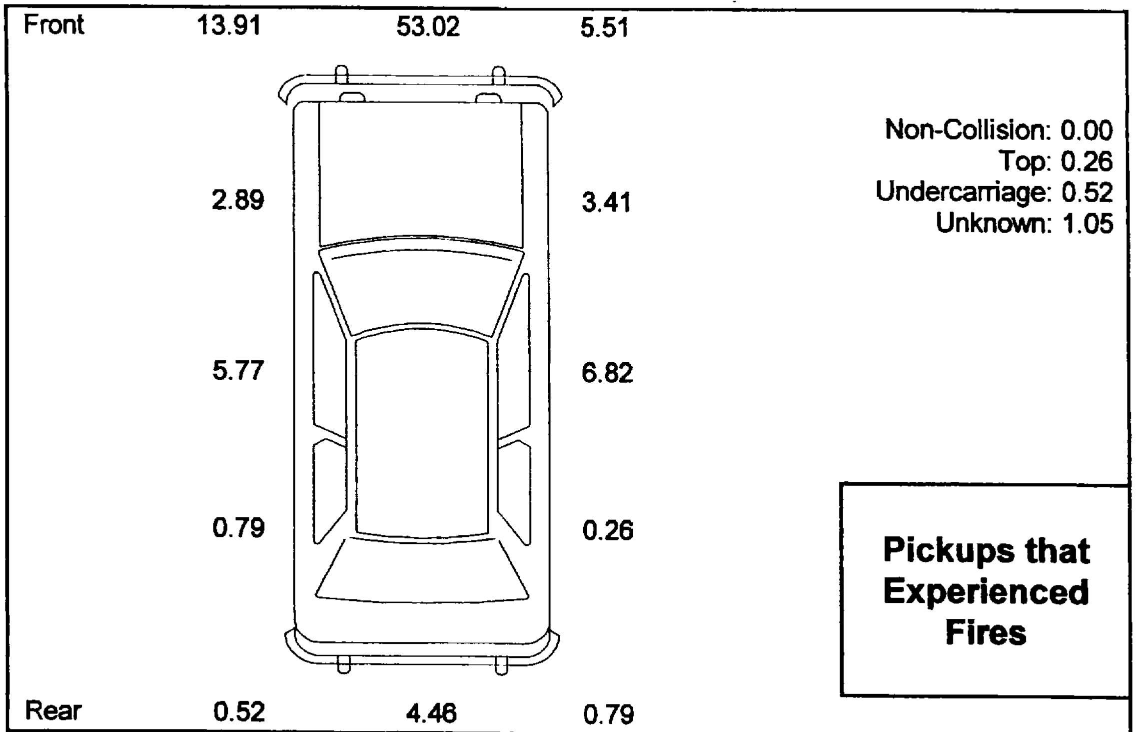


Figure 24(a): Percentage Distribution of <u>Initial</u> Impact Points on Pickups that Experienced Fires in Multi-Vehicle Crashes (N=381)

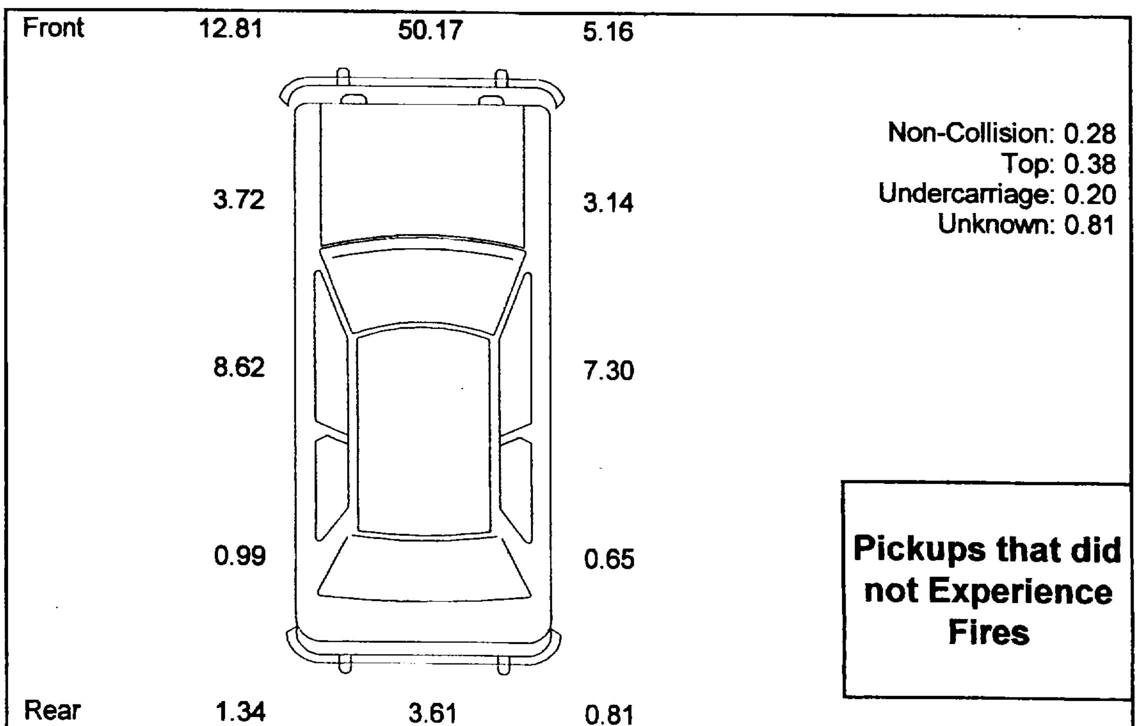


Figure 24(b): Percentage Distribution of <u>Initial</u> Impact Points on Pickups that Did Not Experience Fires in Multi-Vehicle Crashes (N=6,043)

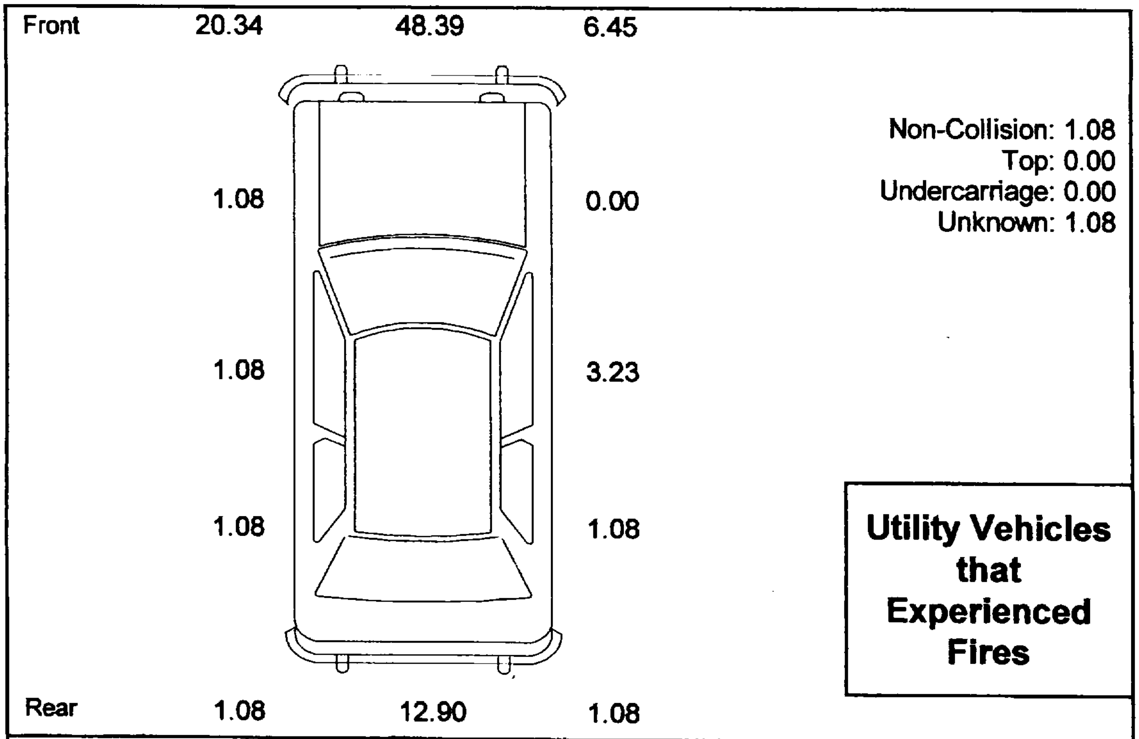


Figure 25(a): Percentage Distribution of <u>Initial</u> Impact Points on Utility Vehicles that Experienced Fires in Multi-Vehicle Crashes (N=93)

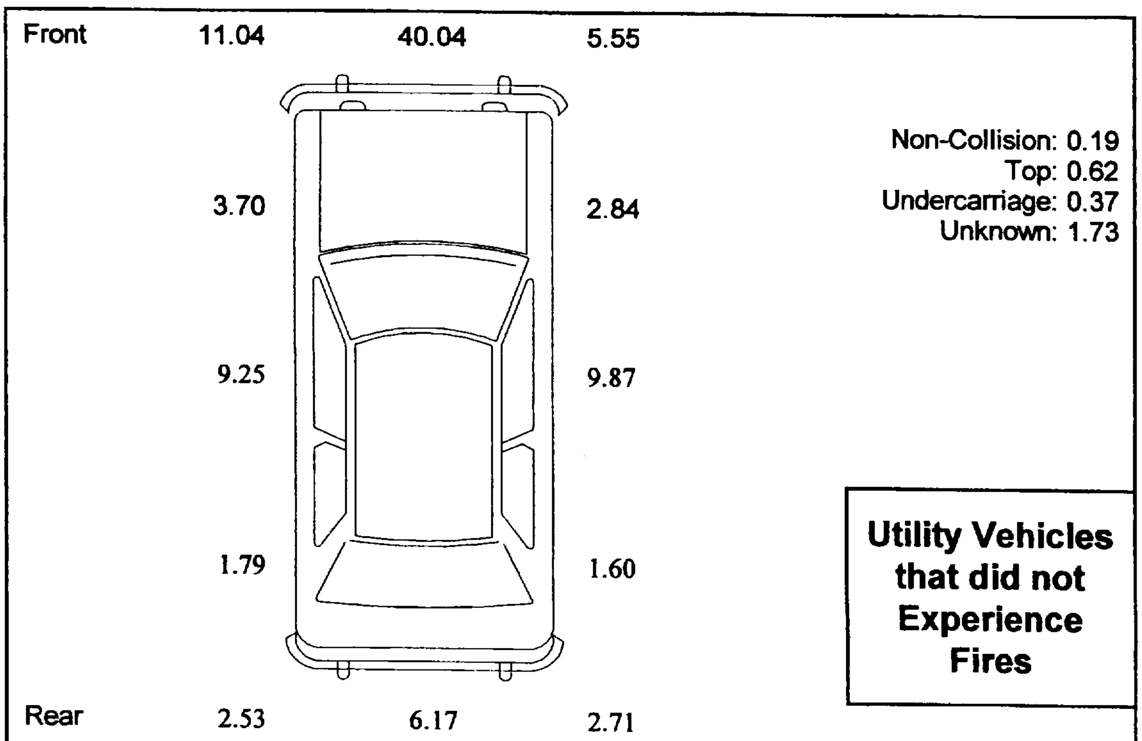


Figure 25(b): Percentage Distribution of <u>Initial</u> Impact Points on Utility Vehicles that Did Not Experience Fires in Multi-Vehicle Crashes (N=1,621)

