Center for
National Truck Statistics

FATALITIES AND INJURIES IN TRUCK CRASHES BY TIME OF DAY

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Fatalities and injuries in truck crashes by time of day

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16. Abstract

The Federal Highway Administration (FHWA) currently is considering proposals to change the regulations governing the hours-of-service (HOS) of commercial truck drivers. The purpose of the present report is to provide information on the distribution of crashes, injuries, and fatalities by time of day and to measure the consequences of truck crashes by time of day, both to truck occupants and to other road users. Older sources of VMT data (vehicle miles traveled) are used to illustrate the relative risk of day and night travel.

About 20% of all fatal crashes and fatalities and 10% of all injuries involving a long-haul truck (tractor pulling at least one trailer) occur between midnight and 6 a.m. Crashes at night tend to be more severe, with about 435 injuries per thousand crashes between midnight and 6 a.m., compared with 320 injuries per thousand for the remainder of the day. There are about three times as many fatalities per thousand crashes midnight-6 a.m.

Truck travel estimates by hour of the day are not currently available. Using exposure data classifying night as 9 p.m. to 6 a.m., truck travel during that period is associated with a relative risk about twice that of the rest of the day. Truck driver fatigue in single-vehicle fatal crashes is a significant factor. Driver fatigue and alcohol use in nontruck drivers also form a significant component of the higher risk of night travel. Almost 40% of the nontruck drivers in multiple-vehicle crashes with trucks between midnight and 3 a.m. had used alcohol, compared with 2.7% of the truck drivers. Fatigue was also coded more often for nontruck drivers than for truck drivers in multiple-vehicle crashes.

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Fatalities and injuries in truck crashes by time of day

Introduction

The Federal Highway Administration (FHWA) is currently considering proposals to change the regulations governing the hours of service (HOS) of commercial truck drivers. A recent report [11], sponsored by the FHWA and Transport Canada, identified time of day as a primary factor in truck driver fatigue and reduced alertness, quite separate from time on task. Accordingly, as HOS regulations are revamped, one approach might be to discourage driving during the hours that drivers are most likely to be drowsy and to encourage driving during those times of day when drivers are most likely to be fully awake.

The purpose of the present work is to provide information on the distribution of crashes, injuries, and fatalities by time of day and to measure the differential consequences of truck crashes by time of day, both to truck occupants and to other road users. Tables will be presented showing the distribution of crashes involving a truck, fatalities, and injuries by the hour of the day.

The best approach to evaluating the consequences of any changes in HOS would be to determine the relative risk of truck travel by hour of the day, but that is not possible because there is no currently available source of truck vehicle miles traveled (VMT) that would permit calculating crash rates by hour of the day. However, there are two sources of older truck exposure data that break truck VMT down between night, defined as 9 p.m. to 6 a.m., and day. This breakdown is too crude to be useful in evaluating HOS regulations, but rates showing the relative risk of day and night will be presented to illustrate the increased risk of night travel. We will also provide example calculations showing the effect of restricting night travel.

Data

Three files contributed to the data in this report: the Fatal Accident Reporting System (FARS, now the Fatality Analysis Reporting System); the Trucks Involved in Fatal Accidents (TIFA) file; and the General Estimates System (GES) file. Three years of data, 1993 through 1995, were used from each file.

The TIFA file was used to identify all medium and heavy trucks involved in a fatal crash during the three-year period. Having identified all truck vehicles, the person records of all individuals involved in the crash were extracted from FARS. With the resulting analytic files, counts of all fatalities in a truck crash could be determined, along with identifying whether the fatality occurred to a truck occupant or to some other participant in the crash. In the tables, fatalities and injuries are allocated between truck and nontruck, which means any person in the crash not in a truck.

The GES file is a nationally representative file of police-reported traffic crashes. This file was used to extend the analysis to nonfatal crashes. All trucks were identified in the file and then the records of all individuals involved in the crash were extracted. The GES file is used to estimate the total number of police-reported crashes involving medium and heavy trucks. It is also used to estimate the number of injuries occurring to truck and nontruck occupants involved in a crash. An "injury" includes injuries of all severities reported in the GES file: incapacitating (A), evident but not incapacitating (B), and complaint of pain (C).

Since it is a sample file, estimates from the GES file are subject to sampling and nonsampling errors. A full discussion of the methodology of the GES file and procedures for estimating sampling errors is available in reference 10. Three years of GES were aggregated to improve sample sizes and narrow sampling errors, but confidence intervals for the estimates were not calculated.

In this report, two truck configurations are discussed: (1) all medium and heavy trucks; and (2) tractors pulling at least one trailer. The definition of all medium and heavy trucks includes all truck vehicles with a gross vehicle weight rating (GVWR) of 10,000 pounds or above. This is the usual definition of a truck and is included here for the sake of comprehensiveness.

The focus of the analysis, however, is on tractors pulling one or more trailers. These vehicles include all tractor-semitrailers, doubles, and triples. Bobtails and all straight trucks are excluded. All GVWRs meeting the definition of a truck are included. This definition is intended to capture trucks used for long-distance freight hauling. It is acknowledged that not all such vehicles are used for over-the-road trips and that not all over-the-road trips are limited to such vehicles [9]. However, given the available data on truck type and operating authority, the tractor-with-trailer definition probably provides the best possible.

Results

Figure 1 shows the overall distribution of fatalities for truck and nontruck occupants by hour of the day. All fatal crashes involving any truck are included in the figure. The frequencies aggregate three years of data from TIFA and FARS. The frequencies of fatalities to both truck and nontruck occupants vary over the course of the day, with higher numbers killed during the daylight hours and fewer fatalities per hour between midnight and 6 a.m. About 20% of all fatal crashes and fatalities involving a truck occur between midnight and 6 a.m., with 80% occurring during the rest of the day.

