

Pedestrian Fatalities, Motor Vehicle Occupant Fatalities, and Daylight Saving Time

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All responsibility for the contents of this paper resides with the authors.

Abstract

The purpose of this paper is to analyze the effects of daylight and daylight saving time on pedestrian and motor vehicle occupant fatalities in the United States. Multivariate analyses of county level data from the Fatality Analysis Reporting System for two week periods in 1998 and 1999 are used. Results show that a switch to full year daylight saving time would reduce pedestrian fatalities by 343 over the 1998-1999 period, or by 13 percent of all pedestrian fatalities in the 5 AM to 10 AM and in the 4 PM to 9 PM time periods examined in this research. Motor vehicle occupant fatalities would be reduced by 390, or 3 percent during the same time periods. In metropolitan areas, full year daylight saving time would reduce pedestrian fatalities by 255 in the 1998-1999 period, or by 12 percent, and would reduce pedestrian fatalities in non-metropolitan areas by 81 or 17 percent. However, full year daylight saving time would increase motor vehicle fatalities in metropolitan areas by 70 (a 10 percent increase) but would reduce motor vehicle fatalities in non-metropolitan areas by 364 or 8 percent.

1. Introduction

Pedestrian fatalities and motor vehicle occupant fatalities on a given day in the U.S. should be related to the amount of daylight and the distribution of that daylight over the activities of vehicle users and pedestrians. The more daylight and the better it matches vehicle user and pedestrian activity, the more visible and safer these roadway users should be. Daylight saving time (DST) is a government regulation to improve the matching of daylight hours with the activities of the population. DST moves an hour of daylight from the morning to the evening in the spring, summer, and early fall.¹

Ferguson et al. (1995) estimate that the extension of DST to the full calendar year from the present DST period, which runs from the first Sunday in April to the last Saturday in October, would have reduced pedestrian deaths by 727 and motor vehicle occupant deaths by 174 in 1987-1991. Annual pedestrian fatalities and annual motor vehicle occupant fatalities averaged about 7,000 and 35,000, respectively, during these years. The authors explain that extended daylight saving time is safety enhancing because there is more vehicle and pedestrian activity in the evening than in the morning and DST moves morning light to the evening. The smaller motor vehicle effect is explained by the presence of vehicle lights, which makes vehicles more visible in the dark to the drivers of other vehicles than are pedestrians.² In this paper we revisit this topic and estimate the effects of daylight and full year DST on pedestrian fatalities and on motor vehicle occupant fatalities for the 1998-1999 period, the most recent years for which data are available from the Fatality Analysis Reporting System.

In this project, we also examine the question of what impact expanded daylight saving time would have on metropolitan areas in America. Although opposition to daylight saving time in many farming communities is well known and long standing, there is no research that

adequately addresses the effects of daylight saving time on public health or on other indicators of the quality of life in urban areas. Moving an hour of daylight from the morning to the evening has the potential to significantly reduce pedestrian and motor vehicle fatalities in densely populated areas. Our results show that extending daylight in the evening will save lives in both urban and rural areas, and surprisingly, the savings are much greater for rural communities, where the opposition to such a policy has often originated.

2. Data Explorations

In Table 1, the number of pedestrian fatalities and motor vehicle occupant fatalities by hour of the day are presented for the months of October and November in 1998 and 1999. DST ended and standard time returned at the very end of October in each of these years, so comparing data from these two months may be a good indicator of daylight effects on pedestrian and motor vehicle occupant fatalities.³ The population weighted average sunrise and sunset across counties of the U.S. was 7:25 AM and 6:35 PM in the October months and 6:56 AM and 5:06 PM in the November months.⁴ There was then an average of about one half hour more light in the mornings in November and one and one half hours more light in the evenings in October.

A relationship between daylight and pedestrian fatalities is evident in Table 1. From the 9 AM hour through the 3 PM hour there is rough equality in the number of fatalities in October and November in the two years. These hours are ones of full daylight. The 5 PM and 6 PM hours contain much more daylight in October than in November and pedestrian fatalities are 126 in the October hours and 299 in the November hours in the two years. The 6 AM and 7 AM hours, in which there is more daylight in November than in October, show 55 fatalities in the

November months and 90 in the October months. Repeating this exercise for motor vehicle occupant fatalities reveals no clear differences between the two months.