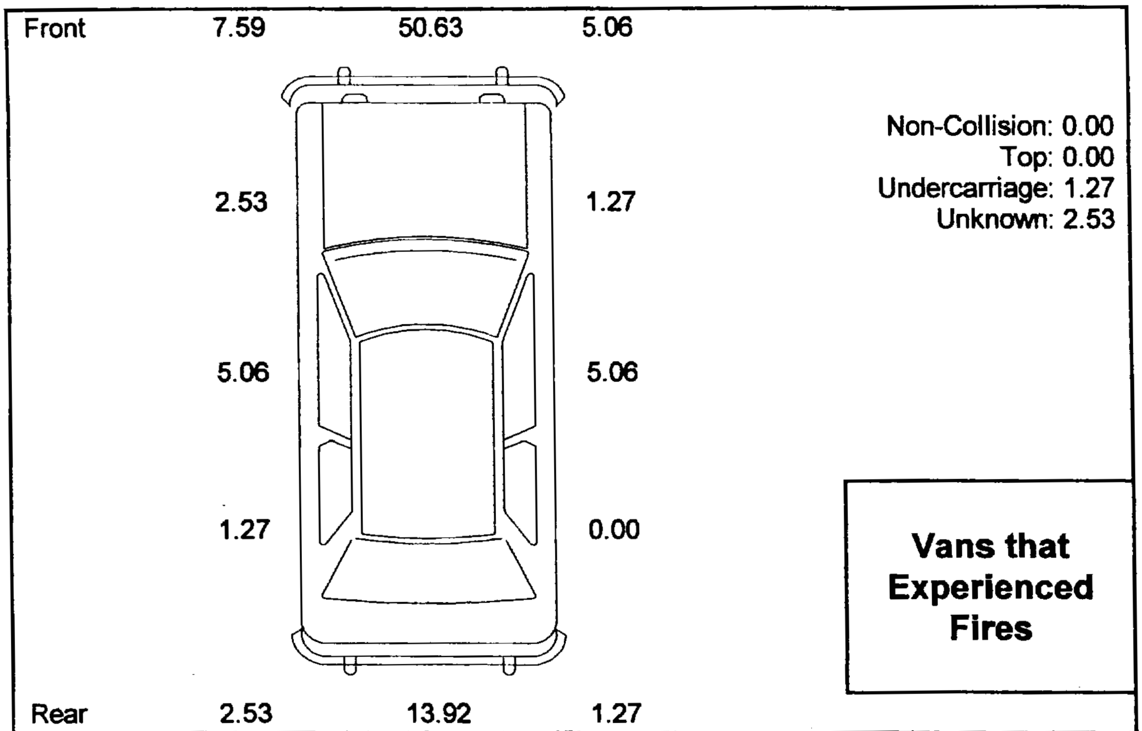


Figure 26(a): Percentage Distribution of <u>Initial</u> Impact Points on Vans that Experienced Fires in Multi-Vehicle Crashes (N=79)

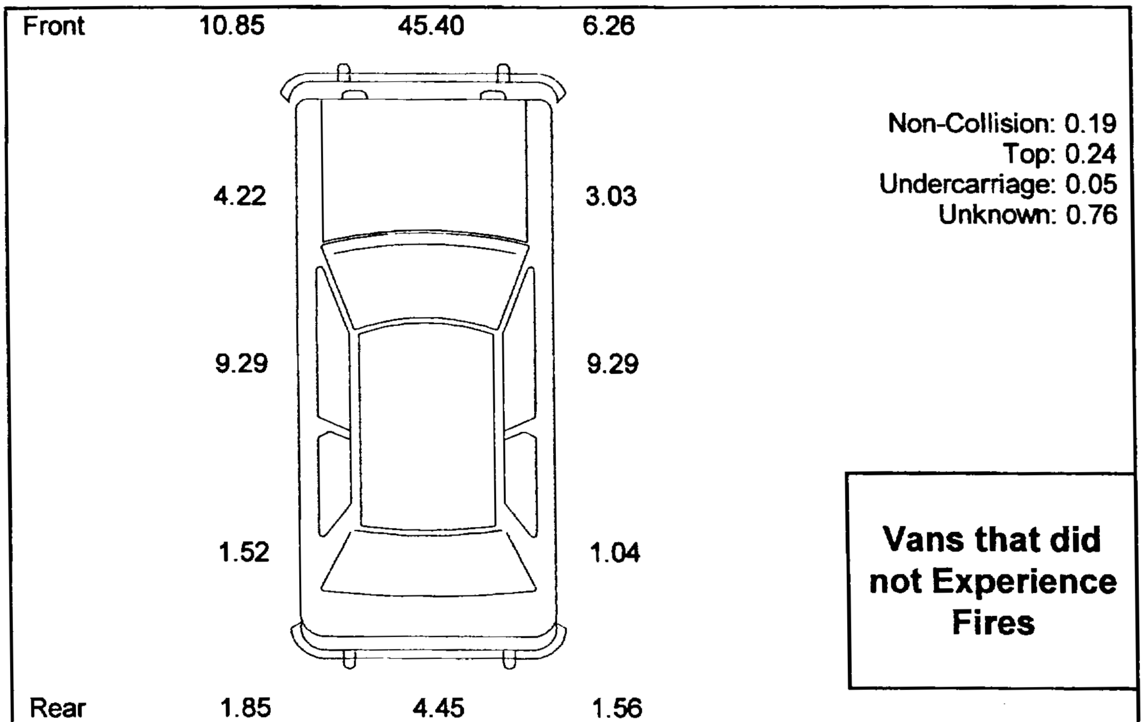


Figure 26(b): Percentage Distribution of <u>Initial</u> Impact Points on Vans that Did Not Experience Fires in Multi-Vehicle Crashes (N=2,110)

In order to summarize some of the differences found in the previous section, the relative odds of fires in passenger vehicles were calculated for several antecedent or predisposing factors (e.g., darkness, male drivers, vehicle rollovers, etc.). Table 9 demonstrates how the relative odds of vehicles experiencing fires were calculated for these factors.

Table 9: Explanation of Relative Odds

		Antecedent Factor			
		Dark	Daylight	Equation for Relative Odds (RO)	Significance
Example 1: Passenger Cars in Single-Vehicle Crashes	Fire	854 (a)	283 (c)	RO = a/b ÷ c/d	z = 9.25 pr < 0.05
	No Fire	14,718 (b)	9,306 (d)	1.91 = (854/14,718) ÷ (283/9,306)	
	Interpretation: The odds that a passenger car involved in a single-vehicle crash after dark (in which one or more vehicle occupants are killed) will experience a fire are 1.91 times greater than the odds that a passenger car involved in a single-vehicle crash during daylight hours (in which someone is killed) will experience a fire. The relative odds ratio of 1.91 is significantly different from 1.0 at α = 0.05.				

		Antecedent Factor			
		Striking	Struck	Equation for Relative Odds (RO)	Significance
Example 2: Utility Vehicles in Multi-Vehicle Crashes	Fire	63 (a)	19 (c)	RO = a/b ÷ c/d	z = 2.38 pr < 0.05
	No Fire	951 (b)	542 (d)	1.89 = (63/19) ÷ (951/542)	
	Interpretation: The odds that a "striking" utility vehicle involved in a multi-vehicle crash will experience a fire are 1.89 times greater than the odds that a "struck" utility vehicle involved in a multi-vehicle crash will experience a fire—assuming, again, that both striking and struck vehicles contain at least one fatally-injured occupant. This relative odds ratio of 1.89 is significant at α = 0.05.				

The natural logarithm (ln) of RO is asymptotically normal with a standard error that is equal to the square root of the sum of the reciprocals of the four frequencies used in the calculation of RO.	$z = \dfrac{\ln(RO)}{\sqrt{1/a + 1/b + 1/c + 1/d}}$

The relative odds ratios depicted in Table 10 were calculated as explained in Table 9. Note that when the relative odds associated with a given factor are significantly above 1.0, vehicle fires are over represented for that factor. Conversely, when the relative odds associated with a given factor are significantly below 1.0, vehicle fires are under represented for that factor. And, when the relative odds do not differ significantly from 1.0, there is insufficient evidence to indicate that the antecedent factor in question is associated with vehicular fire.

Table 10: Relative Odds of Fire by Type of Crash, Antecedent Factor, and Vehicle Class					
Type of Crash	Antecedent Factor	Passenger Cars	Pickups	Utility Vehicles	Vans
Single-Vehicle Crashes	Crash Occurred in a Rural Area	***1.00***	***1.01***	***1.01***	***0.85***
	First Harmful Event was Striking a Tree	1.61	2.18	3.51	1.96
	Rollover as the First Event in the Crash	0.30	0.28	0.15	0.24
	Crash Occurred After Dark	1.91	1.34	2.00	2.15
	Driver was Male	1.38	***1.23***	2.25	1.93
Multi-Vehicle Crash	Crash Occurred in a Rural Area	1.31	1.82	***1.44***	***1.41***
	Striking Vehicle in the Crash	1.83	1.84	1.89	***1.34***
	Crash Occurred After Dark	1.75	1.40	***1.42***	***1.43***
	Driver was Male	1.55	***1.08***	1.74	***1.01***
Relative odds ratios in ***bold italics*** are not significantly different from 1.00 at $\alpha = 0.05$					

The overall impression that might be gained from the data in Table 10 is that vehicles that experience fires are involved in somewhat more severe crashes—witness the fact that vehicles that experience fires are relatively more often driven by males, occur after dark.[10]

In single-vehicle fatal crashes, passenger vehicles that collide with trees are much more likely to experience fires than those that do not. Passenger vehicles that overturn are relatively less likely to experience fires.

In multi-vehicle fatal crashes, passenger vehicle fires are relatively more common for "striking" vehicles than for "struck" vehicles. For passenger cars and pickups, vehicle fires are also more common in rural areas.

PASSENGER VEHICLE FIRE AS A PROXIMAL CAUSE OF DEATH AND INJURY TO VEHICLE OCCUPANTS IN TRAFFIC CRASHES

The fact that a crash-involved passenger vehicle experiences a fire is no guarantee that the occupants of that vehicle will suffer fire-related deaths or injuries. In Table 3, for example, almost six

[10]Note that several of the relative odds ratios for utility vehicles and vans (particularly those involved in multi vehicle crashes) are not significantly different from 1.0, though these ratios are in the same direction exhibited by passenger cars and pickups.

in ten passenger vehicle occupants who were killed in vehicles that experienced fires, were not coded as having suffered any fire-related or burn-related injuries. Moreover, for passenger vehicle occupants who are killed in vehicles that do experience fires—and who do sustain fire-related or burn-related injuries—the fire may, or may not, have been consequential in the production of fatalities.

For example, in the fall of 1992, a 29 year-old male driver of a passenger vehicle traveling at a high rate of speed left the road, struck a guardrail, spun around and struck the concrete base to a traffic sign with the rear of his vehicle. The vehicle caught fire. The driver, the sole occupant of the vehicle, was killed. In FARS, "fire or explosion" was listed as the most harmful event for this vehicle. The medical examiner's report on the decedent indicates a blood alcohol concentration of 0.204 percent. Pathological diagnoses on the body (in order) were: (1) crushed head, (2) broken neck, (3) broken back, (4) crushed chest, (5) crushed abdomen, and (6) charred body. The opinion of the medical examiner read: "It is our opinion that the decedent, ... , came to his death as a result of a crushed head, chest and abdomen, and broken neck and back, motor vehicle accident, driver." Clearly this decedent sustained burn-related injuries, but just as clearly, vehicular fire was not consequential to the outcome of the crash. Had this passenger vehicle not experienced a fire, other things being equal, this individual would still have succumbed to the mechanical trauma of diagnoses 1 through 5.

Two points: (1) fatally-injured passenger vehicle occupants whose vehicles' experience fires do not necessarily sustain thermal trauma, smoke inhalation, and/or asphyxiation, and (2) even those passenger vehicle occupant who do sustain thermal trauma, smoke inhalation, and/or asphyxiation, do not necessarily die as a consequence of these fire-related or burn-related injuries.

Between 1994 and 1996 some 95,210 passenger vehicle occupants died in traffic crashes in the United States. Of these, 4,102 fatalities (4.31 percent) were recorded in passenger vehicles that experienced fires—or, on average 1,370 passenger vehicle occupants are killed each year in vehicles that experience fires, as shown in Figure 27.

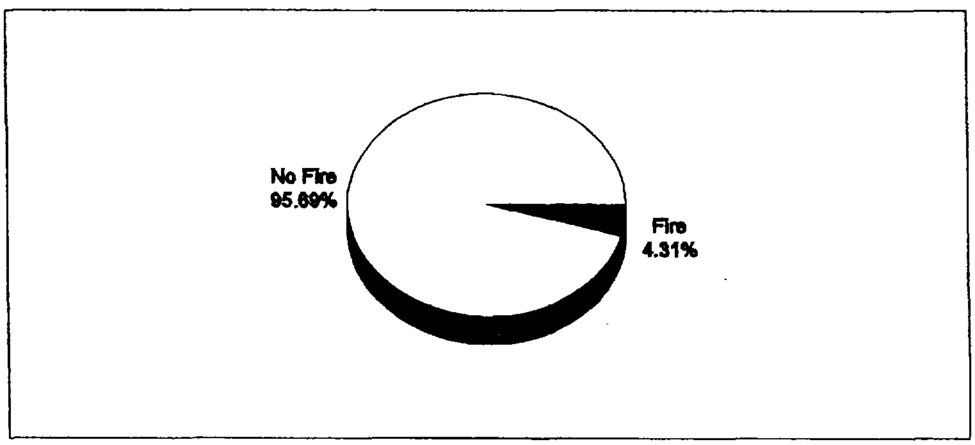


Figure 27: Passenger Vehicle Fatalities (N = 95,210) Recorded in Vehicles that Did or Did Not Experience Fires (FARS 1994-1996)

A Clinical Evaluation of the Cause of Death for Passenger Vehicle Occupants Riding in Vehicles that Experienced Fires[11]

The question might reasonably be asked: of those passenger vehicle occupants who are killed in an average year in passenger vehicles that experience fires, what percentage of these fatalities are the result of fires, and what percentage are the result of other factors?