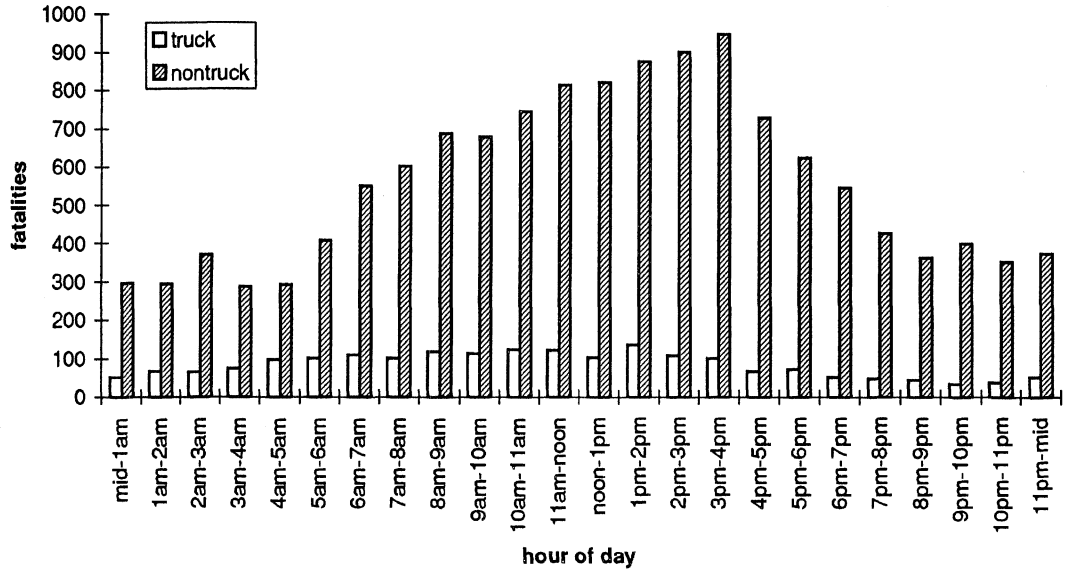

Figure 1 Fatalities by hour of the day
all truck crashes
TIFA and FARS 1993-1995

Figure 2 shows the number of nonfatal injuries to truck and nontruck occupants by time of day. All truck crashes are included in this figure. The figure reflects three years of data; injury counts are not annualized. Injuries occur disproportionately during the day, even more so than fatalities. Note also that the difference in the number of injuries between truck and nontruck occupants is less than for fatalities, particularly at night, where more truck than nontruck occupants were injured between 3 a.m. and 5 a.m. About 10% of all injuries in traffic crashes involving a truck occur in the period between midnight and 6 a.m.

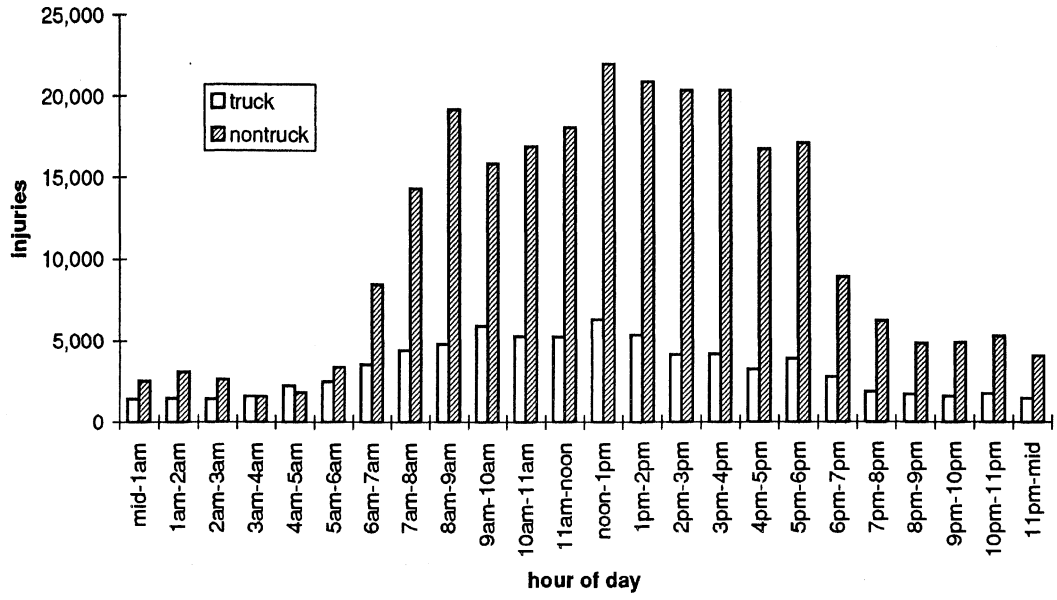

Figure 2 Injuries by hour of the day
all truck crashes
GES 1993-1995

Tables 1 through 4 display the fundamental results from this study. Tables 1 and 3 cover all trucks. Tables 2 and 4 cover tractors pulling one or more trailers.

Table 1 shows counts of accidents and fatalities in all truck crashes. The frequencies shown here, as in all tables, are for three years of data. Fatalities are broken down into truck occupants (typically drivers) and nontruck occupants (primarily occupants of passenger vehicles but including also pedestrians, bicyclists, and other nonmotorists). The columns titled "fatalities per fatal accident" show the average number of fatalities by hour of the day by location (that is, whether the fatality occurred to an occupant of a truck or outside of the truck), and the total for the hour. The columns headed "fatalities per 1000 accidents" show the number of fatalities for all police-reportable crashes by location and hour of the day. Estimates for the number of crashes of all severities are determined from the GES file.