Further evidence of a daylight pedestrian fatality relationship is seen in Figure 1, where pedestrian fatalities in the U.S. in 1998 and 1999 by time of day are plotted against calendar time in two week intervals from the first of each year to the end. The first graph plots pedestrian fatalities between 4 PM and 9 PM; the second, pedestrian fatalities between 5 AM and 10 AM; and the third pedestrian fatalities between 10 AM and 4 PM.⁵ The evening and morning periods experience substantial light changes throughout the year, with less light at the beginning and end of the year and more light in the middle of the year. There is very little light change in the midday period. The evening period pedestrian fatality graph shows a U shaped relationship with calendar time. The morning period does also, although the relationship is not as distinct as in the evening. Midday pedestrian fatalities are not obviously related to calendar time.

To consider these relationships another way, ordinary least squares regression results are presented with the evening and the morning pedestrian fatalities regressed on the population weighted average county sunset and sunrise, respectively, over the 52 two week time periods in the two years. The results are:

$$\text{PMPedfat} = 455.4 - 20.5 \text{ sunset} \quad \text{Rsqr} .87 \quad n=52$$

$$(t=21.3) \quad (t=-18.3)$$

$$\text{AMPedfat} = -43.0 + 10.3 \text{ sunrise} \quad \text{Rsqr} .51 \quad n=52$$

$$(t=-4.4) \quad (t=7.2)$$

The regression coefficients indicate a one hour later sunset would reduce 4 PM-9 PM pedestrian fatalities (PMPedfat) by 20 over two weeks and a one hour earlier sunrise would reduce 5 AM - 10 AM fatalities (AMPedfat) by 10 over two weeks.⁶ These effects are roughly one third of the sample means of 67 in the evening hours and 26 in the morning hours. The results imply that

moving an hour of daylight from the morning to the evening year round (making double hour daylight time during the usual DST period and single hour daylight time during the standard time period) would result in a net reduction of 10 fatalities (20-10) over two weeks, or 260 over one year. Pedestrian fatalities were 5,228 in 1998 and 4,939 in 1999.

3. Data, Methods, and Results

In this section we estimate more complete models of the relationships between daylight, daylight saving time, and pedestrian fatalities and motor vehicle occupant fatalities. We focus first on the entire United States and then divide the country into metropolitan counties and non-metropolitan counties. Our data are at the county level for 52 two week periods in 1998 and 1999. Counties in Alaska and Hawaii are excluded. There are 3,111 counties remaining in the U.S., meaning there are 161,722 observations possible for the analysis (3,111*52). The advantage of county level data over two week periods is that the variation in sunrise and sunset described in note 4 is reflected in the data.⁷ The dependent variables in the models are counts of pedestrian fatalities or of motor vehicle occupant fatalities in the counties during the two week periods. Results are presented for the 5 AM to 10 AM morning hours and the 4 PM to 9 PM evening hours because daylight changes occur during these hours. The count values are usually small and often zero, meaning a Poisson or a negative binomial distribution best describes the dependent variables.⁸ Huber robust standard errors clustered on counties are computed because counties repeat in the data and not all independent variables may be accounted for in the models that distinguish one county from another.

Independent variables in the fatality models are standard to the highway safety literature (Keeler 1994; Loeb, et al. 1994) and include the following: sunrise or sunset time; the percent of the county population living in a rural area in 1990; the percent of the county population age

25 and up with a four year college degree in 1990; motor vehicles miles traveled by state and month for 1998 and 1999, the average annual inches of rain in principal metropolitan area(s) of states for 1998 and 1999; the average annual inches of snow and ice pellets in principal metropolitan area(s) of states for 1998 and 1999; county income per capita in 1990; county unemployment rate in 1990; the percent of county population traveling 30 minutes or more to work in 1990; and dummy indicators for season and year.

In some of the models we also include state identifiers to capture the effects of highway safety determinants that do not vary within states or for which data are not available at the county level. These determinants include state speed limits, seat belt and motor vehicle inspection regulations, alcohol control policies including excise tax levels, and weather. State identifiers also help to control for the “supply of pedestrians.” States in the southern one half of the U.S., for example, have warmer weather than states in the northern one half. As a result, these southern states may have more pedestrian activity in a given hour and more opportunity for a pedestrian death.