Data used in the Analysis: In an attempt to answer this, crash data and medical examiner data were collected from two states: Texas and North Carolina. The Texas data were recorded for crashes that occurred between 1990 and 1992; the North Carolina data were recorded for crashes in 1995 and 1996. FARS was used to identify fatal crashes in which one or more vehicles experienced fires in Texas (1990-1992) or North Carolina (1995-1996).

For Texas, the FARS crashes were matched to the State accident data base. A list of the State accident numbers for 256 crashes in which vehicles experienced fires (and recorded one or more fatalities in vehicles that experienced fires) was forwarded to the Texas Department of Public Safety (DPS). DPS in turn provided hard copies of the police accident reports (PAR) for these 256 crashes. These 256 crashes were then culled to include only those crashes that occurred in and around Harris County and Dallas County. From the PARs of interest, the names of persons who died in passenger vehicles that experienced fire were compiled. The list was sent to the Harris County and Dallas County Medical Examiners (MEs). Officials at the respective ME Offices provided the available pathological and toxicological information on the decedents.

In Texas, the Harris County and Dallas County MEs were able to provide information on 107 decedents. Three of these decedents, however, were eliminated after they were determined to have been drivers of tractor semi-trailers. The remaining 104 cases (i.e., decedents) came from 80 separate crashes.

For North Carolina, FARS case numbers of interest were forwarded directly to the North Carolina Department of Transportation, Division of Motor Vehicles. From the FARS case numbers supplied, the Division of Motor Vehicles was able to provide hard copies of 103 PARs. From these PARs, the names of those decedents who were the subject of this study were identified. The list of names was sent to the North Carolina ME's Office. Officials with that agency then forwarded the requested information on the decedents.

For North Carolina, the ME's Office was able to provide information on 117 (of 120) decedents for whom information was sought. Of the three decedents on whom information was not received, two died out of state and one died in 1997. Of the 117 who remained, 14 were eliminated because they were not occupants of vehicles that experienced fires (though other vehicles in the crash did experience fires). One other decedent (for whom ME data were available) was eliminated because the individual could not be matched to a specific state accident number. The remaining 102 decedents

[11]For more detail on the data and methods used in this study see Davies and Griffin, 1999.

of interest died in 90 separate crashes.

Analysis of the Collected Data: The data collected from the ME Offices in Texas and North Carolina were in the form of death investigation reports, autopsy reports (if an autopsy was performed on the body), and toxicology results. In addition, for each of the cases included in the study, a photocopy of the original PAR was available for review. The PAR typically included both a diagram of the crash and a narrative report provided by the investigating officer.

The 104 Texas cases and the 102 North Carolina cases were reviewed to determine whether the proximal cause of death in each of these cases was the result of the fire, or some other factor(s). Deaths due to fire may have resulted from burns (i.e., thermal trauma), smoke inhalation, and/or asphyxiation. The coding of proximal cause of death took one of three values, as shown below:

- Yes, the fatality likely resulted from a vehicular fire (Y)
- No, the fatality likely resulted from some factor(s) other than fire (N)
- The proximal cause of death could not be determined from the available information (Und)

Results of the Review: In Texas, 32 of the 104 cases reviewed were thought by the reviewer to have died as the result of the fire; other factors (i.e., mechanical trauma) were thought to have produced 45 deaths; and for 27 cases the reviewer was undecided as to the proximal cause of death. Of the 102 decedents in the North Carolina sample, 17 were thought to have died from fire; 66 were thought to have been lost to other factors; and for 19 fatalities, the proximal cause of death was not evident from the available data (Figure 28).

If it can be assumed that the fatalities in the undecided category can be distributed in the same proportions as "fire" and "other factors," then it is estimated that perhaps 41 or 42 of the Texas fatalities resulted from fires and 58 or 59 resulted from other factors. For North Carolina it is estimated that perhaps 20 or 21 fatalities resulted from "fires" and 79 or 80 resulted from "other factors " (Figure 29).

Comments on the Study Results: Although fires were judged to be the proximal cause of death in fewer than half the cases drawn from both states, the decedents in the Texas sample were twice as likely to have succumbed to fire-related injuries as the decedents in the North Carolina sample. The reasons for this two-fold difference are not clear. Perhaps there are driver, vehicular, highway, or environmental factors that might explain why Texas passenger vehicle occupants were more apt to die of fire-related injuries than were North Carolina passenger vehicle occupants. Or, perhaps the death investigation materials provided by the ME offices (as interpreted in the review process) are responsible for part of the observed difference in Texas and North Carolina fire-related fatalities. Either or both of these explanations may have played a role in the analysis. Nevertheless, the analyses suggest that many (and perhaps most) of those killed in passenger vehicles that experience fires would have died even if the vehicles in which they were riding had not caught fire.

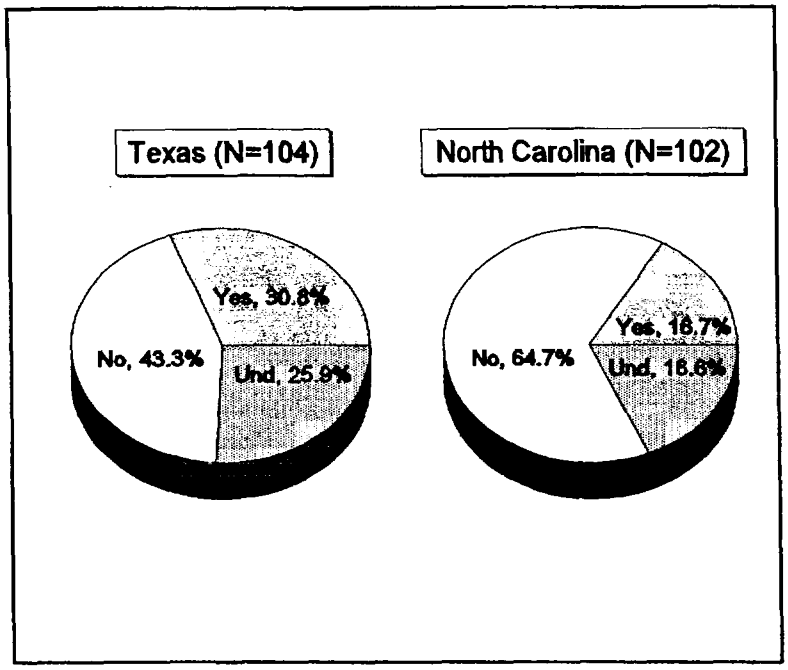


Figure 28: Proximal Cause of Death for Fatally-Injured Occupants Riding in Passenger Vehicles that Experienced Fires [Death by Fire: Yes, No, Undetermined]

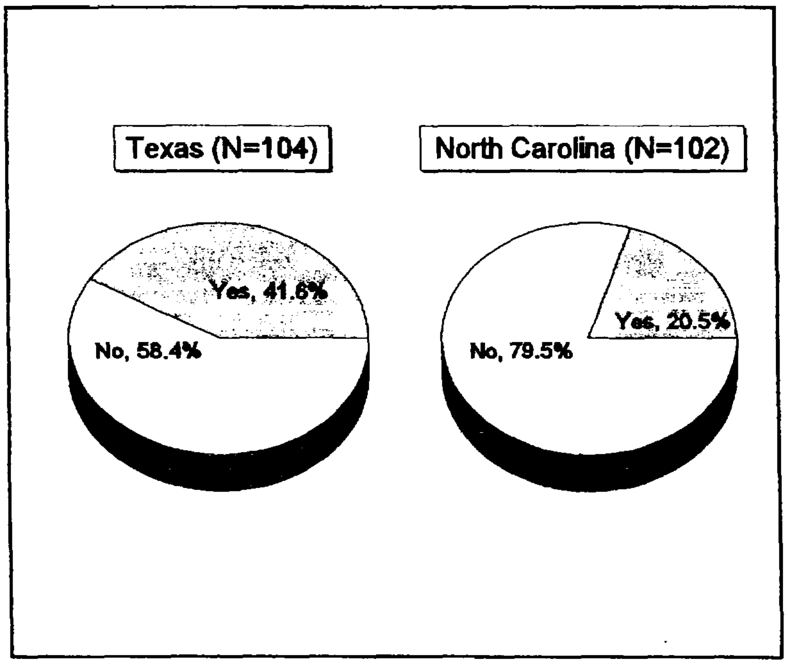


Figure 29: Proximal Cause of Death for Fatally-Injured Occupants Riding in Passenger Vehicles that Experienced Fires [Death by Fire: Yes, No]

A Statistical Evaluation of Passenger Vehicle Fires as the Cause of Death and Serious Injury for Vehicle Occupants.[12]

Between 1991 and 1996, some 254,227 drivers of passenger vehicles in the State of North Carolina were involved in single-vehicle crashes. 1,954 (0.76 percent) of these drivers were riding in vehicles that experienced fires. Of these 1,954 drivers, 88 (4.50 percent) were killed and another 249 (12.74 percent) sustained A-level ("incapacitating") injuries. For the 252,273 drivers who were riding in passenger vehicles that did not experience fires, 1,736 (0.69 percent) were killed and another 13,026 (5.2 percent) sustained A-level injuries (Figure 30).

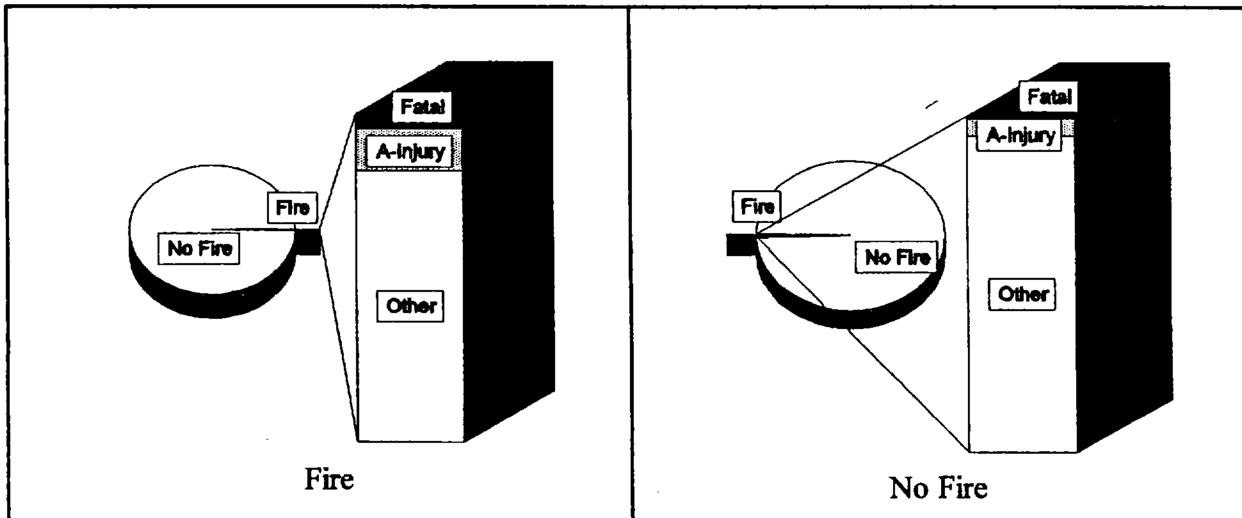


Figure 30: Fatal and A-Level Injuries Sustained by Drivers Riding in Passenger Vehicles that Did and Did Not Experience Fires in Single Vehicle Crashes (North Carolina, 1991-1996)

During the same time period in North Carolina (1991-1996), 1,606,370 drivers of passenger vehicles were involved in multi-vehicle crashes. 5,851 (0.36 percent) of these drivers were riding in passenger vehicles that experienced fires. Ninety (1.54 percent) of these 5,851 drivers were killed and another 171 (2.92 percent) sustained A-level injuries. Of the remaining drivers who were riding in vehicles that did not experience fires, 2,178 (0.1 percent) were killed and 25,999 (1.62 percent) sustained A-level injuries (Figure 31).

If the statistics presented in the previous two paragraphs are taken at face value, it would appear that the relative likelihood of a driver being killed while riding in a passenger vehicle that experienced a fire in a single vehicle crash are about 6.5 to 1 (4.50/0.69), when compared to drivers whose vehicles did not experience fires. For A-level injuries, the relative likelihood is about 2.5 to 1 (12.74/5.16). In multi-vehicle crashes, the relative likelihood of a passenger vehicle driver being

[12]For more detail on the data, methods, and statistics used in this study see Griffin and Flowers, 2000.

killed if his or her vehicle experiences a fire is about 11 to 1 (1.54/0.14), when compared to drivers whose vehicles did not experience fires. For A-level injuries the relative likelihood is about 1.8 to 1 (2.92/1.62).

