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Daylight Saving Time and Motor Vehicle Crashes: The Reduction in Pedestrian and Vehicle Occupant Fatalities

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ABSTRACT

Fatal crashes were tabulated for 6-hour periods around sunrise and sunset, from 13 weeks before the fall change to standard time until 9 weeks after the spring change to daylight saving time. Fatal-crash occurrence was related to changes in daylight, whether these changes occurred abruptly with the fall and spring time changes or gradually with the changing seasons of the year. During daylight saving time, which shifts an hour of daylight to the busier evening traffic hours, there were fewer fatal crashes. An estimated 901 fewer fatal crashes (727 involving pedestrians, 174 involving vehicle occupants) might have occurred if daylight saving time had been retained year-round from 1987 through 1991. (*Am J Public Health.* 1995;85:92–96)

Introduction

When daylight saving time is implemented in the spring, clock times are advanced 1 hour. In the fall, with the return to standard time, clock times are moved back 1 hour. Daylight saving time has been in effect for most of the United States from the first Sunday in April to the last Saturday in October since 1987.

The transition from standard time to daylight saving time in the spring makes 1 more hour of daylight available in the evening and 1 less hour of daylight available in the morning. Because darkness increases the risk of motor vehicle crashes,[1,2] it has been argued that this shift results in fewer motor vehicle crashes in the evening and more crashes in the morning.[3,4] However, there is typically more traffic during the affected evening hours than during the morning; thus, the net effect of daylight saving time should be an overall reduction in crashes.[5,6]

In the current study, the effect of daylight saving time on pedestrian and vehicle occupant fatalities was estimated from a model relating light level during morning and evening hours to fatal motor vehicle crashes. The model accounts for both the abrupt changes in morning and evening light levels associated with the April and October time changes and the gradual day-to-day changes in light level in a given hour with the changing seasons of the year.

Methods

In the early morning, there is a period when it is dark, followed by approximately 1 hour of twilight (slightly longer in the northern United States, slightly shorter in the South), followed by the moment of sunrise, and then by daylight. The reverse is true in the afternoon. The left half of Table 1 shows light conditions on the day just before and the day of the spring time change; the right half shows light conditions on the day just before and the day of the fall time change. In Table 1, the 6 morning and 6 evening hours are termed AM 0–AM 5 and PM 0–PM 5. Actual clock times for fall AM and PM hours (that is, from late summer

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to the end of the year) are defined in relation to the moments of sunrise and sunset on the last day before the change back to standard time. For example, the first minute of AM4 in the fall is sunrise on the last day of daylight saving time. Spring AM and PM hours (from the beginning of the year until early summer) are similarly defined on the last day before the change to daylight saving time. Note that sunrise and sunset times at the fall and spring time changes may differ by up to 1.75 hours because they are at different intervals from the winter solstice.

Sunrise and sunset times are subject to considerable geographic variation as well. This geographic variation was controlled by calculating actual sunrise and sunset times for each year based on the longitude and latitude of the county seat for each county in the contiguous United States, fall and spring. Thus, actual clock hours represented by, for example, AM0 or PM5, vary from county to county and from spring to fall for a given county.

Sunrise and sunset times also vary across the study weeks with the transition from one season to another. For example, fall AM3 is a full hour of daylight in the late summer, shifting gradually to a full hour of twilight before the fall time change, shifting abruptly back to a full hour of daylight immediately after the fall time change, and finally shifting gradually back to twilight as winter approaches.

We estimated variations in light level for the weeks before and after the fall and spring time changes using the midweek sunrise and sunset times applicable to Steelville, Mo, the weighted population center of the United States per the 1990 census. The light level was set equal to 0.0 for a full hour of darkness, 1.0 for a full hour of twilight, and 2.0 for a full hour of daylight. Thus, the light level was equal to 0.0, 1.0, or 2.0 for each of the morning and afternoon hours on the days before the fall and spring time changes and was modified accordingly as the light conditions in each hour changed either abruptly or gradually. The value of the light level was computed as a function of the number of minutes of daylight, twilight, or dark in a given hour for each week. For example, if AM3 in a given late summer week had 6 minutes before sunrise (twilight value 1.0) and 54 minutes after sunrise (daylight value 2.0) it was assigned a light level of 1.9.