Table 1
Fatal crash and fatality frequencies and rates by hour of the day
All trucks
FARS and TIFA 1993-1995, GES 1993-1995

		Fatalities, all trucks			Fatalities per fatal accident			Fatalities per 1000 accidents		
Hour	Accidents	Truck	Nontruck	Total	Truck	Nontruck	Total	Truck	Nontruck	Total
mid-1am	308	51	296	347	0.17	0.96	1.13	5.88	34.14	40.02
1am-2am	313	68	295	363	0.22	0.94	1.16	7.58	32.88	40.46
2am-3am	371	66	370	436	0.18	1.00	1.18	7.58	42.51	50.09
3am-4am	303	74	288	362	0.24	0.95	1.19	8.19	31.89	40.09
4am-5am	346	97	292	389	0.28	0.84	1.12	11.62	34.98	46.60
5am-6am	461	101	408	509	0.22	0.89	1.10	6.25	25.23	31.48
6am-7am	585	110	550	660	0.19	0.94	1.13	4.00	20.02	24.02
7am-8am	630	102	601	703	0.16	0.95	1.12	1.64	9.65	11.29
8am-9am	678	118	687	805	0.17	1.01	1.19	1.69	9.84	11.54
9am-10am	680	113	678	791	0.17	1.00	1.16	1.66	9.96	11.62
10am-11am	736	124	743	867	0.17	1.01	1.18	1.60	9.58	11.18
11am-noon	794	122	812	934	0.15	1.02	1.18	1.52	10.14	11.67
noon-1pm	794	103	819	922	0.13	1.03	1.16	1.38	10.95	12.33
1pm-2pm	849	136	874	1,010	0.16	1.03	1.19	1.71	10.97	12.68
2pm-3pm	820	108	900	1,008	0.13	1.10	1.23	1.39	11.55	12.94
3pm-4pm	877	101	946	1,047	0.12	1.08	1.19	1.33	12.48	13.82
4pm-5pm	651	68	728	796	0.10	1.12	1.22	1.09	11.62	12.70
5pm-6pm	604	72	623	695	0.12	1.03	1.15	1.26	10.87	12.13
6pm-7pm	482	52	544	596	0.11	1.13	1.24	1.57	16.40	17.97
7pm-8pm	395	48	426	474	0.12	1.08	1.20	2.05	18.24	20.29
8pm-9pm	347	44	362	406	0.13	1.04	1.17	2.00	16.45	18.45
9pm-10pm	371	33	399	432	0.09	1.08	1.16	1.49	18.07	19.57
10pm-11pm	315	38	352	390	0.12	1.12	1.24	2.09	19.39	21.48
11pm-mid	356	52	373	425	0.15	1.05	1.19	4.37	31.33	35.70
unknown	9	4	5	9	0.44	0.56	1.00	1.25	1.56	2.81
Total	13,075	2,005	13,371	15,376	0.15	1.02	1.18	1.99	13.28	15.27

Overall, 1.18 persons are killed per accident in all truck crashes involving a fatality, 0.15 in the truck and 1.02 outside the truck. As is widely known, fatalities occur primarily outside of the truck because of mass and structural differences between trucks and other vehicles. Examining the distribution of fatalities per crash by time of day, differences between day and night hours appear to be slight. For truck occupants, the hours between midnight and 6 a.m. have higher numbers of truck occupants killed per fatal crash, which reflects the higher proportion of single-vehicle crashes during that period. The ratio of nontruck to truck fatalities is somewhat lower during those hours, though still substantially in favor of the truck.

The rate of fatalities per 1000 accidents reflects a higher probability of fatal injury, given a crash, at night. From about 7 a.m. to 6 p.m., about 10 to 12 nontruck occupants are killed per 1000 truck crashes. The rate increases to 42.51 per 1000 truck crashes between 2 a.m. and 3 a.m. Truck occupants experience a similar increase in the probability of fatality, given a crash, at night. During the day, fewer than two truck occupants are killed per 1000 truck crashes, but at night the ratio increases to between six and eight fatalities, with a peak of 11.62 between 4 a.m. and 5 a.m.

Table 2 includes the same categories as table 1 but is restricted to tractors pulling one or more trailers, in other words, trucks primarily engaged in long-haul trucking. Patterns by hour of the day of fatalities per fatal accident and fatalities per 1000 accidents are similar to all trucks, though with somewhat higher numbers of fatalities per crash and per 1000 accidents.

Table 2
Fatal crash and fatality frequencies and rates by hour of the day
Tractors pulling one or more trailers
FARS and TIFA 1993-1995, GES 1993-1995