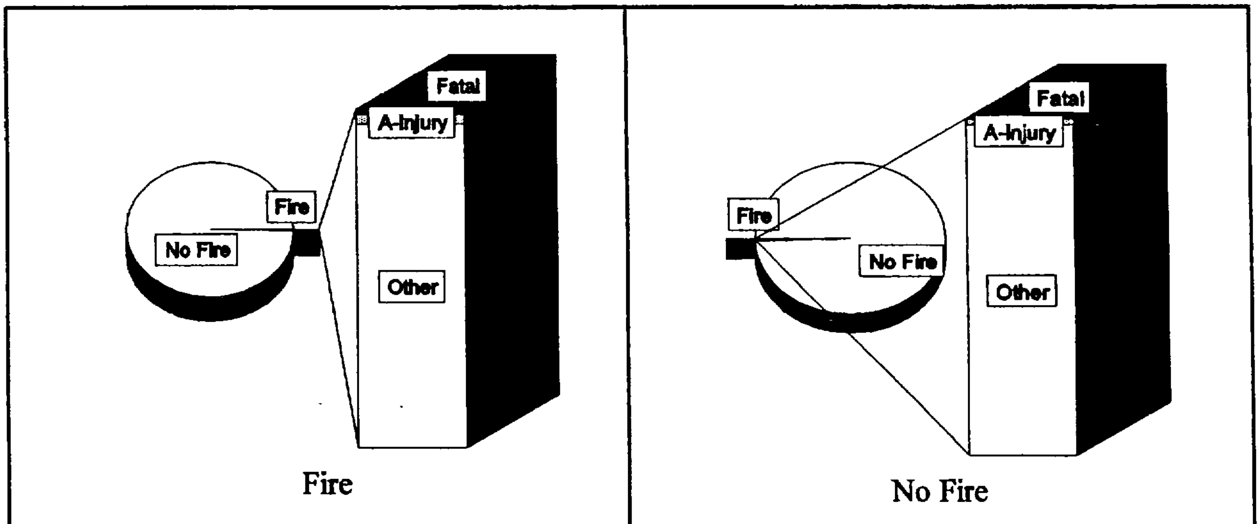


Figure 31: Fatal and A-Level Injuries Sustained by Drivers Riding in Passenger Vehicles that Did and Did Not Experience Fires in Multi-Vehicle Crashes (North Carolina, 1991-1996)

Before these estimates of the degree to which passenger vehicles that experience fires are associated with driver injury and death are given any credence, it should be pointed out that those vehicles that experience fires are generally involved in more severe crashes than vehicles that do not experience fires. Therefore, any direct comparison of the injuries sustained by drivers whose vehicles experienced fires—versus the injuries sustained by drivers whose vehicles had not experienced fires—could be misleading.

Crash Data used in the Analysis: Six years of North Carolina crash data (1991-1996) were used in this analysis. The crash-involved vehicles contained in this six-year data set were screened to include only passenger vehicles—some 2,033,360 vehicles. Passenger vehicles were defined to be any one of six vehicle types: 1 (2,4 Door Sedan); 2 (SW-Passenger); 3 (SW-Truck); 11 (Taxicab); 23 (Pickup Truck); or 25(Van). These 2,033,360 passenger vehicles were then divided into two groups: vehicles involved in single vehicle crashes (276,597) and vehicles involved in multi-vehicle crashes (1,756,763).

For each of the 2,033,360 passenger vehicles in the reduced data set, driver injury and fire experience were recorded, as shown in Table 11. Note that of the initial 2,033,360 vehicles in the reduced data set, 172,763 records (8.5 percent) were lost, i.e., driver injury and/or fire information was unavailable for 172,763 of these 2,033,360 records.

Table 11: Crash-Involved Passenger Vehicles by Crash Type (Single Vehicle vs. Multi-Vehicle) and Driver Injury (North Carolina, 1991-1996)						
	Single Vehicle Crashes		Multi-Vehicle Crashes		All Crashes	
Driver Injury	Fire	No Fire	Fire	No Fire	Fire	No Fire
Fatal	88	1,736	90	2,178	178	3,914
A-Level	249	13,026	171	25,999	420	39,025
Other	1,617	237,511	5,590	1,572,342	7,207	1,809,853
Total	1,954	252,273	5,851	1,600,519	7,805	1,852,792
	254,227		1,606,370		1,860,597	

The 1,860,597 crash-involved passenger vehicles shown in Table 11, were further categorized by location and severity of impact through use of the Traffic Accident Data (TAD) codes provided by the investigating officers. TAD codes consist of an alphabetic code that defines the location of vehicle impact and a numeric code (ranging from 1 to 7) that defines the severity of the impact. A TAD numeric code of 1 is minimal damage; a code of 7 is maximal damage.[13] To simplify the analyses that follow, the 19 TAD alphabetic codes (impact locations) were collapsed into five abbreviated locations, as shown in Table 12. Of the 1,860,597 driver/vehicles in Table 11, another 111,701 cases (another 2.3 percent of the initial 2,033,360 cases) were lost, i.e., for 111,701 of the driver/vehicles represented in Table 11, TAD data were not available. Of the 243,109 passenger vehicles involved in single vehicle crashes, 1,840 (0.76 percent) experienced fires. Another 1,505,787 passenger vehicles were involved in multi-vehicle crashes. Some 5,413 (0.36 percent) of these experienced fires.[14]

Tables 13 and 14 show the percent of drivers who sustained fatal (K) or A+K injuries in single vehicle and multi-vehicle crashes in vehicles that did or did not experience fires, by impact location (Table 13) and impact severity (Table 14). With the exception of top-damaged vehicles involved in single vehicle crashes, driver injury is greater—and often substantially greater—in those vehicles that experienced fires.

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[13]Investigating officers in North Carolina may submit up to three TAD alpha and numeric codes for each crash-involved vehicle. Only the first TAD alpha (TAD1) and numeric (TADSEV1) codes recorded for each passenger vehicle were used in the analyses that follow.

[14]Because so few data were available for top-damaged passenger vehicles involved in multi-vehicle (221 cases), these cases were dropped from the data set and not further analyzed. See the shaded area in Table 12, the last row in the table before the totals.

Table 12: Passenger Vehicles in Single Vehicle and Multi-Vehicle Crashes that Did or Did Not Experience Fires (North Carolina 1991-1996)

Impact Locations (TAD1)	Collapsed Locations	Single Vehicle Crashes		Multi-Vehicle Crashes	
		No Fire	Fire	No Fire	Fire
Front Distributed Front Concentrated Front Left Front Right	Front	13,163	792	665,999	2,367
Right Front Quarter Right Passenger Right Distributed, Right Side Swipe Right Back Quarter Right and Top	Right	52,666	497	254,249	969
Back Distributed Back Concentrated Back Left Back Right	Back or Rear	6,159	39	310,989	1,169
Left Front Quarter Left Passenger Left Distributed, Right Side Swipe Left Back Quarter Left and Top	Left	50,500	503	268,918	906
Top	Top	581	9	219	2
Total		241,269	1,840	1,500,374	5,413
			243,109		1,505,787
			1,748,896		

In Table 15, the driver/vehicle cases shown in Table 12 were subdivided into four vehicle categories (cars and station wagons, truck based station wagons, pickups, and vans). To better assess just what kinds and types of vehicles were included in the four vehicle categories shown in Table 15, the VINDICATOR program developed by the Highway Loss Data Institute was used to further characterize these vehicles. Approximately one thousand vehicle identification numbers (VINs) were systematically selected from each of the four vehicle categories developed for this study by taking every n^{th} case in each of the four categories. No attempt was made to edit or modify the VINS that were contained in the data sets that were received from HSRC. The results of this analysis are shown in Table 16.

"Cars and station wagons," as defined in this study, are predominantly "passenger cars," as defined by VINDICATOR. Truck based station wagons are predominantly utility vehicles, pickups are predominantly pickup trucks, and vans include both passenger vans and cargo vans, in roughly equal measure.

Table 13: Percent of Drivers Who Sustained Fatal (K) and A+K Injuries in Passenger Vehicles that Did and Did Not Experience Fires in Single Vehicle and Multi-Vehicle Crashes, by Impact Location (TAD1) (North Carolina, 1991-1996)

Impact Location	Single Vehicle Crashes				Multi-Vehicle Crashes			
	Fatal (K) Injuries		A+K Injuries		Fatal (K) Injuries		A+K Injuries	
TAD1	No Fire	Fire	No Fire	Fire	No Fire	Fire	No Fire	Fire
Front	0.49	6.31	5.48	20.08	0.15	2.20	2.23	7.01
Right	0.88	4.63	6.51	15.90	0.12	1.44	1.45	3.72
Back	0.24	2.56	2.57	12.82	0.02	0.51	0.77	1.11
Left	1.10	2.19	6.64	15.71	0.27	1.66	2.30	3.64
Top	2.07	-	9.29	-	-	-	-	-

Table 14: Percent of Drivers Who Sustained Fatal (K) and A+K Injuries in Passenger Vehicles that Did and Did Not Experience Fires in Single Vehicle and Multi-Vehicle Crashes, by Severity of Impact (TADSEV1) (North Carolina, 1991-1996)

Impact Severity	Single Vehicle Crashes				Multi-Vehicle Crashes			
	Fatal (K) Injuries		A+K Injuries		Fatal (K) Injuries		A+K Injuries	
TADSEV1	No Fire	Fire	No Fire	Fire	No Fire	Fire	No Fire	Fire
1	0.12	0.65	1.39	4.19	0.00	0.07	0.22	0.26
2	0.17	1.19	2.02	5.97	0.01	0.07	0.69	0.37
3	0.34	1.53	4.26	8.26	0.05	0.51	1.89	2.88
4	0.74	3.36	8.02	19.03	0.14	3.03	4.36	9.47
5	1.28	4.37	13.62	22.27	0.60	2.01	9.07	15.44
6	2.90	11.88	20.75	38.75	1.66	11.72	15.86	40.69
7	6.04	17.36	29.52	46.45	5.93	27.46	27.66	58.03

Table 15: Passenger Vehicles Involved in Single Vehicle and Multi-Vehicle Crashes, by Category (North Carolina, 1991-1996)			
NC Vehicle Type	Vehicle Category	Single Vehicle Crashes	Multi-Vehicle Crashes
1 (2,4 Door Sedan) 2 (SW-Passenger) 11 (Taxicab)	Cars and Station Wagons	191,189	1,255,378
3 (SW-Truck)	Truck Based SWs	3,452	16,207
23 (Pickup Truck)	Pickups	41,012	176,441
25 (Van)	Vans	7,456	57,761
Total		243,109	1,505,787
		1,748,896	

Table 16: Vehicle Categories Used in the Present Study Compared to Vehicle Categories Based on Vehicle Identification Numbers (North Carolina, 1991-1996)				
VINDICATOR Vehicle Categories Based on VINs	Vehicle Categories for the Present Study			
	Cars and Station Wagons	Truck Based Station Wagons	Pickups	Vans
Passenger Car	532	4	1	10
Utility	26	560	5	5
Pickup Truck	8	15	504	4
Passenger Van	7	14	0	295
Cargo Van	1	13	0	231
No Match/Missing VIN	419	394	483	447
Total	993	1000	993	992

Statistical Methodology: Twelve separate analyses were performed in this study as outlined in Table 17. Each analysis began by developing a logit function or model to represent the raw data. Conceptually, the logit models developed in these analyses might be thought of as three-dimensional figures that are five columns wide (TAD location = Front, Left, Back, Right, or Top), by seven rows tall (TAD severity values from 1 to 7), by two layers deep (Fire; No Fire). Within each of the 70 (5 x 7 x 2) cells in this three-dimensional figure, the expected probability that a driver received a severe injury [i.e., a fatal (K) injury or an "incapacitating" or fatal (A+K) injury] is calculated.

Table 17: Outline of the Twelve Analyses Performed in this Study

Analysis	Dependent Variable	Vehicle Category	Crash Type
1	(A + K) + (0,B,C)	All Passenger Vehicles	Single Vehicle Crashes
2	K + (0,C,B,A)		
3	(A + K) + (0,B,C)	Passenger Cars and Station Wagons	
4	K + (0,C,B,A)		
5	(A + K) + (0,B,C)	Pickups	
6	K + (0,C,B,A)		
7	(A + K) + (0,B,C)	All Passenger Vehicles	Multi-Vehicle Crashes
8	K + (0,C,B,A)		
9	(A + K) + (0,B,C)	Passenger Cars and Station Wagons	
10	K + (0,C,B,A)		
11	(A + K) + (0,B,C)	Pickups	
12	K + (0,C,B,A)		

To make this explanation more concrete, data from the first of the 12 analyses outlined in Table 17 will used. The data set for the first analysis contains some 243,109 passenger vehicles and drivers that had been involved in single vehicle crashes. For each vehicle/driver included in the analysis, four pieces of information were of interest: driver injury [A+K or lesser injury (0,C,B)], TAD location (Front, Right, Back, Left, Top), TAD severity (1 through 7), and fire (Yes or No). The first four columns in Table 18 depict the raw data for this first analysis.