The first three regressions in Table 2 are for pedestrian fatalities 4 PM to 9 PM for the full two year period. The fourth regression in Table 2 is for pedestrian fatalities 4 PM to 9 PM during the standard time period only (approximately November through March in each year). The results presented in columns 5-8 of Table 2 follow the same pattern for the 5 AM to 10 AM period. The regressions in columns 2 and 6 in the table include a larger number of independent variables than those in columns 1 and 5, while the regressions in columns 3, 4, 7 and 8 include the state identifiers.⁹ The marginal effects of sunrise and sunset, presented at the bottom of the table, are stable across the first three regressions for each time period. They indicate that an hour later sunset would reduce pedestrian fatalities in the evening by .006 and that an hour later sunrise

would increase pedestrian fatalities in the morning by .003. These marginal effects refer to changes in the number of fatalities per county per two weeks and are .27 and .38, respectively, of the sample means of .022 and .008. Thus, an hour later sunset would reduce evening pedestrian fatalities by about one third and an hour later sunrise would increase morning fatalities by about one third.

The standard time period regression (regressions 4 and 8) in Table 2 can be used to evaluate the effects of a change to full year DST on pedestrian fatalities.¹⁰ The PM sunset marginal effect is -.008 and the AM sunrise marginal effect is .003. The results indicate that shifting an hour of daylight to the evening from the morning in the standard time period in 1998 and 1999 would have changed pedestrian fatalities by $(-.008 * 3,111 * 22) + (.003 * 3,111 * 22) = -343$ over these two years, or about 171 per year. This is 13 percent of the pedestrian fatalities that occurred in these morning and evening hours.¹¹ These results are similar in nominal value to those of Ferguson et al., which were summarized above. They reported that an annual average of about 150 pedestrian fatalities would have been avoided with full year DST in 1987-91. Our results are larger as a proportion of all pedestrian fatalities because of the 30 percent decline in pedestrian fatalities in the decade of the 1990s.

If the same procedure is applied to the motor vehicle occupant fatality results in regressions 4 and 8 in Table 3, the calculations show that full year DST would decrease fatalities by 390, or 3 percent of motor vehicle occupant fatalities during these morning and evening hours.¹²

Tables 4 and 5 contain the results for observations in the standard time period for metropolitan and non-metropolitan counties. Counties are grouped into metropolitan status according to the Rural-Urban Continuum Codes devised by the U.S. Department of Agriculture.

Table 4 shows that in metropolitan areas, the switch to full year daylight saving time would reduce pedestrian fatalities in the evening by 438, but would increase morning fatalities by 183. The net effect is 255 lives saved, or 12 percent of the total. Pedestrian fatalities in non-metropolitan areas would fall in both the evening and the morning for a total of 81 lives saved (a 17 percent decrease). However, Table 5 shows that full year daylight saving time would increase total motor vehicle fatalities in metropolitan areas by 70 (a 10 percent increase) but would reduce total motor vehicle fatalities in non-metropolitan areas by 364 or 8 percent.

4. Conclusions

Daylight is an important determinant of morning and evening pedestrian fatalities in the U.S. Our results show that extending daylight in the evening will save lives in both urban and rural areas, and in fact, the savings are much greater in for rural communities, where the opposition to such a policy has often originated. For the entire country, an additional hour of daylight would reduce pedestrian fatalities by about one third in the 5 AM to 10 AM and in the 4 PM to 9 PM time periods. Because pedestrian activity is greater in the evening period than in the morning period, full year daylight saving time, or the moving of an hour of daylight from the morning to the evening in the standard time period, would reduce pedestrian fatalities by about 343, or by 13 percent of all pedestrian fatalities in these two time periods. Daylight is a less consistent determinant of motor vehicle occupant fatalities in the morning and evening time periods. However, results for the standard time period indicate that full year daylight saving time would decrease fatalities by 390, or 3 percent of motor vehicle occupant fatalities during the morning and evening hours. The smaller percentage decrease in motor vehicle occupant deaths

relative to pedestrian deaths may be explained by the presence of vehicle lights, which make vehicles visible to other drivers during darkness.