		Fatalities			Fatalities per fatal accident			Fatalities per 1000 accidents		
Hour	Accidents	Truck	Nontruck	Total	Truck	Nontruck	Total	Truck	Nontruck	Total
mid-1am	260	44	251	295	0.17	0.97	1.13	7.67	43.78	51.45
1am-2am	253	52	241	293	0.21	0.95	1.16	8.06	37.33	45.39
2am-3am	307	52	316	368	0.17	1.03	1.20	8.24	50.08	58.33
3am-4am	250	64	240	304	0.26	0.96	1.22	8.54	32.03	40.57
4am-5am	289	82	246	328	0.28	0.85	1.13	13.74	41.21	54.94
5am-6am	352	86	297	383	0.24	0.84	1.09	8.63	29.82	38.45
6am-7am	400	87	367	454	0.22	0.92	1.14	5.12	21.58	26.69
7am-8am	361	54	351	405	0.15	0.97	1.12	1.65	10.71	12.36
8am-9am	377	74	389	463	0.20	1.03	1.23	1.95	10.25	12.20
9am-10am	401	65	420	485	0.16	1.05	1.21	1.97	12.70	14.66
10am-11am	387	75	392	467	0.19	1.01	1.21	2.05	10.73	12.78
11am-noon	447	79	458	537	0.18	1.02	1.20	1.81	10.47	12.28
noon-1pm	467	59	498	557	0.13	1.07	1.19	1.58	13.33	14.91
1pm-2pm	491	79	517	596	0.16	1.05	1.21	2.02	13.21	15.23
2pm-3pm	457	60	516	576	0.13	1.13	1.26	1.65	14.23	15.88
3pm-4pm	514	68	564	632	0.13	1.10	1.23	1.79	14.89	16.68
4pm-5pm	383	38	443	481	0.10	1.16	1.26	1.21	14.14	15.35
5pm-6pm	387	45	412	457	0.12	1.06	1.18	1.41	12.90	14.31
6pm-7pm	347	35	415	450	0.10	1.20	1.30	1.73	20.47	22.19
7pm-8pm	272	26	299	325	0.10	1.10	1.19	1.80	20.69	22.49
8pm-9pm	271	29	295	324	0.11	1.09	1.20	1.72	17.54	19.26
9pm-10pm	300	25	328	353	0.08	1.09	1.18	1.69	22.11	23.80
10pm-11pm	243	25	277	302	0.10	1.14	1.24	2.06	22.83	24.89
11pm-mid	292	39	310	349	0.13	1.06	1.20	4.46	35.49	39.95
unknown	7	1	4	5	0.14	0.57	0.71	0.46	1.83	2.29
Total	8,515	1,343	8,846	10,189	0.16	1.04	1.20	2.46	16.19	18.65

Table 3 presents data on crashes and injuries in traffic crashes for all trucks, derived from the GES file. All crash severities are included in the table, not just fatal crashes as in the two previous tables. While there are fewer crashes and injuries per hour between midnight and 7 a.m. than during the day, the crashes are more serious in terms of injury. Some of the hourly variation is probably due to sampling error (frequencies in the previous tables are census counts, not estimates), but the pattern of higher numbers of injuries per 1000 truck-involved crashes in the early morning hours is clear. Both truck occupants and nontruck occupants experience higher rates of injury per 1000 crashes between midnight and 7 a.m. The disproportion is greater for truck occupants than for nontruck occupants. The mean number of truck occupant injuries per 1000 crashes overall is 77.8, but between midnight and 7 a.m., the rate per hour varies between 128.1 and 269.6. The highest rate, almost 270, occurs between 4 a.m. and 5 a.m.

Table 3
Crash and injury frequencies and rates by hour of day
All trucks
GES 1993-1995

		Injuries			Injuries per 1000 accidents		
Hour	Accidents	Truck	Nontruck	Total	Truck	Nontruck	Total
mid-1am	8,671	1,416	2,558	3,974	163.3	295.0	458.3
1am-2am	8,972	1,460	3,087	4,546	162.7	344.0	506.7
2am-3am	8,704	1,444	2,600	4,044	165.9	298.7	464.6
3am-4am	9,030	1,590	1,555	3,145	176.1	172.2	348.3
4am-5am	8,348	2,251	1,835	4,086	269.6	219.8	489.4
5am-6am	16,171	2,503	3,356	5,859	154.8	207.6	362.4
6am-7am	27,477	3,520	8,449	11,969	128.1	307.5	435.6
7am-8am	62,256	4,419	14,336	18,755	71.0	230.3	301.3
8am-9am	69,786	4,803	19,189	23,992	68.8	275.0	343.8
9am-10am	68,053	5,920	15,866	21,786	87.0	233.1	320.1
10am-11am	77,577	5,279	16,918	22,197	68.0	218.1	286.1
11am-noon	80,061	5,259	18,076	23,335	65.7	225.8	291.5
noon-1pm	74,781	6,293	21,963	28,256	84.2	293.7	377.9
1pm-2pm	79,661	5,392	20,876	26,268	67.7	262.1	329.7
2pm-3pm	77,911	4,140	20,332	24,472	53.1	261.0	314.1
3pm-4pm	75,773	4,210	20,346	24,556	55.6	268.5	324.1
4pm-5pm	62,664	3,280	16,735	20,015	52.3	267.1	319.4
5pm-6pm	57,293	3,919	17,104	21,023	68.4	298.5	366.9
6pm-7pm	33,171	2,775	8,898	11,672	83.7	268.2	351.9
7pm-8pm	23,359	1,878	6,206	8,084	80.4	265.7	346.1
8pm-9pm	22,006	1,687	4,841	6,528	76.7	220.0	296.7
9pm-10pm	22,077	1,612	4,850	6,462	73.0	219.7	292.7
10pm-11pm	18,154	1,759	5,283	7,042	96.9	291.0	387.9
11pm-mid	11,905	1,482	4,073	5,555	124.5	342.1	466.6
unknown	3,205	66	196	261	20.5	61.1	81.5
Total	1,007,065	78,354	259,526	337,880	77.8	257.7	335.5

Table 4 completes the series, showing crashes, injuries, and injury rates for crashes involving long-haul trucks. The pattern of rates in this table is very similar to table 3.