The data used in this study cover 5 years of fatal crashes, 1987 through 1991, for the contiguous United States.[7] Arizona and most of Indiana were excluded because they do not observe daylight saving time; also excluded were those few counties split between two time zones. Weekly numbers of fatal crashes were tabulated for 13 weeks before the fall time change, 9 weeks after the fall time change, 13 weeks before the spring time change, and 9 weeks after the spring time change (44 weeks centered around the winter solstice; 22 under daylight saving time and 22 under standard time). The data included 14 659 crashes fatal to one or more pedestrians and 60 152 crashes fatal to one or more vehicle occupants (but not fatal to a pedestrian or bicyclist).

Linear regression models were used to relate the natural log of the number of fatal crashes to season (spring and fall), week (22 levels), time (AM and PM), hour

TABLE 1—Study Design: Light Conditions on Spring and Fall Days of Time Change

Hour	Spring Time Change: Standard Time	Spring Time Change: Daylight Saving Time	Fall Time Change: Daylight Saving Time	Fall Time Change: Standard Time
Morning				
AM0	Darkness	Darkness	Darkness	Darkness
AM1	Darkness	Darkness	Darkness	Darkness
AM2	*Twilight*	Darkness	Darkness	*Twilight*
AM3	Light	*Twilight*	*Twilight*	Light
AM4	Light	Light	Light	Light
AM5	Light	Light	Light	Light
Afternoon				
PM0	Light	Light	Light	Light
PM1	Light	Light	Light	Light
PM2	*Twilight*	Light	Light	*Twilight*
PM3	Darkness	*Twilight*	*Twilight*	Darkness
PM4	Darkness	Darkness	Darkness	Darkness
PM5	Darkness	Darkness	Darkness	Darkness

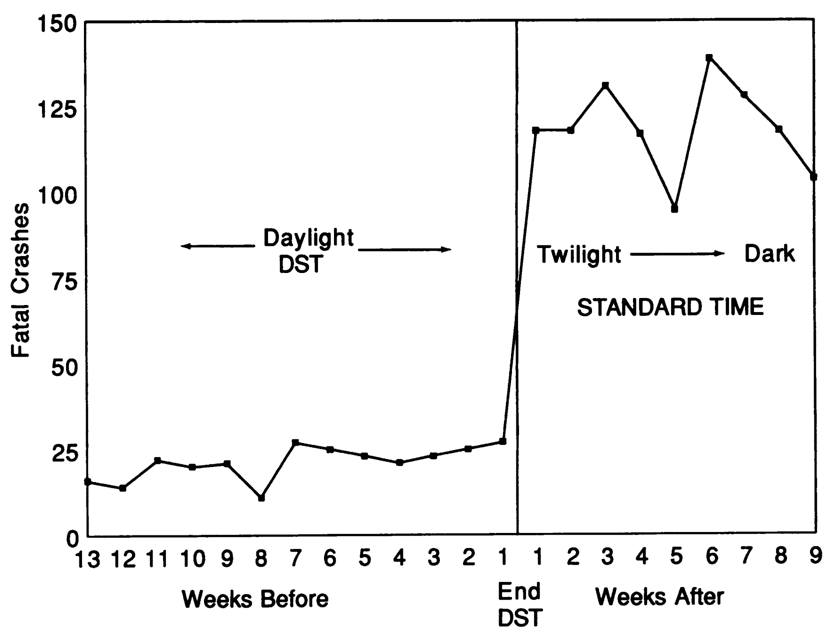

FIGURE 1—Pedestrian fatal crashes before and after the change to standard time in the fall PM2 hour, 1987 through 1991.

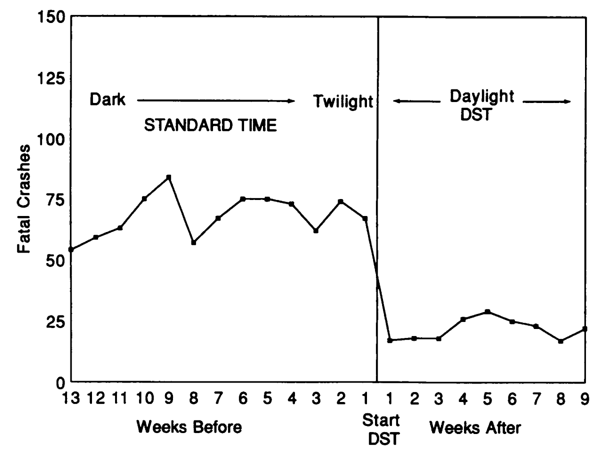

FIGURE 2—Pedestrian fatal crashes before and after the change to daylight saving time in the spring PM2 hour, 1987 through 1991.