From the first row in Table 18 we see that 11 drivers (Col 2) whose vehicles sustained frontal, minor (TAD severity = 1) damage in single vehicle crashes—and whose vehicles experienced fires—suffered A- or K-level injuries. Another 173 (Col 1) suffered lesser injuries [C-level (possible) injuries, B-level (non-incapacitating) injuries] or no injuries at all (0). Expressing these frequencies as probabilities, we see that the probability of an A+K injury is 0.05978 (11/184) while the probability of a 0-C-B injury is 0.94022 (173/184).

Again, from the first row in Table 18, we see another 483 drivers (Col 4) who suffered A+K injuries in single vehicle crashes in which their vehicles sustained frontal, minor (TAD severity = 1) damage—but their vehicles did <u>not</u> experience fires. Another 32,824 drivers (Col 3) suffered 0-C-B injuries. Or, the probability of an A+K injury (in vehicles that did not experience fires) is 0.014501 (483/33,307) while the probability of a 0-C-B injury is 0.985499 (32,824/33,307). In similar fashion, the raw data from Table 18 can be used calculate the probability of an A+K (or 0-C-B) injury in each of the 70 combinations of TAD location by TAD severity by Fire experience.

Table 18: Raw and Fitted Data Used in the First Analysis									
		Raw Data				Fitted Data from a Logit Model			
		Post Crash Fire		No Fire		Post Crash Fire		No Fire	
		Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
TAD Values		0-C-B	A + K	0-C-B	A + K	0-C-B	A + K	0-C-B	A + K
Front	1	173	11	32824	483	176.19	7.81	32813.28	493.72
	2	136	11	37290	815	138.06	8.94	37285.66	819.34
	3	124	14	27162	1241	121.11	16.89	27118.76	1284.24
	4	72	27	14180	1327	77.54	21.46	14174.99	1332.01
	5	53	22	6827	1164	49.95	25.05	6828.45	1162.55
	6	29	28	3492	1026	30.97	26.03	3514.74	1003.26
	7	46	46	2384	1148	39.18	52.82	2423.13	1108.87
Right	1	60	0	10649	144	58.47	1.53	10655.08	137.92
	2	93	5	12359	252	94.39	3.61	12377.02	233.98
	3	76	4	10378	457	73.91	6.09	10410.86	424.14
	4	77	11	6892	549	75.64	12.36	6884.46	556.54
	5	56	16	4282	634	55.55	16.45	4287.96	628.04
	6	28	16	2539	605	29.40	14.60	2524.16	619.84
	7	28	27	2140	786	30.64	24.36	2099.47	826.53
Back	1	8	0	1852	16	7.84	0.16	1857.00	11.00
	2	5	0	1498	17	4.85	0.15	1502.00	13.00
	3	5	0	1112	19	4.69	0.31	1110.29	20.71
	4	7	1	710	23	7.07	0.93	706.84	26.16
	5	5	1	41	23	4.85	1.15	59.98	4.02
	6	3	1	230	24	2.86	1.14	228.33	25.67
	7	1	2	188	36	1.84	1.16	189.80	34.20
Left	1	56	2	10144	134	56.64	1.36	10139.09	138.91
	2	79	4	12372	226	80.18	2.82	12351.06	246.94
	3	93	9	9988	446	94.82	7.18	10003.00	461.00
	4	59	12	6600	564	61.72	9.28	6599.74	564.26
	5	63	12	3922	616	58.94	16.06	3929.33	608.67
	6	37	17	2264	583	37.07	16.93	2260.04	586.96
	7	37	23	1857	784	34.63	25.37	1864.63	776.37
Top	1	0	0	108	4	-	-	110.32	1.68
	2	2	0	101	1	2.00	-	99.78	2.22
	3	2	0	92	5	2.00	-	92.56	4.44
	4	2	0	75	17	2.00	-	84.00	8.00
	5	1	0	71	9	1.00	-	68.23	11.77
	6	1	0	49	7	1.00	-	43.43	12.57
	7	1	0	31	11	1.00	-	28.61	13.39
Total		1518	322	227073	14196	1518.00	322.00	227073.00	14196.00
		243109				243109			

Through the fitting of logit models to the raw data, "smoothed" estimates were developed for use in the 12 analyses that follow. In Table 18, for example, the raw data in columns 1-4 have been fitted with a logit model to produce the "smoothed" estimates in columns 5-8. From a statistical point of view, these fitted ("smoothed") values constitute better estimates of driver injury than the raw data shown in columns 1 through 4. Note, however, that within the rows in Table 18: (Col 1 + Col 2) = (Col 5 + Col 6) and (Col 3 + Col 4) = (Col 7 + Col 8).

Look once again at Table 18—at the sums at the bottom of the table. Here we see that the probability of an A+K injury is 0.058839 (14,196/241,269) for drivers who did not experience fires. Now, if we apply this coefficient (0.058839) to the 1,840 drivers who were riding in vehicles that did experience fires, we would estimate or predict that 108.26 drivers riding in vehicles that experienced fires would have suffered A+K injuries if vehicular fire were inconsequential in the production of driver death and injury. Since 322 drivers riding in vehicles that experienced fires suffered A+K injuries, 213.74 of these 322 A+K driver injuries are estimated to be associated with fire. Or, A+K driver injuries in vehicles that experienced fires were 2.97 times as high as might have been anticipated on the basis of vehicles that did not experience fires.

It should immediately be pointed out that this estimate of excess injuries—213.74 more A+K injuries than predicted—is biased. It fails to account for any differences in the vehicle damage (TAD location and severity) to which drivers of vehicles that do, and do not, experience fires are exposed.

From the fitted data in the first row in Table 18, we estimate that 0.014823 (493.72/33,307) of the 184 drivers (i.e., 2.73 drivers) riding in vehicles experiencing fires would have suffered A+K injuries if fires were of no consequence in the production of A+K injuries. For the second row in Table 18, we estimate that 3.16 drivers riding in vehicles that experienced fires would have suffered A+K injuries if vehicle fire were inconsequential in the production of injuries. For the third row we estimate 6.24. And so on for all 35 rows in Table 18. These 35 estimates of A+K injuries are shown in the last column in Table 19.

The sum of the estimated A+K injuries to drivers (if fires do not contribute to the production of drivers' A+K injuries) is 172.53. The observed (and fitted) number of drivers suffering A+K injuries while riding in vehicles that experienced fires is 322—149.47 more than estimated (not 213.74 more than estimated), or, 1.87 times as many A+K injuries were associated with vehicle fires as expected (not 2.97 times as many). This estimate of excess driver, A+K injuries associated with vehicle fires does take into account differences in the impact locations and impact severities recorded for passenger vehicles that do and do not experience fires.

Table 19: Driver Injuries in Single Vehicle Crashes with Fires, by Location and Severity of Impact (TAD)						
Region and Severity of Impact (TAD)		Driver Injuries Observed			Driver Injuries from Model	
		Total Cases	Lesser Injuries or None (O-C-B)	Serious and Fatal Injuries (A+K)	Fitted A+K Injuries	Estimated A+K Based on Vehicles that Did Not Experience Post Crash Fires
Front	1	184	173	11	7.81	2.73
	2	147	136	11	8.94	3.16
	3	138	124	14	16.89	6.24
	4	98	72	27	21.46	8.50
	5	75	53	22	25.05	10.91
	6	57	29	28	26.03	12.66
	7	92	46	46	52.82	28.88
Left	1	60	60	0	1.53	0.77
	2	98	93	5	3.61	1.82
	3	80	76	4	6.09	3.13
	4	88	77	11	12.36	6.58
	5	72	56	16	16.45	9.20
	6	44	28	16	14.60	8.67
	7	55	28	27	24.36	15.54
Back	1	8	8	0	0.16	0.05
	2	5	5	0	0.15	0.04
	3	5	5	0	0.31	0.09
	4	8	7	1	0.93	0.29
	5	6	5	1	1.15	0.38
	6	4	3	1	1.14	0.40
	7	3	1	2	1.16	0.46
Right	1	58	56	2	1.36	0.78
	2	83	79	4	2.82	1.63
	3	102	93	9	7.18	4.21
	4	71	59	12	9.28	5.59
	5	75	63	12	16.06	10.06
	6	54	37	17	16.93	11.13
	7	60	37	23	25.37	17.64
Top	2	2	2	0	-	0.04
	3	2	2	0	-	0.09
	4	2	2	0	-	0.17
	5	1	1	0	-	0.15
	6	1	1	0	-	0.22
	7	1	1	0	-	0.32
		1,847	1,525	322	322.00	172.53

Results: From the 1991-1996 North Carolina data used in the analyses performed herein, about 0.76 percent of all passenger vehicles involved in single vehicle crashes (243,109) experienced fires. About 0.36 percent of all passenger vehicles involved in multi-vehicle crashes (1,505,566) experienced fires. The percentages of passenger cars and pickups that experienced fires in single vehicle and multi-vehicle crashes are equal. See Table 20.

Table 20: Passenger Vehicles Involved in Single Vehicle and Multi-Vehicle Crashes that Experienced Fires, by Type of Vehicle (North Carolina, 1991-1996)

	Single Vehicle Crashes		Multi-Vehicle Crashes	
Type of Vehicle	N	Percent	N	Percent
Passenger Cars and Station Wagons	1,431	0.75	4,423	0.35
Pickups	308	0.75	618	0.35
Other Passenger Vehicles	101	0.93	370	0.50
Total	1,840	0.76	5,411	0.36

In Table 21 observed and expected driver fatalities (K) derived from the logit models developed in analyses 2, 4, 6, 8 , 10, and 12 are shown. "Expected fatalities" are estimates of the numbers of drivers who would have died in vehicles that experienced fires if their vehicles had not experienced fires. When expected (or estimated) fatalities are divided by observed fatalities, that proportion of driver deaths that can be explained by the models that were developed (i.e., by impact location and severity, TAD1 and TADSEV1) is calculated.

Of the 61 passenger car/station wagon drivers who were killed in single vehicle crashes while riding in vehicles that experienced fires, it is estimated (based on the developed model) that 18.93 would have died if their vehicles had not experienced fires. Or, 31 percent of the 61 driver fatalities (18.93) recorded in these fire-related crashes would have been expected due to crash circumstances (i.e., impact location and severity), if the vehicles had not experienced fires.

$$P = \left(\frac{\text{Expected Fatalities}}{\text{Observed Fatalities}}\right) = \left(\frac{18.93}{61}\right) \approx 0.31$$

Where, P equals the proportion of the fatalities (K) explained by the models.

In single vehicle crashes in which passenger vehicle drivers were killed in vehicles that experienced fires, it is estimated that 29 percent (of 85 drivers) would have been lost even if their vehicles had not experienced fires. The corresponding figure for multi-vehicle crashes is 18 percent (of 87 drivers). Or, of the 172 fatalities shown in Table 21, about 23 percent can be explained in terms of impact location and severity.

Table 21: Observed and Expected Driver Fatalities (K) in Passenger Vehicles that Experienced Fires in Single Vehicle and Multi-Vehicle Crashes, by Type of Vehicle (North Carolina, 1991-1996)						
	Single Vehicle Crashes			Multi-Vehicle Crashes		
Type of Vehicle	Observed K	Expected K	Proportion of Fatalities (K) Explained by Models	Observed K	Expected K	Proportion of Fatalities (K) Explained by Models
Passenger Cars and Station Wagons	61	18.93	0.31	63	12.24	0.19
Pickups	21	4.44	0.21	16	1.92	0.12
All Passenger Vehicles	85	24.71	0.29	87	15.37	0.18

Table 22 is structurally equivalent to Table 21, but depicts A+K injuries rather than fatalities (K). Table entries come from analyses 1, 3, 5, 7, 9, and 11. In single vehicle crashes in which passenger vehicle drivers sustained A+K injuries in vehicles that experienced fires, it is estimated that 54 percent (of 322 drivers) would have sustained A+K injuries even if their vehicles had not experienced fires. For multi-vehicle crashes, the corresponding figure is 52 percent (of 248 drivers). Of, of the 570 A+K injuries shown in Table 22, about 53 percent can be accounted for in term of impact location and severity.

Table 22: Observed and Expected Driver A+K Injuries in Passenger Vehicles that Experienced Fires in Single Vehicle and Multi-Vehicle Crashes, by Type of Vehicle (North Carolina, 1991-1996)						
	Single Vehicle Crashes			Multi-Vehicle Crashes		
Type of Vehicle	Observed A+K	Expected A+K	Proportion of A+K Injuries Explained by Models	Observed A+K	Expected A+K	Proportion A+K Injuries Explained by Models
Passenger Cars and Station Wagons	243	134.74	0.55	198	104.56	0.53
Pickups	65	25.62	0.39	34	15.41	0.45
All Passenger Vehicles	322	172.53	0.54	248	128.20	0.52

The reciprocals of the proportions shown in Tables 21 and 22 are simple measures of the excess injuries associated with vehicles that experienced fires. See Table 23. Looking at the top, left cell: 3.22 times as many deaths were recorded for passenger car/station wagon drivers involved in single vehicle crashes as expected. 3.22 is the reciprocal of 0.31 (shown in Table 21).