Table 4
Crash and injury frequencies and rates by hour of day
Tractors pulling one or more trailers
GES 1993-1995

		Injuries			Injuries per 1000 accidents		
Hour	Accidents	Truck	Nontruck	Total	Truck	Nontruck	Total
mid-1am	5,734	698	1,604	2,302	121.8	279.8	401.6
1am-2am	6,455	1,042	1,916	2,958	161.4	296.7	458.2
2am-3am	6,309	1,187	1,844	3,031	188.2	292.3	480.5
3am-4am	7,494	1,400	1,353	2,753	186.9	180.5	367.4
4am-5am	5,970	1,915	1,546	3,461	320.8	258.9	579.7
5am-6am	9,961	1,600	2,155	3,755	160.6	216.3	377.0
6am-7am	17,007	2,219	4,815	7,035	130.5	283.1	413.6
7am-8am	32,771	2,400	8,019	10,419	73.2	244.7	317.9
8am-9am	37,951	2,521	9,703	12,224	66.4	255.7	322.1
9am-10am	33,073	2,977	7,664	10,641	90.0	231.7	321.7
10am-11am	36,543	2,490	8,177	10,668	68.1	223.8	291.9
11am-noon	43,745	2,391	9,098	11,489	54.7	208.0	262.6
noon-1pm	37,349	2,332	10,211	12,543	62.4	273.4	335.8
1pm-2pm	39,138	2,303	11,632	13,935	58.8	297.2	356.0
2pm-3pm	36,270	2,010	9,039	11,048	55.4	249.2	304.6
3pm-4pm	37,890	1,703	9,499	11,202	45.0	250.7	295.6
4pm-5pm	31,339	1,784	7,641	9,425	56.9	243.8	300.7
5pm-6pm	31,932	1,812	9,087	10,899	56.8	284.6	341.3
6pm-7pm	20,276	1,215	4,568	5,783	59.9	225.3	285.2
7pm-8pm	14,452	1,210	3,616	4,826	83.7	250.2	333.9
8pm-9pm	16,822	936	3,870	4,807	55.7	230.1	285.7
9pm-10pm	14,834	751	4,088	4,838	50.6	275.6	326.2
10pm-11pm	12,136	1,004	4,178	5,182	82.7	344.3	427.0
11pm-mid	8,735	1,124	3,534	4,658	128.7	404.6	533.2
unknown	2,188	46	127	174	21.2	58.1	79.3
Total	546,375	41,071	138,981	180,053	75.2	254.4	329.5

Tables 5 summarizes injury and fatality rates by time of day for long-haul trucks. The rates are show for three-hour increments in order to better display the underlying pattern. Overall, the injury rate per 1000 crashes is highest between midnight and 6 a.m.; it is lowest between 6 p.m. and 9 p.m. Much of the variation is accounted for by injuries to truck occupants. The 3 a.m. to 6 a.m. period has the highest rate of injury per accident to truck occupants, while nontruck occupants have the lowest rate. Considering fatalities per fatal accident, the overall rate is lower in the midnight to 6 a.m. period, but the proportion of fatalities for truck occupants is higher in that period. Single-vehicle crashes account for this pattern.

Fatalities per 1000 injuries is a measure of crash severity. Overall, there are 56.6 fatalities per 1000 injuries in long-haul truck crashes. Fatalities are about twice as likely in the period between midnight and 6 a.m. The relative increase in the probability of fatality given involvement in an injury crash is even higher for a nontruck occupant than a truck occupant. There are about 150 fatalities per 1000 injuries for nontruck occupants between midnight and 6 a.m., compared with the overall rate of 63.6 for a factor of 2.4, while the rate for occupants of long-haul trucks in the same period increases only from 32.7 to about 50, a factor of 1.5. Reporting bias may influence the rates per 1000 crashes, since minor accidents may be less likely to be reported at night, but reporting bias should not be a major influence for injury crashes.

Thus it appears that crashes involving long-haul trucks at night tend to be more serious in terms of fatalities.

Table 5
Injury and fatality rates by time of day
Tractors with one or more trailers
GES, FARS, and TIFA 1993-1995

	Injuries per 1000 crashes			Fatalities per fatal crash			Fatalities per 1000 injuries		
Hour	Truck	Nontruck	Total	Truck	Nontruck	Total	Truck	Nontruck	Total
mid-3am	158.3	290.0	448.2	0.18	0.99	1.17	50.6	150.6	115.3
3am-6am	209.8	215.7	425.6	0.26	0.88	1.14	47.2	154.9	101.8
6am-9am	81.4	256.9	338.3	0.19	0.97	1.16	30.1	49.1	44.5
9am-noon	69.3	220.0	289.3	0.18	1.03	1.21	27.9	50.9	45.4
noon-3pm	58.9	273.9	332.8	0.14	1.08	1.22	29.8	49.6	46.1
3pm-6pm	52.4	259.3	311.6	0.12	1.11	1.22	28.5	54.1	49.8
6pm-9pm	65.2	233.8	299.0	0.10	1.13	1.23	26.8	83.7	71.3
9pm-mid	80.6	330.5	411.1	0.11	1.10	1.20	30.9	77.5	68.4
unknown	21.2	58.1	79.3	0.14	0.57	0.71	21.5	31.5	28.8
Total	75.2	254.4	329.5	0.16	1.04	1.20	32.7	63.6	56.6

Relative risk of night travel

Currently, exposure data are not available to calculate crash rates by VMT by hour of the day. However, there are two sources of exposure data that allow classification of VMT into coarse categories of day and night. The National Truck Trip Information Survey (NTTIS) and the Michigan Truck Trip Information Survey (MTTIS) surveyed truck travel nationally and in the state of Michigan, respectively [3, 4]. For both surveys, "night" was defined as 9 p.m. to 6 a.m. and day as 6 a.m. to 9 p.m. Clearly, this classification is not fine-grained enough to be useful in evaluating the risk of time of day in HOS applications. Nevertheless, it does shed some light on the relative risk of night travel. It can also be used in an example calculation to illustrate the safety consequences of restricting truck operations at night.