References

- Barky IR, Harrison E. Standard and Daylight Saving Time. *Scientific American*. 1979; 240: 46-54.
- California Energy Commission. Effects of Daylight Saving Time on Electrical Energy Use. Staff Report P400-01-013. 2001; 1-37.
- Coren S. Accidental Death and the Shift to Daylight Savings Time. *Perceptual and Motor Skills*. 1996; 83; 921-922.
- Ferguson SA, Preusser DF, Lund AK, Zador PL, Ulmer RG. Daylight Savings Time and Motor Vehicle Crashes: The Reduction in Pedestrian and Vehicle Occupant Fatalities. *American Journal of Public Health*. 1995; 85: 92-97.
- Hicks RA, Lindseth K, Hawkins J. Daylight Savings Time Changes Increase Traffic Accidents. *Perceptual and Motor Skills*. 1983; 56: 64-66.
- Hicks GR, Davis JW, Hicks RA. Fatal Alcohol Related Traffic Crashes Increase Subsequent to Changes To and From Daylight Savings Time. *Perceptual and Motor Skills*. 1998; 86; 879-882.
- Keeler TE. Highway Safety, Economic Behavior, and Driving Enforcement. *American Economic Review*. 1994; 84; 684-693.
- Loeb PD, Talley WK, Zlatoper TJ. Causes and Deterrents of Transportation Accidents. 1994.
- Sinnott RW. Sunrise/Sunset Challenge: The Winners. *Sky and Telescope*. 1995; 89: 84-87.

Endnotes

¹ Federally mandated DST was first established as a wartime regulation during World War I as an energy conservation measure. It was abolished in 1919 at wars end. Federally mandated DST returned during World War II to save energy and was abolished again at wars end in 1945. The immediate elimination of DST after the two World Wars was due to opposition in farming communities and a broader concern over the safety of school children during their morning journey to school. However, in 1966 a federal mandate returned and DST was established from the last Sunday in April to the last Saturday in October. Then, in 1973, after the first OPEC oil shock, the U.S. Congress moved the start of DST to January 6 in 1974, again with the goal of saving energy. However, concern over the safety of school children in the morning hours led Congress to push forward DST to February 23 in 1975 and to its normal April starting date thereafter. This brief history is largely from Barky and Harrison (1979). In 1986, Congress shifted the daylight savings start date from the last Sunday in April to the first Sunday in April.

² Several studies show an *increase* in motor vehicle fatalities or motor vehicle accidents during the first week of daylight saving time in the spring as drivers adjust to the time change. See R. Hicks et al. (1983); Coren (1996); G. Hicks (1998).

³ Sunday, November 1, 1998, and Sunday, October 31, 1999 were the first fall days of standard time in these years. The data in Table 1 are not sensitive to adjustments for the four day Thanksgiving weekend. There are about six percent more vehicle miles traveled in October than November in these years.

⁴ The data source for county sunrise and sunset is described in section 3. There is substantial variation in the amount of daylight by day of the year in the United States and on a given day, by north - south location in the U.S. Given the day of the year and north - south location, the distribution of daylight by clock time depends on east - west location in the time zone and on whether clock time is standard or daylight. Calculating the average sunrise and sunset for the whole country, then, is not straightforward. Calculating a countrywide average from population weighted county sunrise and sunset data takes into account these considerations.

⁵ More precisely, the time periods are 4:00 PM-8:59 PM, 5:00 AM-9:59 AM, and 10:00 AM-3:59 PM.

⁶ Although these regression results are meant to just summarize the data and are not complete pedestrian fatality models, the marginal effects approximate the results for the fuller model estimated in section 3 because sunrise and sunset are not strongly correlated with other independent variables.

⁷ The computer program we used to calculate sunrise and sunset times was written by James Brimhall in response to a challenge issued by Sky and Telescope Magazine. His program provides sunrise and sunset times for any given longitude, latitude, and time zone, and is accurate within two minutes (Sinnot 1995).

⁸ Because likelihood ratio tests reject the null hypothesis that the underlying distribution is Poisson, the negative binomial distribution is used to characterize the fatality models presented below. The estimated marginal effects are similar for Poisson, negative binomial, and weighted (by county population) least squares regressions.