Table 23: Over Representation of Fatal (K) and A+K Injuries for Drivers Experiencing Fires in Single Vehicle and Multi-Vehicle Crashes, by Type of Vehicle (North Carolina, 1991-1996)

Type of Vehicle	Single Vehicle Crashes		Multi-Vehicle Crashes	
	Fatal (K) Injury	A+K Injury	Fatal (K) Injury	A+K Injury
Passenger Cars and Station Wagons	3.22	1.80	5.15	1.89
Pickups	4.73	2.54	8.33	2.21
All Passenger Vehicles	3.44	1.87	5.66	1.93

Discussion: When a passenger vehicle driver is killed or seriously injured in a crash in which his or her vehicle experiences a fire, the proximal cause of death (K) or serious (A-level) injury may be the fire (e.g., thermal trauma, asphyxiation, etc.) or some other factor (e.g., mechanical trauma). To the extent that the circumstances surrounding drivers whose vehicles experience fires differ from those whose vehicles do not experience fires—and to the extent that these circumstances are associated with the likelihood of death or serious injury—these differences must be accounted for in assessing any excess injuries that might be associated with fires.

The likelihood that a driver will be killed or seriously injured in a single vehicle or multi-vehicle crash is a function of many variables: crash factors (e.g., impact location and severity, fire, etc.), driver factors (e.g., age, gender, health, use of seat belts, etc.), vehicle factors (e.g., make, model, curb weight, air bags, etc.) In this study, differences in crash circumstances for passenger vehicles that did and did not experience fires were modeled for single vehicle and multi-vehicle crashes using the Traffic Accident Data (TAD) scale. The TAD scale is an alpha-numeric scale used to document impact location (Front, Right, Back, Left, and Top) and severity [as measured along a seven-point (i.e., 1-7), ordinal scale of increasing vehicle deformation].

In Table 21 some 172 passenger vehicle drivers were reported to have died in North Carolina between 1991 and 1996 in vehicles that experienced fires. Based on the analyses performed in this study, 23 percent (of these 172 drivers) might have been expected to die if the vehicles in which they were riding had not experienced fires. Or, the drivers who were riding in vehicles that experienced fires were 4.29 times as likely to die as expected—4.29 times as likely to die as drivers involved in comparable crashes (as defined by TAD1 and TADSEV1), but whose vehicles did not experience fires.

Stated in slightly different terms, of the 172 reported decedents considered in the previous paragraph, 40 might have been expected based on the locations and severities of vehicle impacts sustained, i.e., 40 of these 172 driver deaths would have been expected even if their vehicles had not experienced fires. The remaining 132 deaths were "unexpected," i.e., not accounted for by the likelihood of death in passenger vehicles that did not experience fires. Although these 132 deaths were "unexpected," it should not be assumed that they were caused by vehicular fires. Other explanations or factors (e.g., driver age, sex, etc.) might be posited to account for the occurrence of these 132 deaths.

ASSESSMENT OF FIRE-RELATED VARIABLES IN CRASH OUTCOME DATA EVALUATION SYSTEMS (CODES)

> CODES consists of linked statewide crash and injury data that match vehicle, crash, and human behavior characteristics to their specific medical and financial outcomes. These state data are located in multiple sources: crash data collected by police at the scene; EMS data collected by EMTs who provide treatment at the scene and enroute; medical data collected by physicians, nurses and others who provide treatment at the emergency department, in the hospital, or outpatient setting; and third party payors who pay. Linkage enables persons involved in the motor vehicle crash to be traced from the scene to their final and financial outcomes.
>
> *Catalog of Types of Applications Implemented Using Linked State Data*, page 1, DOT HS 808 581, April 1997

NHTSA was unable to provide the project with any of the CODES databases from the various participating states. However, Wisconsin and Utah were able to provide us with data that could be used to assess the fire-related information contained in the CODES projects in those two states.

Wisconsin Database

Description of the Data: The State of Wisconsin provided the project with 12 data files, three files per year for four years (1991, 1992, 1993, and 1994). The first file for each of these years was from the Department of Transportation and included police-reported data. The second file was from the Office of Health Care Information and contained hospital discharge information. The third file was a linking file that allowed the first two files to be merged together. It should be noted that the information that was made available to us did not include all of the information contained in the Wisconsin CODES project. These two files do, however, form the basic framework for the Wisconsin CODES project. Information contained in the crash files included such variables as: occupant's role in the crash, severity of injury, age, sex, day or week, month, type of vehicle, etc. Information contained in the hospital discharge files included such variables as: length of stay, diagnosis codes (up to five), discharge status, admission source, hospital charges, etc.

Table 24 summarizes the data that were available for the analyses that follow. Note that the Wisconsin data used herein represent 44 more fatalities and 4,261 more injuries than were seen in a previous Wisconsin report. Note also, that of the 254,656 persons killed or injured in motor vehicle crashes in Wisconsin between 1991 and 1994, hospital discharge data were available for 20,030 (7.9 percent). Some of those who were fatally injured may have been killed at the scene and, thus, no hospital discharge data would be available. Those who received minor injuries may not have been gone to a hospital and, thus, hospital data would not be available.

Table 24: Wisconsin Traffic Crash Data and Hospital Data (1991-1994)						
	Data Made Available to Project by Wisconsin				Published Wisconsin Data[1]	
Year	Persons in Crashes	Hospital Cases	Persons Killed (Crash Data)	Persons Injured (Crash Data)	Persons Killed (Crash Data)	Persons Injured (Crash Data)
1991	384,298	4,956	800	60,805	795	60,055
1992	363,953	5,292	657	61,087	645	60,142
1993	377,425	4,880	715	61,322	703	60,902
1994	379,092	4,902	721	68,549	706	66,403
Total	1,504,768	20,030	2,893	251,763	2,849	247,502

[1] *1994 Wisconsin Traffic Crash Facts*, Wisconsin Department of Transportation, Madison, WI.

Persons with Fire-Related or Burn-Related Injuries: In order to determine which of the 20,030 injured persons in the merged (i.e., linked) data sets had sustained fire-related or burn-related injuries, five fields were scanned: (1) primary diagnosis, (2) first other diagnosis, (3)second other diagnosis, (4) third other diagnosis, and (5) fourth other diagnosis. Each of these fields contained a five-digit code, typically an N-code (i.e., a nature of injury code) , but sometimes an E-code or a V-code. All persons with N-codes ($\geq$940 and <950) or ($\geq$986 and <988) were defined as having suffered thermal trauma, smoke inhalation, and/or asphyxiation.[15] By this definition, some 101 persons were identified, as shown in Table 25. Of these 101 cases, some 72 were passenger vehicle occupants, i.e., drivers of—or passengers in— passenger cars or utility trucks.

The first case in Table 25 is that of a male passenger car driver who was not transported to the hospital by EMS. In the opinion of the investigating officer, this individual was not injured. Nevertheless, five diagnostic codes are provided for this individual, all of which are indicative of fire-related injuries. The remaining cases in Table 25 can be read in similar manner.

The 72 passenger vehicle occupants who suffered fire-related or burn-related injuries stayed in hospital for an average of 16 days, with a range from 0 to 187 days. The average cost of their hospitalization was $49,752, ranging from a low of $979 to a high of $924,454. The 15,002 passenger vehicle occupants who did not suffer fire-related or burn-related injuries stayed in hospital for an average of 7 days, with a range from 0 to 306 days. The average cost of hospitalization for these patients was $13,293, ranging from a low of $190 o $974,414 (Table 26). The longer hospital stays and added costs for patients who experienced fire-related or burn-related injuries reflect both the added trauma attributable to fire and smoke, as well as the increased crash severity associated with passenger vehicle fires. See for example Table 14.

[15]See "The International Classification of Diseases 9th Revision, Clinical Modification," (ICD-9-CM) . See also Table 2 to this report.

Table 25: Persons Suffering Fire-Related or Burn-Related Injuries by Vehicle Type, Occupant Role in Crash, Sex, EMS Transport to Hospital, Injury Severity, and Diagnosis Codes (N-Codes 1 through 5)

Obs	VEHICLE TYPE	ROLE	SEX	EMS TRANS TO HOSPITAL	INJURY SEVERITY	N-CODE 1	N-CODE 2	N-CODE 3	N-CODE 4	N-CODE 5
1	Passenger Car	Driver	Male	No	Not Injured	941.39	948.00	943.12	942.13	944.10
2	Passenger Car	Driver	Male	No	Not Injured	941.29	942.22	948.30	132.20	.
3	Passenger Car	Driver	Male	No	Not Injured	947.20	.	.	.	.
4	Passenger Car	Driver	Male	No	Not Injured	986.00	426.13	911.00	427.89	.
5	Passenger Car	Driver	Male	No	Not Injured	943.29	944.27	.	.	.
6	Passenger Car	Driver	Male	No	Not Injured	945.32	958.30	.	.	.
7	Passenger Car	Driver	Male	No	Not Injured	986.00	.	.	.	.
8	Passenger Car	Driver	Male	No	Not Injured	945.29	941.09	941.08	.	.
9	Passenger Car	Driver	Female	No	Not Injured	965.10	986.00	.	.	.
10	Passenger Car	Driver	Male	No	Not Injured	943.35	347.00	.	.	.
11	Passenger Car	Driver	Male	Yes	Incapacitating	946.30	948.33	873.49	808.00	808.41
12	Passenger Car	Driver	Male	Yes	Incapacitating	946.30	948.55	997.40	998.10	518.81
13	Passenger Car	Driver	Female	Yes	Incapacitating	850.00	847.00	946.00	924.80	.
14	Passenger Car	Driver	Female	Yes	Incapacitating	987.90	824.80	.	.	.
15	Passenger Car	Driver	Male	Yes	Incapacitating	507.00	986.00	987.90	305.00	942.22
16	Passenger Car	Driver	Female	Yes	Incapacitating	780.40	923.20	945.50	924.20	847.00
17	Passenger Car	Driver	Female	Yes	Incapacitating	806.00	861.21	942.31	948.00	910.00
18	Passenger Car	Driver	Male	Yes	Incapacitating	943.31	944.30	941.20	941.28	942.29
19	Passenger Car	Driver	Male	Yes	Incapacitating	801.06	943.33	.	.	.
20	Passenger Car	Driver	Male	Yes	Incapacitating	824.60	808.20	945.39	948.11	865.09
21	Passenger Car	Driver	Female	Yes	Incapacitating	813.32	861.21	943.23	884.10	881.12
22	Passenger Car	Driver	Female	Yes	Incapacitating	853.00	945.42	805.03	805.20	518.50
23	Passenger Car	Driver	Male	Yes	Incapacitating	943.21	948.00	682.30	.	.
24	Passenger Car	Driver	Male	Yes	Incapacitating	805.02	808.20	807.01	805.60	942.32
25	Passenger Car	Driver	Male	Yes	Incapacitating	941.29	944.28	276.80	.	.
26	Passenger Car	Driver	Male	Yes	Incapacitating	850.50	861.21	944.43	944.23	924.01
27	Passenger Car	Driver	Male	No	Nonincapacitating	427.31	780.30	873.44	922.10	986.00
28	Passenger Car	Driver	Male	Yes	Nonincapacitating	436.00	943.03	427.31	851.80	298.90
29	Passenger Car	Driver	Female	Yes	Nonincapacitating	946.40	948.00	812.21	808.20	867.00
30	Passenger Car	Driver	Male	Yes	Nonincapacitating	987.10	998.40	298.90	873.00	891.00
31	Passenger Car	Driver	Male	Yes	Nonincapacitating	946.30	958.30	305.00	948.10	.
32	Passenger Car	Driver	Male	Yes	Nonincapacitating	303.91	947.00	780.30	.	.
33	Passenger Car	Driver	Male	Yes	Nonincapacitating	944.10	.	.	.	.
34	Passenger Car	Driver	Male	Yes	Nonincapacitating	823.00	943.20	924.80	412.00	780.57
35	Passenger Car	Driver	Male	No	Possible	682.30	943.21	707.10	250.61	357.20

Table 25 (continued): Persons Suffering Fire-Related or Burn-Related Injuries by Vehicle Type, Occupant Role in Crash, Sex, EMS Transport to Hospital, Injury Severity, and Diagnosis Codes (N-Codes 1 through 5)