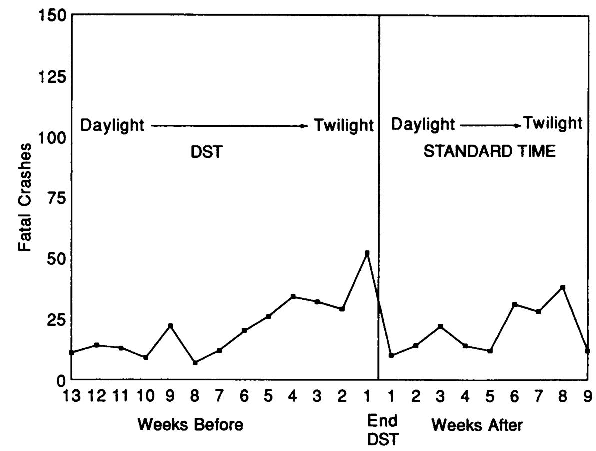

FIGURE 3—Pedestrian fatal crashes before and after the change to standard time in the fall AM3 hour, 1987 through 1991.

TABLE 2—Light Level Parameters and the Percentage Change in Fatal Crashes with Changes in Light Level

	Parameter Estimates	Standard Error	Percentage Change in Crashes	
			Light to Twilight	Twilight to Dark
Pedestrian	−0.207	.006	+326	+23
Vehicle occupant	−0.020	.003	+15	+2

TABLE 3—Estimated Number of Fatal Crashes during the Fall and Spring with Standard Time and Year-Round Daylight Saving Time

	No. of Crashes Predicted		
	Standard[a] Time	Daylight Saving Time	Difference
Crashes fatal to pedestrians			
Fall AM	1 987	2 337	+350
Fall PM	5 725	5 038	−687
Spring AM	1 450	1 882	+432
Spring PM	5 056	4 234	−822
Total	14 218	13 491	−727
Crashes fatal to vehicle occupants			
Fall AM	11 235	11 372	+137
Fall PM	20 751	20 528	−223
Spring AM	9 876	10 044	+168
Spring PM	17 991	17 735	−256
Total	59 853	59 679	−174

Note. Numbers of crashes include the full 44 weeks (22 fall, 22 spring) and the full 6-hour AM and PM periods. Most hour-by-week tabulations would be unaffected by retention of daylight saving time. Differences arise only from those hour-by-week combinations in which there would be a change in light level.

[a]The expected numbers of fatal crashes under either standard time or daylight saving time were obtained from the models relating light level to the log of fatal crashes. Actual numbers of fatal crashes under standard time were slightly higher than estimated by the model, and their use in calculating the benefits of daylight saving time would have led to an overestimation of the difference in fatal crashes.

(six levels), and light (continuous variable).

Preliminary examination of the data indicated that the most notable changes occurred when the light level was changing from daylight to twilight (or vice versa). Thus, the cube of the light level was selected to more adequately reflect these changes. Light level cubed changed from 0 to 1 for transitions between dark and twilight and from 1 to 8 for transitions between twilight and daylight.

Results

The most notable effects of changing light levels on fatal crashes were seen when light levels changed from light to twilight (crashes increased) and when twilight changed to light (crashes decreased). These effects were greatest for pedestrians.

The increase in pedestrian fatal crashes associated with an abrupt change from daylight to twilight is illustrated in Figure 1 for the fall PM2 hour. During this hour of full daylight for the weeks before the fall time change, crash counts remained relatively stable. With the start of standard time, the fall PM2 hour became a full hour of twilight, and the number of crashes increased substantially. Figure 2 shows the reverse effect for the PM2 hour for the change to daylight saving time in the spring. (Note that clock times for PM2 in the fall and PM2 in the spring are not identical. Thus, the absolute numbers of crashes varied from fall to spring.) Figure 3 shows the fall AM3 hour, in which there were both gradual and abrupt changes in light level from daylight to twilight. Note that the change in fatal crashes was of about the same magnitude whether light conditions changed gradually or abruptly, suggesting that it is light level rather than clock times that affects fatal crashes.