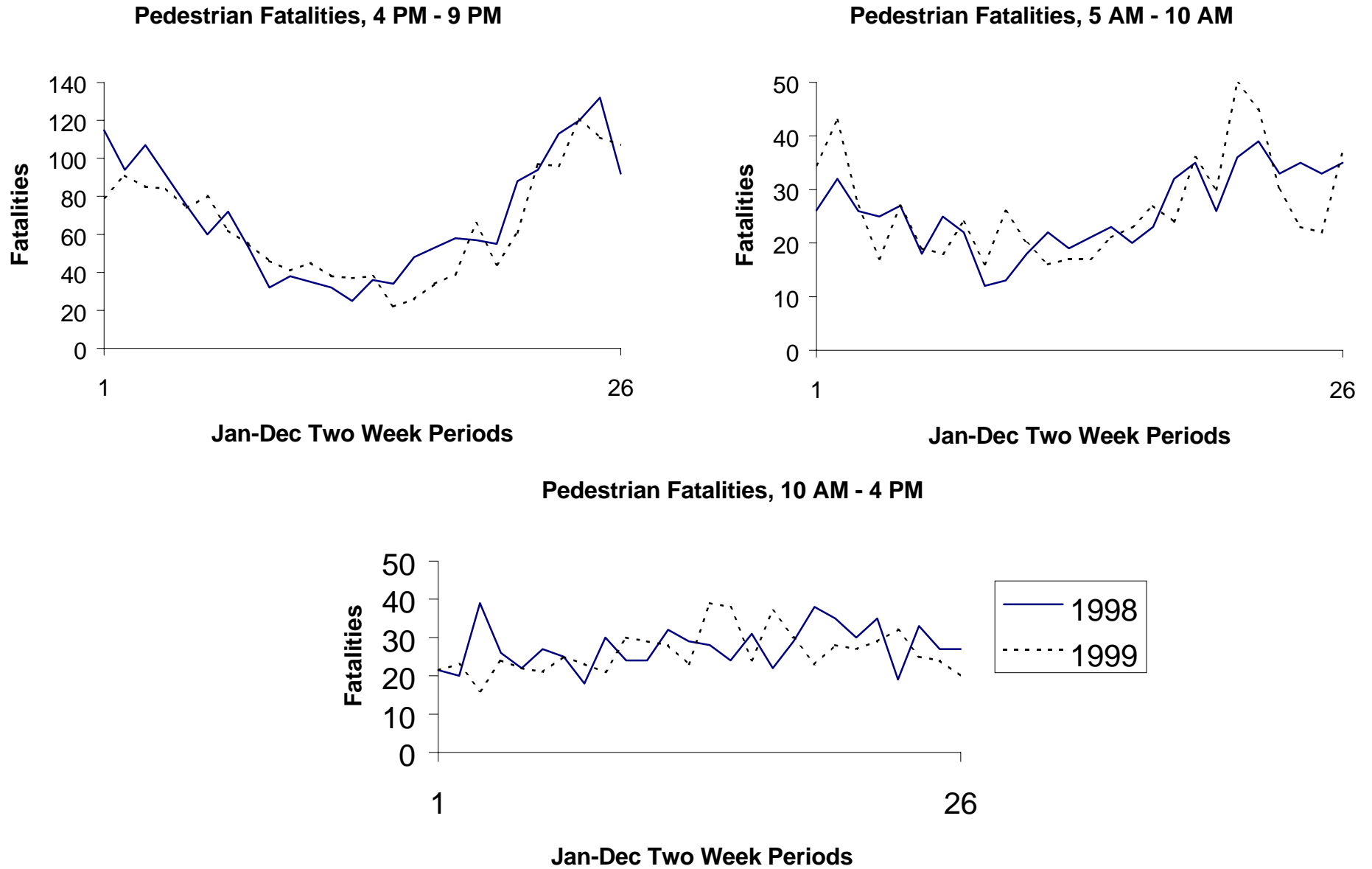
⁹ The rural population parameter estimates have different signs in the pedestrian and motor vehicle models. Motor vehicle fatality rates are higher in rural areas because travel distances and travel speeds are greater than in urban areas and because travel is on less safe roadways (e.g., more travel on two way roadways). Pedestrian fatality rates are probably lower in rural areas because the supply of pedestrian activity is less. In urban areas, destinations are more proximate and amenable to pedestrian travel.

¹⁰ Recently, the California state legislature considered an extension of daylight saving time to the winter months because of electrical energy disruptions and rolling blackouts in the spring and summer of 2001. The California Energy Commission (2001) estimated up to three per cent of peak electricity use could be saved as a result of a move to full year daylight saving time.

¹¹ These models show no increased risk to school children from full year DST. When the AM models are estimated with pedestrian fatalities in the 5-13 or 5-18 age group as the dependent variable, sunrise is not an important variable.

¹² Evening motor vehicle occupant fatalities are not negatively related to time of sunset in models 1-3 in table 5, which are estimated over the full sample of 52 two week periods. When the sample is confined to the two 11 week standard time periods in the two years (regression 4), however, the coefficient is negative ($z=-3.75$). These more robust results may be explained by the fact that sunset during the standard time period occurs earlier in the evening when rush hour traffic is heavier.

Figure 1



Source: Fatality Analysis Reporting System, National Highway Traffic Safety Administration, 1998 and 1999.