Obs	VEHICLE TYPE	ROLE	SEX	EMS TRANS TO HOSPITAL	INJURY SEVERITY	N-CODE 1	N-CODE 2	N-CODE 3	N-CODE 4	N-CODE 5
36	Passenger Car	Driver	Male	No	Possible	987.90	.	.	.	.
37	Passenger Car	Driver	Male	Yes	Possible	303.00	986.00	.	.	.
38	Passenger Car	Driver	Male	Yes	Killed	854.05	948.30	860.40	958.40	946.30
39	Passenger Car	Driver	Male	Yes	Unknown	946.20	941.11	948.00	780.60	.
40	Passenger Car	Passenger	Male	No	Incapacitating	807.20	987.90	807.02	493.90	.
41	Passenger Car	Passenger	Male	Yes	Incapacitating	823.20	945.21	948.00	880.03	.
42	Passenger Car	Passenger	Female	Yes	Incapacitating	945.39	948.00	839.04	839.05	839.06
43	Passenger Car	Passenger	Male	Yes	Incapacitating	953.40	942.34	808.20	881.00	599.70
44	Passenger Car	Passenger	Male	Yes	Incapacitating	854.01	882.00	873.42	943.23	943.25
45	Passenger Car	Passenger	Female	Yes	Incapacitating	942.33	942.34	945.39	944.28	948.20
46	Passenger Car	Passenger	Female	Yes	Incapacitating	942.23	945.20	941.20	948.00	.
47	Passenger Car	Passenger	Male	Yes	Incapacitating	941.39	942.32	943.39	944.38	945.39
48	Passenger Car	Passenger	Male	Yes	Incapacitating	946.30	948.33	802.40	802.60	801.00
49	Passenger Car	Passenger	Female	Yes	Incapacitating	943.32	860.00	305.00	807.01	894.00
50	Passenger Car	Passenger	Female	Yes	Incapacitating	.	922.80	945.23	.	.
51	Passenger Car	Passenger	Male	Yes	Incapacitating	947.10	518.81	458.90	486.00	.
52	Passenger Car	Passenger	Male	Yes	Incapacitating	801.26	945.06	38.10	507.00	518.50
53	Passenger Car	Passenger	Female	Yes	Incapacitating	944.30	941.19	.	.	.
54	Passenger Car	Passenger	Male	Yes	Nonincapacitating	873.10	880.00	873.42	945.26	.
55	Passenger Car	Passenger	Male	Yes	Nonincapacitating	946.40	948.99	958.30	518.81	38.80
56	Passenger Car	Passenger	Female	Yes	Nonincapacitating	648.33	648.43	303.01	648.93	945.06
57	Passenger Car	Passenger	Male	No	Possible	941.20	944.20	.	.	.
58	Passenger Car	Passenger	Male	Yes	Killed	946.30	948.77	997.30	511.80	286.60
59	Passenger Car	Passenger	Male	Yes	Killed	941.30	948.95	944.30	945.32	940.40
60	Utility Truck	Driver	Male	No	Not Injured	944.36	943.21	943.22	948.00	.
61	Utility Truck	Driver	Male	No	Not Injured	941.39	958.30	802.40	948.00	.
62	Utility Truck	Driver	Male	Yes	Incapacitating	943.31	.	.	.	.
63	Utility Truck	Driver	Male	Yes	Incapacitating	810.00	945.24	919.00	924.80	864.01
64	Utility Truck	Driver	Male	Yes	Incapacitating	941.29	942.39	948.32	820.80	805.40
65	Utility Truck	Driver	Male	Yes	Incapacitating	807.01	512.80	945.26	944.21	864.01
66	Utility Truck	Driver	Male	Yes	Nonincapacitating	890.00	891.00	942.23	272.00	.
67	Utility Truck	Driver	Male	Yes	Nonincapacitating	808.43	808.00	867.00	946.20	835.01
68	Utility Truck	Driver	Male	No	Possible	945.34	285.10	305.63	303.93	.
69	Utility Truck	Driver	Male	Yes	Killed	801.25	946.30	250.00	.	.
70	Utility Truck	Passenger	Male	Yes	Incapacitating	854.06	854.06	945.26	942.34	918.10

Table 25 (continued): Persons Suffering Fire-Related or Burn-Related Injuries by Vehicle Type, Occupant Role in Crash, Sex, EMS Transport to Hospital, Injury Severity, and Diagnosis Codes (N-Codes 1 through 5)

Obs	VEHICLE TYPE	ROLE	SEX	EMS TRANS TO HOSPITAL	INJURY SEVERITY	N-CODE 1	N-CODE 2	N-CODE 3	N-CODE 4	N-CODE 5
71	Utility Truck	Passenger	Female	Yes	Incapacitating	945.29	942.24	944.28	948.20	987.90
72	Utility Truck	Passenger	Male	Yes	Incapacitating	813.01	944.47	919.00	873.00	881.01
73	Straight Truck	Driver	Male	Yes	Nonincapacitating	824.70	825.00	943.21	825.25	891.00
74	Straight Truck	Driver	Male	Yes	Possible	946.20	599.00	948.10	.	.
75	Straight Truck	Passenger	Male	Yes	Possible	943.29	945.26	941.18	948.10	.
76	Truck Tractor	Driver	Male	Yes	Incapacitating	946.30	8.45	958.30	948.30	.
77	Truck Tractor	Passenger	Male	Yes	Incapacitating	823.32	823.00	946.20	873.00	873.49
78	Motorcycle	Motorcyclist	Male	No	Incapacitating	945.30	919.00	.	.	.
79	Motorcycle	Motorcyclist	Female	Yes	Incapacitating	823.30	823.01	891.20	944.00	285.10
80	Motorcycle	Motorcyclist	Female	Yes	Incapacitating	942.13	881.01	916.00	.	.
81	Motorcycle	Motorcyclist	Male	Yes	Incapacitating	864.04	866.01	863.21	942.39	943.30
82	Motorcycle	Motorcyclist	Male	Yes	Incapacitating	943.31	946.20	890.10	38.10	276.10
83	Motorcycle	Motorcyclist	Male	Yes	Incapacitating	836.52	836.54	946.20	948.50	808.43
84	Motorcycle	Motorcyclist	Male	Yes	Incapacitating	948.11	810.00	873.52	881.01	.
85	Motorcycle	Motorcyclist	Male	Yes	Incapacitating	945.39	854.06	941.29	942.23	944.28
86	Motorcycle	Motorcyclist	Male	Yes	Incapacitating	945.39	860.00	948.10	.	.
87	Motorcycle	Motorcyclist	Male	Yes	Incapacitating	824.90	825.10	946.20	948.11	.
88	Motorcycle	Motorcyclist	Male	Yes	Nonincapacitating	946.20	340.00	.	.	.
89	Motorcycle	Motorcyclist	Male	Yes	Nonincapacitating	946.20	948.00	755.64	.	.
90	Motorcycle	Motorcyclist	Male	Yes	Nonincapacitating	946.30	948.22	.	.	.
91	Snow Plow	Driver	Male	Yes	Incapacitating	808.00	808.20	453.80	941.36	944.37
92	Bicycle	Bicyclist	Male	Yes	Incapacitating	807.01	941.28	943.25	874.80	880.00
93	Pedestrian	Pedestrian	Male	Yes	Incapacitating	942.32	801.00	941.30	948.00	824.80
94	Pedestrian	Pedestrian	Female	Yes	Incapacitating	821.01	812.21	808.20	807.05	942.39
95	Pedestrian	Pedestrian	Male	Yes	Incapacitating	824.80	945.03	.	.	.
96	Pedestrian	Pedestrian	Male	Yes	Incapacitating	945.40	942.44	873.00	910.00	911.00
97	Pedestrian	Pedestrian	Female	No	Nonincapacitating	821.01	946.20	.	.	.
98	Pedestrian	Pedestrian	Female	No	Nonincapacitating	945.34	945.14	945.24	910.00	911.00
99	Pedestrian	Pedestrian	Male	Yes	Nonincapacitating	941.39	944.26	.	.	.
100	Pedestrian	Pedestrian	Male	Yes	Nonincapacitating	944.38	945.34	314.01	.	.
101	Pedestrian	Pedestrian	Male	Yes	Possible	821.01	924.00	945.24	.	.

Table 26 Injured Passenger Vehicle Occupants (Drivers and Passengers) with and without Fire-Related Injuries by Length of Stay in Hospital and Hospital Charges						
	Length of Stay in Hospital			Hospital Charges		
Injured Persons:	Total Days in Hospital	Number of Persons	Average Stay per Person	Total Hospital Charges ($)	Number of Persons	Average Charge ($) per Person
with Fire-Related Injuries	1,130	72	15.69	$3,582,139	72	$49,752
without Fire-Related Injuries	103,786	15,002	6.92	$199,426,967	15,002	$13,293
Total	104,916	15,074	6.96	$203,009,106	15,074	$13,468

Comments: Of the 20,030 persons hospitalized for injuries sustained in motor vehicle crashes in Wisconsin between 1991 and 1994, 101 (0.50 percent) suffered fire-related or burn-related injuries. Seventy-two (72) of these 101 patients were passenger vehicle occupants. For statistical purposes these hospital data are quite sparse.

In addition to being quite sparse, the reliability of some of the cases reported can be questioned Looking at the very first case in Table 25 we see that this passenger car driver was reported as not having been injured and not having been transported to hospital by EMS. Yet, as a hospital patient this same man received five nature of injury codes that are indicative of burns (941.39, 948.00, 943.12, 942.13, and 944.10). Altogether, ten (13.9 percent) of the 72 passenger vehicle occupants who were hospitalized with fire-related or burn-related injuries were coded by investigating officers as being "not injured" in the crash and not transported by EMS personnel to hospital. These seeming contradictions between the police-reported crash data and the hospital data are disturbing.

Case 88 in Table 25 is a motorcyclist who was transported to the hospital by EMS and coded by the investigating officer as having non-incapacitating injuries. Diagnoses at the hospital were:

(946.20) "Burns of multiple specified sites: blisters, epidermal loss [second degree]"
(340.00) "Multiple sclerosis"

No mechanical trauma is cited for this motorcyclist.

Case 90 in Table 25 is another motorcyclist who was transported to hospital by EMS and who, in the opinion of the investigating officer, sustained non-incapacitating injuries. Diagnoses at the hospital were:

(946.30) "Burns of multiple specified sites: full-thickness skin loss [third degree NOS (not otherwise specified)]"
(948.22) "Burns classified according to extent of body surface involved: 20-29 percent

of body with 20-29 percent third degree"

No mechanical trauma is cited for this motorcyclist.

Turning now to pedestrians who suffered burns: for cases 99 and 100, the only diagnostic codes that are cited are burn codes (and one mental disorder):

Case 99 (941.39) "Burn of face, head, and neck: full-thickness skin loss [third degree NOS (not otherwise specified)], multiple sites [except with eye] of face, head, and neck"

(944.26) "Burn of wrist(s) and hand(s): blisters, epidermal loss [second degree], back of hand"

Case 100 (944.38) "Burn of wrist(s) and hand(s): full-thickness skin loss [third degree NOS (not otherwise specified)], multiple sites of wrist(s) and hand(s)"

(945.34) "Burn of lower limb(s): full-thickness skin loss [third degree NOS (not otherwise specified)], lower leg"

(314.01) "Hyperkinetic syndrome of childhood: attention deficit disorder, with hyperactivity" (NOTE: This case is a 7-year old child)

Again, no mechanical trauma is cited for either of these pedestrians.

It is hard to imagine how motorcyclists and pedestrians can suffer such serious burn-related injuries in traffic crashes without at the same time sustaining some sort of mechanical trauma. The anomalies documented in the data are a concern that brings into question the reliability of the input data and/or the linking file that merges the crash and hospital files.

Utah Database

Description of the Data: The State of Utah provided the project with its 1991 PASSCAR database. This database contains 98,373 passenger vehicle drivers (n = 66,035) and non-drivers (n = 32,338).[16] The vehicle types in which the drivers and non-drivers were riding included: 68,307 passenger cars (69.4 percent), 29,892 pickups or panel trucks (30.4 percent), and 174 "other" vehicles (0.2 percent).

Some 230 separate variables were drawn from state crash files, EMS files, hospital inpatient files, hospital outpatient files, etc. to define or describe the cases in the database. Not all variables were available or applicable for all 98,373 cases. Only 1,103 (1.1 percent) of the 98,373 cases in the

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[16]All of the non-drivers contained in the 1991 PASSCAR file appear to be vehicle occupants, though the documentation is not clear on this point. *"Crash Outcome Data Evaluation System (CODES), 1991 Crash Database Dictionary,"* University of Utah, Salt Lake City, Utah.

database contained hospital admission data.[17] Another 9,311 (9.5 percent) of the cases contained hospital outpatient data.

Persons with Fire-Related or Burn-Related Injuries: In order to subset those individuals in the database who had suffered fire-related or burn-related injuries, searches were carried out on (1) EMS data, (2) hospital inpatient data, and (3) hospital outpatient data.

EMS personnel collect and record up to five injury codes for each individual, i.e., a first injury code, a second injury code, ... a fifth injury code. Each of the five injury codes contains the same list of 31 ailments plus a miscellaneous category. One of the categories that can be selected by EMS personnel to describe an individual's condition is "burns." By searching through all five injury codes for all of the individuals in the data set served by EMS, seven crash victims with burns were identified.