In addition to the travel data on heavy trucks, a recent National Highway Traffic Safety Administration (NHTSA) study reports crash, injury, and fatality rates by time of day for passenger vehicles [6]. Rates are calculated by the hour of the day. These data can be aggregated to the day/night categories available for trucks to provide a comparison of the relative risk of night travel for passenger vehicles.

The following table presents normalized crash rates by VMT for day and night. The rates are calculated from three sources of travel information. The columns headed "passenger vehicles" show normalized rates derived from the NHTSA report on crash, injury, and fatality rates for passenger vehicles. VMT for these rates was estimated from the National Personal Transportation Survey (NPTS); injury and fatality data was derived from the FARS and GES files. The column headed "NTTIS" is based on travel data for tractors pulling at least one trailer (the definition of a long-haul truck adopted here) from the NTTIS study; the TIFA file was used to generate counts of fatalities [6]. The "MTTIS" columns are based on travel estimates from the MTTIS survey and crash figures from Michigan police-reported crash files [1, 2]. The original rates published from the NTTIS and MTTIS studies were *involvement* rates, counting the involvement of a truck in a crash of a particular severity. The involvement rates were scaled to fatality and

casualty rates by determining the appropriate correction factors using the TIFA and GES files, respectively. Normalized rates avoid issues relating to different methods of estimating travel.

Table 6
Normalized crash rates for day and night
from three sources

	Passenger vehicles		NTTIS	MTTIS	
	Casualty	Fatality	Fatality	Casualty	All crashes
Day	0.92	0.73	0.81	0.90	1.01
Night	1.57	2.93	1.79	1.69	0.93
All	1.00	1.00	1.00	1.00	1.00
Relative risk of night	1.71	4.01	2.21	1.88	0.92

Despite the differences in data, there is a certain congruity between the estimates of the relative risk of night. Considering casualty rates, the relative risk of night for long-haul trucks estimated from MTTIS and Michigan police-reported accidents is quite similar to that for passenger vehicles estimated from NPTS, FARS, and GES. Considering fatalities, the relative risk of night is somewhat higher for passenger vehicles than for long-haul trucks, but the difference is not implausible. Night is actually associated with a *lower* risk for all crashes of long-haul trucks, as the last column of the table shows, reflecting the preponderance of property-damage-only crashes during the day when traffic density is higher [1].

Using data from table 2 above, we may now estimate the additional number of fatalities produced by long-haul trucks operating at night. Table 7 shows the number of accidents and fatalities by day and night, along with the mean number of fatalities per crash.

Table 7
Crashes, fatalities and fatalities per crash
Day versus. night
Tractors pulling at least one trailer

	crashes	fatalities	fatalities per crash
Day	5,962	7,209	1.21
Night	2,546	2,975	1.17
Total	8,508	10,184	1.20

From the table above, 2,546 accidents and 2,975 fatalities occurred at night over three years, reflecting the amount of travel and the higher risk of night operations. Assuming the risk of those operations was similar to that during the day, some new number of accidents and fatalities would occur. Using the relative risk of night for fatalities involving long-haul trucks from table 6, we can estimate that about 2,546/2.21=1,152 crashes would have occurred if night operations had the same risk as day operations. Applying the mean number of fatalities per crash during the day, about 1.21*1,152=1,382 fatalities would have occurred. Thus, night long-haul truck travel generates about 1,593 additional deaths over three years, or about 531 "extra" deaths annually.

Table 8
Crashes, injuries, and injuries per crash
day versus night
Tractors pulling at least one trailer

	Crashes	Injuries	Injuries per crash
Day	466,559	146,941	0.31
Night	77,628	32,939	0.42
Total	544,187	179,879	0.33

Similarly, the "extra" injuries from truck travel between 9 p.m. and 6 a.m. may be estimated as follows. A total of 77,628 crashes and 32,939 injuries occurred in crashes involving long-haul trucks at night over three years. If the crashes and injuries occurred at the same rates as during the day, there would be 77,628/1.88=41,291 crashes with 0.31*41,291=12,800 injuries. Thus, there would have been a savings of 36,337 crashes over three years (12,112 per year) and 20,123 injuries (6,709 annually).

These calculations are obviously crude. We used the fatality rate rather than the accident rate, but the difference should be slight. Classifying time into only two categories is too coarse to be truly useful. The purpose of this exercise is merely to illustrate the procedure and to suggest the direction (though not the magnitude) of the outcome.

Alcohol and fatigue

Why is night associated with higher risk? A primary goal in restructuring the HOS regulations is to lessen truck driver fatigue and consequently decrease crash risk. One approach might be to structure HOS regulations to reduce commercial vehicle operations during certain hours of the night. However, truck driver fatigue is not the only risk factor associated with night. HOS regulations that discourage night travel will affect not only fatigue-related risk, but other risk factors associated with night driving, including the factors associated with the other drivers on the road.

It is widely acknowledged that fatigue as a factor contributing to crashes is underestimated in the crash data [7, 8]. Estimates of the proportion of crashes affected by fatigue range from a few percent to over 40%. Studies have concentrated on fatigue in the truck driver.