Table 1
Pedestrian and Motor Vehicle Occupant Fatalities for October and November, 1998 and 1999, by
Hour of the Day

Crash hour	PedOct98	PedNov98	PedOct99	PedNov99	MVOct98	MVNov98	MVOct99	MVNov99
0:01am-0:59am	22	23	31	10	110	134	160	126
1:00am-1:59am	25	16	12	17	150	127	137	130
2:00am-2:59am	8	13	23	13	127	120	146	129
3:00am-3:59am	7	13	15	8	81	87	97	92
4:00am-4:59am	5	3	13	5	64	54	80	94
5:00am-5:59am	18	15	19	10	76	68	81	69
6:00am-6:59am	26	19	30	14	115	120	96	118
7:00am-7:59am	14	15	25	7	113	104	119	109
8:00am-8:59am	10	14	8	14	97	108	114	109
9:00am-9:59am	11	10	16	11	114	86	123	97
10:00am-10:59am	8	10	10	8	93	105	113	115
11:00am-11:59am	15	9	15	9	130	115	141	97
12:00pm-12:59pm	11	6	7	8	106	127	111	137
1:00pm-1:59pm	14	9	10	8	122	113	152	121
2:00pm-2:59pm	18	14	10	6	148	161	154	155
3:00pm-3:59pm	19	11	14	32	176	153	182	177
4:00pm-4:59pm	22	27	13	17	191	179	196	179
5:00pm-5:59pm	35	64	20	68	171	186	199	183
6:00pm-6:59pm	36	96	34	71	146	156	140	159
7:00pm-7:59pm	52	39	63	34	188	156	162	124
8:00pm-8:59pm	46	31	37	37	124	123	158	138
9:00pm-9:59pm	43	31	27	23	121	99	127	107
10:00pm-10:59pm	35	24	32	18	132	117	128	120
11:00pm-11:59pm	28	20	23	18	139	122	105	119
Midnight	0	0	0	1	1	3	1	4
Unknown	8	2	2	5	31	28	33	29
Total	536	534	509	472	3066	2951	3255	3037

Notes: the column headings reference pedestrians (Ped) or motor vehicle occupants (MV) and month and year.

Source: Fatality Analysis Reporting System, National Highway Traffic Safety Administration, 1998 and 1999.

Table 2
 Results of Regressing Pedestrian Fatalities on Time of Sunset, Sunrise and Other Variables,
 Counties of the U.S., 52 Two Week Periods in 1998-1999, Negative Binomial Count Models with Huber Standard Errors

	4PM-9PM	4PM-9PM	4PM-9PM	4PM-9PM	5AM-10AM	5AM-10AM	5AM-10AM	5AM-10AM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sunset/Sunrise	-0.240 (-9.69)	-0.248 (-9.32)	-0.304 (-11.28)	-0.368 (-8.52)	0.292 (4.24)	0.368 (5.47)	0.348 (4.43)	0.319 (3.40)
Percent rural	-0.457 (-3.68)	-0.362 (-2.98)	-0.259 (-2.39)	-0.233 (-1.58)	-0.708 (-4.15)	-0.535 (-3.27)	-0.402 (-2.91)	-0.467 (-2.23)
College education	-3.488 (-5.22)	-2.300 (-2.15)	-2.453 (-2.23)	-1.959 (-1.42)	-2.714 (-2.83)	-2.472 (-1.79)	-2.743 (-2.06)	-1.979 (-1.02)
1999	-0.079 (-2.29)	-0.075 (-2.15)	-0.082 (-2.35)	-0.083 (-1.88)	0.018 (0.33)	0.019 (0.35)	0.024 (0.42)	-0.060 (-0.70)
Motor vehicle miles	1.18E-08 (3.04)	-6.59E-09 (-1.14)	2.06E-08 (1.35)	8.02E-09 (0.46)	1.05E-08 (1.95)	-8.78E-09 (-1.35)	-1.07E-08 (-0.51)	6.63E-09 (0.24)
Spring	-0.159 (-2.08)	-0.127 (-1.64)	-0.044 (-0.58)		-0.068 (-0.67)	0.021 (0.21)	-0.005 (-0.05)	
Summer	-0.151 (-1.85)	-0.106 (-1.26)	-0.024 (-0.29)		0.136 (1.46)	0.210 (2.31)	0.200 (1.97)	
Fall	0.083 (1.96)	0.108 (2.56)	0.067 (1.37)		0.198 (2.81)	0.220 (3.11)	0.221 (2.78)	
Rain		-0.002 (-0.58)				-0.004 (-0.96)		
Snow		-0.012 (-6.14)				-0.009 (-4.89)		
Income		9.81E-06 (0.64)	1.36E-05 (0.83)	1.56E-05 (0.64)		1.77E-05 (0.94)	2.25E-05 (1.36)	1.20E-05 (0.45)
Unemployment		4.949 (3.23)	4.697 (3.34)	5.823 (2.66)		4.498 (2.38)	5.132 (2.67)	6.653 (2.40)
Commute		0.106 (0.46)	0.260 (1.19)	-0.053 (-0.18)		1.105 (4.36)	0.999 (3.35)	1.276 (3.08)
Intercept	-9.889 (-21.55)	-9.962 (-18.92)	-9.501 (-14.98)	-8.544 (-9.12)	-17.424 (-34.18)	-18.424 (-31.32)	-18.244 (-24.25)	-17.657 (-19.52)
n	161,772	161,772	161,772	68,442	161,772	161,772	161,772	68,442
Marginal Effect	-0.0052	-0.0054	-0.0066	-0.0076	0.0025	0.0031	0.0029	0.0026
State Fixed Effects	No	No	Yes	Yes	No	No	Yes	Yes