Up to 11 diagnostic codes derived from the ICD9-CM were available for individuals who were admitted to hospital: an admitting diagnosis and 10 supplemental diagnoses (DX1-DX10). All 11 diagnoses were scanned to identify persons with N-codes (≥940 and <950) or (≥986 and <988), i.e., to identify persons having suffered thermal trauma, smoke inhalation, and/or asphyxiation. These were the same N-codes used previously in the Wisconsin analyses. By this process, four hospital inpatients were identified.

Up to six diagnostic codes derived from the ICD9-CM were available for individuals who were admitted to hospital as outpatients: an admitting diagnosis and five supplemental diagnoses (DX1-DX5). Once again all six diagnoses were scanned to identify persons with N-codes (≥940 and <950) or (≥986 and <988). Some 15 outpatients were thus identified.

Table 27 indicates that there is some overlap in the three searches that were carried out. One of the four inpatients and one of the 15 outpatients were seen by EMS. For none of the individuals in Table 27 were both inpatient and outpatient data available.

Table 28 documents the diagnostic codes used with the four individuals who were admitted into hospital and the 15 who were treated on an outpatient basis, along with the hospital charges for the services they received. The sum of the hospital charges for the four inpatients was $404,124 (an average of $101,031 per person).[18] By way of comparison, the average hospital inpatient charges for the 1,099 persons who were not found to have suffered fire-related or burn-related injuries was $14,545. This figure of $14,545 in Utah compares favorably to the corresponding figure in Wisconsin

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[17]This figure of 1.1 percent is comparable to the 1.3 percent of Wisconsin cases (1992-1995) that could be linked to hospital records.

[18]This average figure of $101,031 per person is approximately twice as large as the figure seen in Wisconsin ($49,752). Note, however, that the Utah average is based on just four cases.

Table 27: Fire-Related and Burn-Related Cases from EMS, Inpatient, and Outpatient Records							
Case Number	Outpatient	Inpatient	EMS	Case Number	Outpatient	Inpatient	EMS
1	✔			13	✔		
2	✔			14	✔		
3	✔			15	✔		
4	✔			16		✔	
5			✔	17	✔		
6	✔			18	✔		
7		✔		19	✔		
8		✔	✔	20	✔		
9	✔			21	✔		
10			✔	22		✔	
11			✔	23			✔
12			✔	24	✔		✔

of $13,293. The four patients with fire-related or burn-related injuries spent an average of 21.5 days in hospital. By comparison, for 1,099 patients who did not suffer fire-related or burn-related injuries, the average hospital stay was 5.8 days.

For the 15 individuals who were served on an outpatient basis, the sum of their hospital charges for outpatient services was $11,966 (an average of $798 per person). For 9,296 other outpatients who did not suffer fire-related or burn-related injuries, the average charge per person was $496.

Again it should be emphasized that any differences in hospital charges and days in hospital for patients who did and did not suffer fire-related and burn-related injuries is not solely attributable to the effects of the fire. As has been pointed out several times, passenger vehicle occupants who sustain thermal trauma, smoke inhalation, etc. are involved in systematically more severe crashes.

Comment: Although the Utah 1999 PASSCAR database contains 98,373 cases and 230 variables, it contained only 24 individuals who suffered fire-related or burn-related injuries. Of these 24, four were hospital inpatients, 15 were outpatients, and five were served by EMS, but were not hospital inpatients or outpatients. From such a small sample of cases, meaningful estimates or projections are not feasible.

Table 28: Persons Suffering Fire-Related or Burn-Related Injuries by Inpatient or Outpatient Records, Vehicle Type, Driver/Not Driver, Sex, Hospital Charges, Length of Stay, and Diagnosis Codes (Admitting N-Code, N-Codes 1 through 10)

Hospital Inpatient Records

CASE NO.	VEHICLE TYPE	DRIVER	SEX	INPATIENT HOSPITAL CHARGES	LENGTH OF STAY (Days)	ADMITTING N-CODE	N-CODE 1
7	Pickup/Panel	Not Driver	M	$ 5456	1	941.22	941.22
8	Pickup/Panel	Driver	M	$ 310824	54	949.00	943.35
16	Passenger Car	Driver	M	$ 45375	17	949.00	943.33
22	Passenger Car	Not Driver	M	$ 42469	14	942.34	942.34
				=========	=======		
				$ 404124	86		

N-CODE 2	N-CODE 3	N-CODE 4	N-CODE 5	N-CODE 6	N-CODE 7	N-CODE 8	N-CODE 9	N-CODE 10
805.20	948.00	873.41	924.80	.	.	.	.	.
948.32	958.30	577.00	943.33	943.31	944.38	945.34	942.32	941.22
943.32	943.31	944.38	942.24	945.26	948.10	.	987.90	.
948.20	.	910.00	913.00	916.00	945.36	942.32	.	.

Hospital Outpatient Records

CASE NO.	VEHICLE TYPE	DRIVER	SEX	INPATIENT HOSPITAL CHARGES	ADMITTING N-CODE	N-CODE 1	N-CODE 2	N-CODE 3	N-CODE 4	N-CODE 5
1	Pass Car	Driver	F	$ 179	.	944.27	.	.	.	.
2	Pass Car	Driver	F	$ 1460	949.00	949.00	.	.	.	.
3	Pickup/Panel	Driver	M	$ 87	.	940.10	.	.	.	.
4	Pass Car	Not Driver	F	$ 52	945.26	945.26	945.24	.	.	.
6	Pass Car	Not Driver	F	$ 193	.	944.28	.	.	.	.
9	Pass Car	Not Driver	M	$ 313	944.21	944.21	.	.	.	.
13	Pass Car	Driver	F	$ 109	945.22	945.22	.	.	.	.
14	Pickup/Panel	Not Driver	F	$ 369	.	987.90	.	.	.	.
15	Pass Car	Not Driver	F	$ 369	.	987.90	.	.	.	.
17	Pickup/Panel	Driver	M	$ 203	.	943.21	.	.	.	.
18	Pickup/Panel	Not Driver	F	$ 357	948.90	948.90	.	.	.	.
19	Pass Car	Driver	M	$ 156	.	920.00	910.00	940.9	.	.
20	Pickup/Panel	Not Driver	F	$ 293	987.30	987.30	.	.	.	.
21	Pickup/Panel	Driver	M	$ 234	.	987.30	.	.	.	.
24	Pass Car	Not Driver	F	$ 7592	946.20	946.20	.	.	.	.
				=========						
				$ 11966						

THE NATIONAL FIRE INCIDENT REPORTING SYSTEM (NFIRS)

The National Fire Incident Reporting System (NFIRS) is an opportunistic sample of fire-related information provided by participating fire departments located throughout the United States and is maintained by the United States Fire Administration in the Federal Emergency Management Agency. Participation in the collection and reporting of data for this database is voluntary.

There are 11 data collection forms that feed information into NFIRS (as of 5/1/98):

1. Basic
2. Fire
3. Structure
4. Civilian Fire Casualty
5. Fire Service Casualty
6. EMS
7. Hazmat (Hazardous Materials)
8. Wildland Fire
9. Apparatus
10. Personnel
11. Arson

Assessment of Passenger Vehicle Data in NFIRS

1994 Data: In 1994 some 212,190 vehicle fires were included in NFIRS. These 212,190 vehicle fires were reported by 13,851 participating fire departments (56.72 percent of the 24,421 departments nationwide). In total, 1,465 people were reported to have been injured and another 412 were reported to have been killed in these 212,190 vehicles fires. Representative data form 15 participating states are shown in Table 29.

In 1994 all 925 fire departments in Michigan were said to have provided fire data to NFIRS. In that year (1994) Michigan recorded 16,591 vehicle fires (2,799 of which were thought to be arson cases). In these 16,591 fires, 25 civilians were reported to have been killed (one in an arson fire). Analysis of the FARS database for 1994 indicates that 40 vehicle occupants were coded as killed in vehicles that experienced fires in Michigan. Granted that all fire departments in Michigan contribute to NFIRS, and granted that vehicle fires in NFIRS are not restricted to vehicles in motion, it is somewhat surprising to see 15 more decedents in the FARS database than in the NFIRS database.

1995 Data:[19] The NFIRS database for 1995 was purchased from the National Technical Information Service and transformed into SAS (Statistical Analysis System) data sets. Particular attention was paid to one variable contained in that data base, "mobile property use." This is the variable used to define the "vehicles" included in NFIRS.

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[19] "*National Fire Incident Reporting System Handbook,*" Version 4.1, Federal Emergency Management Agency, United State Fire Administration, December 1989. The definitions that are included in this section come from this reference.

Table 29: Vehicle Fires, Deaths, and Injuries in 15 States (NFIRS: 1994)							
		Vehicle Fires		Vehicle Fire Injuries		Vehicle Fire Deaths	
State	Total Fires	Number	Percent of Total	Number	Per 1,000 Fires	Number	Per 1,000 Fires
CA	77,859	18,421	23.66	231	12.54	40	2.17
CO	7,530	1,417	18.82	13	9.17	3	2.12
FL	44,692	11,268	25.21	145	12.87	43	3.82
GA	24,089	6,422	26.66	28	4.36	6	0.93
IL	79,914	20,559	25.73	105	5.11	44	2.14
KS	22,451	3,943	17.56	37	9.38	7	1.78
KY	17,614	4,519	25.66	27	5.97	7	1.55
MA	30,989	7,267	23.45	62	8.53	9	1.24
MI	65,615	16,591	25.29	54	3.25	25	1.51
NJ	27,907	7,005	25.10	36	5.14	9	1.28
NY	56,319	12,489	22.18	52	4.16	19	1.52
OH	58,719	15,286	26.03	89	5.82	24	1.57
TN	19,237	5,025	26.12	26	5.17	13	2.59
TX	94,652	22,459	23.73	148	6.59	52	2.32
VA	25,924	5,804	22.39	53	9.13	3	0.52
US	898,905	212,190	23.61	1,465	6.90	412	1.94

Mobile property use is a two digit code. The first digit defines eight major categories:

1 Passenger road transport vehicles
2 Freight road transport vehicles
3 Rail transport vehicles
4 Water transport vehicles
5 Air transport vehicles
6 Heavy equipment
7 Special vehicles
9 Other mobile property types (note the code for this category is 9 and not 8)

Passenger road transport vehicles are subdivided as follows:

11 Automobile
12 Bus, trackless trolley
13 All terrain vehicles
14 Motor home
15 Travel trailer
16 Camping trailer
17 Mobile home, mobil building
19 Passenger road transport vehicles not classified above
10 Passenger road transport vehicles (insufficient information to classify further)

Pickup trucks are included under mobile property use code 22: General use small trucks under one ton weight, included are pickups wagons, and non-motorized hauling rigs.

Of the 213,242 vehicles in NFIRS in 1995, some 133,705 (62.7 percent) are coded as automobiles and 10,959 (and 5.1 percent) are coded as "general use small trucks under one ton weight." That is to say, there are over 12 times as many automobiles in NFIRS as small trucks. Another 39,882 cases (18.7 percent) were out of range or unknown.

Comment: The first thing that should be understood about the NFIRS database is that it is a sample—an opportunistic sample—of fires to which fire departments have responded. The sample is not necessarily a valid reflection of all fires recorded throughout the United States, i.e., it is not a representative sample.

"Vehicle" fires in NFIRS are very broadly defined to include passenger vehicles, airplanes, boats, mobile homes, trailers, etc. These vehicles may be in motion, at rest, or even inoperable, e.g., "passenger road transport vehicles" includes "abandoned vehicles." Nevertheless, as previously noted, the FARS database indicates that in 1994 some 40 people in Michigan were killed in traffic crashes when the vehicles in which they were riding experienced fires. Yet, the NFIRS database records only 25 deaths in Michigan in 1994, even though all fire departments in the state reported to NFIRS in 1994. It should be noted that the 40 Michigan fatalities in FARS did not necessarily result from thermal trauma, smoke inhalation or asphyxiation. But, by the same token, fatalities in NFIRS are not restricted to fire-related or burn-related deaths.

Finally, the reliability of the vehicular information in NFIRS is bought into question by the analysis of the 1995 data, e.g., 18.7 percent of the vehicle codes were out of range or unknown, 12 times as many automobiles experienced fires as light trucks.

> The National Highway Traffic Safety Administration (NHTSA) is another federal agency with applications for NFIRS data. NHTSA investigates possible safety problems with vehicles, including the incidence of fires. During the course of an investigation, NHTSA looks for trends in data, sometimes from multiple sources, regarding a particular type of vehicle. NFIRS provides a way of investigating the frequency of fires associated with certain models of vehicles.
>
> *"Uses of NFIRS: The Many Uses of the National Fire Incident Reporting System,"* page 12.

It will be very difficult to use NFIRS directly to study trends in motor vehicle fires or to assess the frequency of fires associated with certain models of vehicles. The representativeness of the NFIRS sample, the completeness of the data in that sample, and the reliability of the data collected are all concerns that must be addressed before attempting to use this database to assess trends in motor vehicle fires or the frequency of fires associated with different model vehicles.

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