One source of data on fatigue as a contributing factor is the "driver-related factors" variables in FARS. This variable records any factor considered by a FARS analyst to have contributed to the crash, regardless of whether a formal traffic violation could be charged or not. It consequently has an advantage over the use of traffic violations in studying driver contributions to crashes.

Fatigue is among the factors coded by FARS analysts, and it is coded for all drivers in a crash, not just truck drivers. The table below shows the percentage of long-haul truck and other vehicle drivers coded as fatigued or asleep. In single-vehicle crashes[1], almost 10% of long-haul truck drivers are coded

[1] Single-vehicle crashes account for about 15% of all long-haul truck crashes overall, but at night, between the hours of midnight and 6 a.m., they are 20.5% of long-haul truck crashes.

fatigued/asleep overall. Between midnight and 3 a.m., the proportion is over 20%, with 18.9% from 3 a.m. to 6 a.m. and 12.6% from 6 a.m. to 9 a.m. Single-vehicle fatal crashes accounted for about 15.2% of all fatal long-haul truck crashes from 1993 to 1995. Where more than one vehicle is involved, however, the incidence of fatigue among the other vehicle drivers is actually higher than for long-haul truck drivers. In the period between 3 a.m. and 6 a.m., 6.2% of other vehicle drivers were coded as fatigued, compared with 2.1% of truck drivers. Between midnight and 3 a.m., the proportions were 4.1% and 1.5% respectively. Overall, in multiple-vehicle fatal crashes involving a long-haul truck, 2.4% of the other drivers were coded as fatigued, compared with 0.9% of the truck drivers.

Table 9
Fatigue coded as a factor in fatal crashes involving a long-haul truck, by time of day
Single and multiple vehicle crashes
FARS 1993-1995

	Single vehicle	Multiple vehicle crashes	
Time of day	Truck driver	Truck driver	Other vehicle driver
mid-3am	20.5%	1.5%	4.1%
3am-6am	18.9%	2.1%	6.2%
6am-9am	12.6%	1.6%	3.3%
9am-noon	3.5%	0.6%	1.7%
noon-3pm	4.1%	0.5%	1.4%
3pm-6pm	2.8%	0.5%	1.2%
6pm-9pm	3.9%	0.5%	1.6%
9pm-mid	9.8%	0.7%	2.1%
total	9.7%	0.9%	2.4%

Alcohol is another risk factor associated with night driving by long-haul trucks, as well as all other vehicles. Tables 1 through 5 show that crashes at night are associated with a higher probability of injury and, given injury, a higher probability of fatality. In other words, truck crashes at night tend to be more severe than during the day. One possible explanation for the greater severity of crashes at night is the higher incidence of alcohol use at night, which might mean higher crash speeds and, therefore, more severe crashes. Table 10 shows the incidence of alcohol use by the truck driver and other drivers in fatal crashes involving a long-haul truck (tractor with at least one trailer). Almost 40% of the other drivers involved in a fatal crash with a long-haul truck between midnight and 3 a.m. had been drinking. Between 3 a.m. and 6 a.m., the proportion is still high, at almost 20%. And between 9 p.m. and midnight, 26.7% of the other drivers had been drinking. While alcohol is overinvolved for long-haul truck drivers in multiple-vehicle crashes during night hours, the incidence is substantially lower than for drivers of the other vehicles. Alcohol use is about three times more common among truck drivers in single-vehicle than in multiple-vehicle fatal truck crashes. About 6.0% of long-haul truck drivers in single-vehicle crashes between midnight and 3 a.m. had been drinking. The proportion rises to 6.3% between 3 a.m. and 6 a.m.

Table 10
Driver alcohol use in fatal crashes involving
a long-haul truck, by time of day
FARS 1993-1995

	Single vehicle	Multiple vehicle crashes	
Time of day	Truck driver	Truck driver	Other vehicle driver
mid-3am	6.0%	2.1%	39.8%
3am-6am	6.3%	1.1%	19.6%
6am-9am	1.6%	0.9%	3.1%
9am-noon	3.5%	0.7%	2.8%
noon-3pm	2.8%	1.0%	4.5%
3pm-6pm	1.7%	1.1%	8.2%
6pm-9pm	3.9%	1.2%	16.6%
9pm-mid	3.3%	1.6%	26.7%
All day	3.6%	1.1%	12.2%

Table 11 shows the combination of fatigue and alcohol use for the nighttime period between midnight and 6 a.m. The results for long-haul truck drivers in single-vehicle crashes are shown separately from truck drivers and other drivers in multiple-vehicle crashes. In multiple-vehicle crashes during the period, the other vehicle driver is coded with either fatigue, alcohol use, or both in about one-third of the crashes. Fatigue or alcohol use were recorded for the truck driver in only about 3.3% of the crashes. Alcohol use is by far the dominant factor for other vehicle drivers, with almost 30% of the drivers reportedly using alcohol. For truck drivers in multiple-vehicle crashes, fatigue and alcohol use occur with about the same frequency, and amount to less than 2% each. In single-vehicle crashes, the story is quite different. Fatigue is indicated for the long-haul truck driver in almost 20% of such fatal crashes. Alcohol use is reported in about 6% of fatal single-vehicle crashes.