Notes: t-statistics are in parentheses and are calculated by using Huber standard errors adjusted for clustering by county. Models 1-3 and 5-7 are estimated over 52 two-week periods. Models 4 and 8 are estimated over two 11 week standard time periods.

Table 3
 Results of Regressing Motor Vehicle Fatalities on Time of Sunset, Sunrise and Other Variables,
 Counties of the U.S., 52 Two Week Periods in 1998-1999, Negative Binomial Count Models with Huber Standard Errors

	4PM-9PM	4PM-9PM	4PM-9PM	4PM-9PM	5AM-10AM	5AM-10AM	5AM-10AM	5AM-10AM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sunset/Sunrise	0.050 (3.50)	0.045 (3.29)	0.030 (2.18)	-0.098 (-3.75)	0.053 (1.76)	0.018 (0.63)	-0.006 (-0.20)	0.059 (1.49)
Percent rural	1.252 (18.50)	1.178 (16.72)	1.331 (22.22)	1.402 (16.97)	1.288 (17.07)	1.210 (15.13)	1.402 (19.58)	1.371 (14.37)
College education	-3.785 (-8.10)	-0.458 (-0.82)	-2.716 (-5.25)	-2.276 (-3.15)	-3.588 (-7.11)	-0.217 (-0.34)	-1.960 (-2.99)	-1.321 (-1.46)
1999	0.0003 (0.02)	0.003 (0.14)	-0.007 (-0.38)	0.009 (0.29)	0.037 (1.57)	0.038 (1.65)	0.035 (1.52)	-0.003 (-0.09)
Motor vehicle miles	5.94E-09 (1.99)	-3.48E-09 (-1.19)	5.69E-08 (4.50)	9.41E-08 (5.26)	3.03E-09 (0.89)	-7.90E-09 (-2.19)	9.85E-09 (0.59)	2.74E-08 (1.47)
Spring	0.029 (0.66)	0.047 (1.12)	0.032 (0.78)		0.109 (2.29)	0.083 (1.82)	0.046 (0.99)	
Summer	0.152 (3.33)	0.177 (4.04)	0.145 (3.29)		0.224 (5.24)	0.206 (4.98)	0.172 (3.93)	
Fall	0.231 (8.31)	0.237 (8.65)	0.196 (6.75)		0.204 (6.26)	0.216 (6.74)	0.205 (5.85)	
Rain		-0.008 (-5.51)				-0.010 (-5.15)		
Snow		-0.010 (-11.46)				-0.011 (-10.42)		
Income		-7.62E-05 (-6.59)	-1.74E-05 (-1.57)	-1.17E-05 (-0.79)		-7.76E-05 (-6.13)	-2.44E-05 (-1.95)	-2.93E-05 (-1.73)
Unemployment		-2.609 (-4.06)	-1.906 (-2.65)	-1.510 (-1.41)		-2.768 (-3.77)	-2.295 (-2.81)	-1.749 (-1.44)
Commute		-0.052 (-0.25)	-0.249 (-1.53)	-0.117 (-0.54)		-0.004 (-0.02)	-0.256 (-1.37)	-0.238 (-0.98)
Intercept	-14.207 (-52.01)	-12.712 (-42.40)	-12.832 (-40.33)	-11.105 (-20.40)	-14.142 (-58.12)	-12.394 (-41.33)	-12.444 (-38.91)	-13.150 (-28.50)
n	161,772	161,772	161,772	68,442	161,772	161,772	161,772	68,442
Marginal Effect	0.0060	0.0052	0.0035	-0.0097	0.0039	0.0013	-0.0004	0.0040
State Fixed Effects	No	No	Yes	Yes	No	No	Yes	Yes

Notes: t-statistics are in parentheses and are calculated by using Huber standard errors adjusted for clustering by county. Models 1-3 and 5-7 are estimated over 52 two-week periods. Models 4 and 8 are estimated over two 11 week standard time periods.