The results of the separate regression models for pedestrian and vehicle occupant fatal crashes had R^2s of 0.87 and 0.91, respectively. Both models had significant main effects for season, week, hour, time, and light level and interactions for time by week and for season by hour. The light level parameters, the standard error of the estimates, and the corresponding percentage change in crashes as a function of light level are given in Table 2.

As expected, there was an inverse relationship between light level and the number of fatal crashes. This effect was much larger for pedestrians than for vehicle occupants with the change from daylight to twilight. For pedestrians, a change from daylight to twilight was associated with about a 300% increase in fatal crashes.

The pedestrian and vehicle occupant models were used to estimate the number of fatal crashes that would be expected had all weeks been under daylight saving time as opposed to half under daylight saving time and half under standard time. This estimate was done by modifying the light level for each affected hour to reflect a continuation of daylight saving time throughout the year. As shown in Table 3, the predicted net benefit for retaining daylight saving time was a reduction of 727 fatal pedestrian crashes and 174 crashes fatal to vehicle occupants, for an average of about 180 per year.

Figure 4 shows this predicted crash reduction for the 22 weeks of standard time, 1987 through 1991. The greatest benefits from daylight saving time for pedestrians are just before the spring time change and just after the fall time change. Benefits are smallest during the darkest winter months because the PM reduction is increasingly offset by increases during the AM as sunrise gradually occurs later and later, eventually entering the morning rush hours. For vehicle occupants, the reduction in fatal crashes is lower and relatively constant throughout the winter.

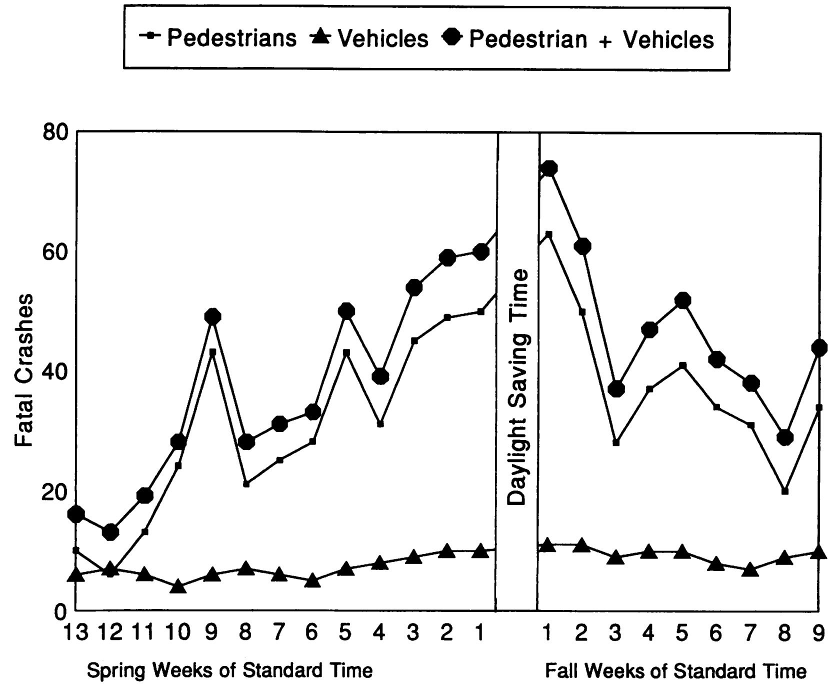

FIGURE 4—Fatal crashes that would be avoided if daylight saving time were retained.

Discussion

The effects found in this study are far more pronounced for pedestrians than for vehicle occupants. Vehicles have headlights and taillights that allow them to see and be seen during periods of twilight and darkness. Pedestrians in the United States rarely carry a flashlight during periods of darkness and do not often wear reflective material. Thus, it is not unexpected that the effects of decreased light would be more pronounced for them.

The results of this study provide strong support for the proposition that daylight saving time saves lives; extending it farther into the winter months could save additional lives. This conclusion is consistent with previous research conducted in the United States and Britain.[3–6] □

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