Table 11
Driver fatigue and alcohol use in single and multiple
vehicle fatal crashes involving a long-haul truck
midnight - 6 a.m.
FARS 1993-1995

	Single vehicle	Multiple vehicle crashes	
factor coded	Truck driver	Truck driver	Other vehicle driver
fatigue and alcohol	1.3%	0.1%	1.6%
fatigue only	18.2%	1.7%	3.6%
alcohol only	4.8%	1.5%	28.1%
neither	75.6%	96.7%	66.7%
total	100.0%	100.0%	100.0%

Summary and discussion

Fatalities and injuries, both in number and per crash, vary with time of day. Most injuries and fatalities occur during the day. About 20% of all fatal crashes and fatalities involving a long-haul truck occur between 6 a.m. and midnight, with 80% occurring during the rest of the day. Similarly, about 10% of all injuries in traffic crashes involving a long-haul truck occur in the period between midnight and 6 a.m. Only 7.7% of accidents involving a long-haul truck occur in that time period, while 92.3% occur between 6 a.m. and midnight.

Crashes between midnight and 6 a.m. tend to be more severe. The number of fatalities per fatal crash does not vary widely by hour of the day, ranging from 1.15 per crash from midnight to 6 a.m. to 1.21 for the rest of the day. But the crashes are more likely to include an injury and the injuries are more likely to include a fatality. There are about 435 injuries per 1000 crashes involving a long-haul truck between midnight and 6 a.m., compared with about 320 injuries per 1000 crashes for the rest of the day. Moreover, there are about three times as many fatalities per 1000 police-reported crashes in the midnight-6 a.m. period than during the rest of the day (47 to 16) and about twice as many fatalities per 1000 injuries (108 to 51).

Why are truck crashes in the night relatively more severe? Fatal crashes do not appear to involve more fatalities during night hours. The mean number of fatalities is actually slightly lower at night. Moreover, it appears, as might be expected, that the proportion of fatalities among truck occupants is higher at night than during the day, consistent with an increase in single-vehicle fatal truck crashes. Traffic densities are lower at night, lowering the probability of involvement with another vehicle, and fatigue-related crashes, which are more probable at night, are often single-vehicle, ran-off-the-road crashes.

However, it is clear that, given a crash, the probability of a fatality or injury is higher at night. Several factors probably contribute to this result. One factor could just be that property-damage-only crashes at night are less likely to be reported than such crashes in daylight hours. The higher incidence of alcohol- and fatigue-related crashes is also consistent with more severe crashes. Both alcohol and fatigue slow or inhibit driver-avoidance maneuvers, leading to more direct collisions at higher speeds than would otherwise occur.

Fatigue is coded in single-vehicle fatal truck crashes in about 10% of the crashes. Clearly, it is a significant contributor to single-vehicle truck crashes, particularly at night. Between midnight and 3 a.m., the driver was coded as fatigued or asleep in over 20% of fatal single-vehicle long-haul truck crashes. Between 3 a.m. and 6 a.m., the proportion is almost as high, at 18.9%.

It is clear, however, that the nontruck population is also important. Both fatigue and alcohol use occur in the nontruck driver populations in fatal multiple vehicle truck crashes at higher rates than for the long-haul truck drivers. Overall, the other driver in multiple-vehicle truck crashes was coded as fatigued almost 2.4% of the time, compared with 0.9% for the long-haul truck driver. Fatigue was indicated more often at night for both the truck and nontruck drivers. During the three hours between midnight and 3 a.m., over 4% of other vehicle drivers in multiple-vehicle crashes with long-haul trucks were coded as fatigued or asleep, compared with 1.5% of the truck drivers. Between 3 a.m. and 6 a.m., the proportion of fatigued nontruck drivers rose to 6.2%, compared with 2.1% of truck drivers.

The disparity in the incidence of alcohol use between truck and nontruck drivers in fatal crashes is significantly greater than it is for fatigue. In the three hour period after midnight, almost 40% of the drivers of other vehicles had been drinking, while only 2.7% of the truck drivers were. Between 9 p.m. and

midnight, almost 27% of the other drivers had been drinking, compared with 1.8% of the long-haul truckers. During the day, the incidence of alcohol use decreases to around 3% for nontruck drivers and 1% for truck drivers.

The incidence of alcohol use and fatigue among other drivers involved in fatal crashes with long-haul trucks is significantly associated with night. This points up the fact that the higher risk of night travel is not just a product of driver fatigue for the truck driver and that the other drivers on the road form a significant component of the risk of operations. About one-third of the other drivers involved in fatal crashes between midnight and 6 a.m. with a long-haul truck are either fatigued or drunk. The incidence of fatigue and alcohol is about 10 times higher for the other driver in multiple-vehicle crashes than it is for the truck driver. Accordingly, HOS regulations that limit night travel might achieve a reduction in truck crashes primarily by limiting the truck's exposure to a high risk population.

Currently, there are no exposure data available that would permit calculation of crash rates by VMT by hour of the day. Such rates would allow a more detailed evaluation of the relative risk of travel at different hours of the day, including the calculation of the safety costs of different time periods. However, older travel files, such as UMTRI's NTTIS and MTTIS data, will support the calculation of crash rates, divided into night (9 p.m. to 6 a.m.) and day (the rest of the time). These rates show that night is associated with higher risk of fatalities and injuries than the day. Overall, it appears that "night," as just broadly defined, has about 2.2 times the risk of a fatality than during the day, and about 1.9 times the risk of an injury or fatality, than during the day.

The categories of night and day supported by the older exposure data, however, are too broad to be useful in evaluating the effect of changes in HOS regulations. A more detailed breakdown of travel would support a more fine-grained analysis of the safety consequence of truck operations during periods that might be affected by any changes in HOS regulations for truck driver. While there is no current prospect for obtaining such exposure data for all road types, efforts are under way to collect exposure and crash data from toll roads, which would permit calculation of crash rates by time of day for that road type.

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