Table 4
 Results of Regressing Pedestrian Fatalities on Time of Sunset, Sunrise and Other Variables,
 Metropolitan and Non-metropolitan Counties of the U.S., Negative Binomial Count Models with Huber Standard Errors

	Metropolitan Counties	Metropolitan Counties	Non- Metropolitan Counties	Non- Metropolitan Counties
	4PM-9PM	5AM-10AM	4PM-9PM	5AM-10AM
	(1)	(3)	(2)	(4)
Sunset/Sunrise	-0.387 (-8.09)	0.408 (3.91)	-0.295 (-2.96)	-0.020 (-0.10)
College education	-2.381 (-1.64)	-3.052 (-1.64)	-1.920 (-0.59)	7.339 (1.98)
1999	-0.072 (-1.48)	-0.073 (-0.76)	-0.130 (-1.24)	-0.017 (-0.09)
Motor vehicle miles	2.87E-09 (0.16)	1.87E-08 (0.64)	6.30E-08 (0.91)	-1.89E-07 (-1.44)
Income	1.66E-05 (0.66)	4.43E-05 (1.91)	-8.85E-05 (-1.48)	-7.02E-05 (-0.61)
Unemployment	3.249 (1.29)	9.892 (3.29)	5.083 (2.04)	2.510 (0.45)
Commute	-0.430 (-1.48)	1.708 (3.80)	0.914 (1.18)	-0.415 (-0.31)
Intercept	-7.307 (-8.18)	-18.370 (-16.89)	-9.490 (-4.49)	-15.409 (-7.27)
n	18,348	18,348	50,094	50,094
Marginal Effect	-0.024	0.010	-0.002	-0.00004
State Fixed Effects	Yes	Yes	Yes	Yes
Full year DST lives saved/lost	438	-183	79	2

Notes: t-statistics are in parentheses and are calculated by using Huber standard errors adjusted for clustering by county. All models are estimated over two 11 week standard time periods.

Table 5
 Results of Regressing Motor Vehicle Fatalities on Time of Sunset, Sunrise and Other Variables,
 Metropolitan and Non-metropolitan Counties of the U.S., Negative Binomial Count Models with Huber Standard Errors

	Metropolitan Counties	Metropolitan Counties	Non- Metropolitan Counties	Non- Metropolitan Counties
	4PM-9PM	5AM-10AM	4PM-9PM	5AM-10AM
	(1)	(3)	(2)	(4)
Sunset/Sunrise	-0.077 (-2.20)	0.146 (2.93)	-0.128 (-3.23)	-0.019 (-0.31)
College education	-7.219 (-6.70)	-5.960 (-4.82)	-0.934 (-0.78)	-0.518 (-0.38)
1999	0.001 (0.03)	-0.006 (-0.13)	0.011 (0.23)	0.003 (0.06)
Motor vehicle miles	7.98E-08 (4.01)	4.47E-08 (2.63)	1.37E-07 (3.54)	1.17E-09 (0.02)
Income	-5.17E-05 (-2.54)	-5.95E-05 (-2.61)	-5.62E-05 (-2.13)	-6.99E-05 (-2.51)
Unemployment	-14.369 (-6.91)	-12.924 (-4.93)	-1.767 (-1.20)	-2.869 (-1.78)
Commute	0.292 (0.88)	0.373 (1.01)	2.007 (6.87)	1.429 (4.00)
Intercept	-10.012 (-10.81)	-23.557 (-27.29)	-9.791 (-12.38)	-11.450 (-17.77)
n	18,348	18,348	50,094	50,094
Marginal Effect	-0.018	0.022	-0.007	-0.001
State Fixed Effects	Yes	Yes	Yes	Yes
Full year DST lives saved/lost	336	-406	327	37

Notes: t-statistics are in parentheses and are calculated by using Huber standard errors adjusted for clustering by county. All models are estimated over two 11 week standard time periods.