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Chapter Author: Thomas S. Dee, William N. Evans

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Teens and Traffic Safety

Thomas S. Dee and William N. Evans

Hollywood has always portrayed teens and cars as a volatile mixture. Whether it was the game of chicken from *Rebel without a Cause,* the drag race in *American Graffiti,* or the misadventures with dad's car in *Risky Business* and *Ferris Bueller's Day Off,* a teen behind the wheel of a car has always moved the plot along to some calamitous event. Although movies are sometimes a poor barometer of what ails society, unfortunately in this case these depictions may not be too far from the truth. In 1997 alone, there were 10,208 motor-vehicle fatalities among young adults aged fifteen to twenty-four, accounting for roughly one-third of all deaths in this age group. Motor-vehicle fatalities are far and away the leading cause of death among young adults.

The large fraction of deaths among young adults attributed to car travel is not entirely unexpected. Driving is an inherently risky activity, and the young rarely die of other nonviolent causes.[1] Furthermore, teens are increasingly dependent on automobiles. In 1995, the average teen aged sixteen to nineteen traveled 11,500 miles in cars, many of them as the driver. This number is nearly double the value for 1983, when teens traveled an average of only 5,861 miles per year in cars.[2] However, although a certain

Thomas S. Dee is assistant professor of economics at Swarthmore College. William N. Evans is professor of economics at the University of Maryland, a research associate of the National Bureau of Economic Research, and a senior research associate for the Project HOPE Center for Health Affairs.

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1. In 1997, accidents of all forms, homicides and other legal interventions, and suicides accounted for 24,797 of the 31,544 deaths of young adults.

2. Authors' calculations based on data from the 1983 and 1995 National Personal Transportation Survey.

amount of traffic-related injury and death is to be expected, teens die at a rate far higher than do older drivers. The teen motor-vehicle-fatality rate (defined as deaths per 100,000 people) is nearly double the rate for adults aged twenty-five and up. When fatalities are denominated by miles of travel, this ratio is nearly 2.5. Part of this difference is almost surely due to the lack of driving experience among teens. For example, compared to older drivers, teens are much more likely to die as occupants in accidents where general driver error is the cause, such as single-vehicle crashes and vehicle rollovers. However, much of the difference in rates across age groups is due specifically to the fact that teens tend to take more risks than do older drivers. In a recent National Highway Traffic Safety Administration (NHTSA) telephone survey, 60 percent of teen drivers reported that they were more likely to pass other cars than to be passed, 16 percentage points higher than the number for twenty-five- to thirty-four-year-olds and more than twice the rate for adults thirty-five to forty-four.[3] In the same survey, 67 percent of teens said that they tended to keep up with faster cars when driving in heavy traffic, a slightly lower rate than that for twenty-one- to twenty-four-year-olds (69 percent) but substantially higher than the responses for twenty-five- to thirty-four- and thirty-five- to forty-four-year-olds (58 and 48 percent, respectively). Nearly all studies have found that young people, and males in particular, were the most likely to be involved in fall-asleep crashes (Pack et al. 1995; Horne and Reyner 1995). Teens are also less likely than adults are to use an important traffic-safety device, a seat belt. Data from the Centers for Disease Control (CDC) indicate that, nationally, belt-use rates are about 10 percentage points higher for adults than for teens aged eighteen and nineteen. Finally, nearly one-quarter of all teen car-occupant fatalities are alcohol related, with the vast majority of these cases being single-vehicle crashes. Interestingly, the fraction of alcohol involvement for adults aged twenty-five and older is only 4 percentage points higher than that for teens, although all states now have a minimum legal drinking age of twenty-one.

In this chapter, we examine four broad questions about teen traffic safety: How has teen traffic safety changed in the past twenty-five years, and what are the possible causes of these changes? Why are teen drivers worse than adults? Who are the bad teen drivers? Which government policies have influenced teen traffic safety? These are by no means an exhaustive set of questions, but, given the trends in travel patterns and government regulation, we believe that we have isolated a number of interesting results that shed light on this risky and highly costly aspect of teen behavior. Our task for this project was made simpler by the extraordinary number of data sets available that include information about teen traffic safety

3. Results of the NHTSA aggressive driving survey can be found at http://www.nhtsa.dot.gov/people/injury/aggressive/unsafe/att-beh/Chapt4.html#1.

and risk taking. Specifically, we used data from a variety of national data sets, including the Fatal Accident Reporting System, the National Personal Transportation Survey, the National Automotive Sampling Survey, the Behavioral Risk Factor Surveillance Survey, the Youth Risk Behavioral Surveillance Survey, and the NHTSA 19 City Survey. We supplemented these sources with demographic data at the state level about the size of the teen population as well as other basic demographic data. We also utilized a number of published sources to isolate the timing of several important state policy changes.

The paper has three main sections. In section 3.1, we summarize the traits and trends in teen traffic safety. In section 3.2, we identify the observed characteristics of risky teen drivers by examining self-reports of hazardous driving practices. Finally, in section 3.3, we look at a number of important state policies that have been adopted over the past twenty-five years that have important ramifications for teen traffic safety. This discussion focuses, in particular, on four classes of state-level policies: policies that influence youth access to alcohol; policies directed at the specific and general deterrence of drunk driving; mandatory seat-belt laws; and highway speed limits. In the final section, we summarize our findings on this important dimension of risky teen behavior.

3.1 Teen Traffic Fatalities—Traits, Trends, and Hypotheses

3.1.1 Teen Traffic Fatalities—Historical and Cross-Sectional Data

To help focus our discussion, we first present cross-sectional and time-series evidence of the demographics of teen traffic safety. Our goal is to provide some evidence about the characteristics of traffic accidents that involve teens, who gets into accidents, and how key factors have changed over time. In this section, we focus on one particular type of traffic accident, namely, that which produces fatalities. This decision will obviously capture only one dimension of teen driving, and, clearly, there are other types of costs generated by such accidents. More specifically, the morbidity and property damage generated by traffic accidents involving teens are not trivial. Our decision is, however, guided by the relative importance of traffic fatalities and by the availability of high-quality, nationally representative data on motor-vehicle fatalities over a long period of time.

The primary data set used to construct the numerator in a motor-vehicle-fatality rate is the Fatal Accident Reporting System (FARS). The FARS is a census of motor accidents resulting in an occupant or a nonmotorist fatality within thirty days of the accident. The FARS collects data that describe the accident, the vehicle, all the persons involved, and the drivers. The FARS is administered by the NHTSA, and data are collected at the state level by FARS analysts, who utilize such information as police

Table 3.1 Distribution of Motor-Vehicle Fatalities, 1998

	Count/% of Passenger-Vehicle-Occupant Fatalities		
Type of Fatality/Group	16–19	20–24	25+
Motor-vehicle fatalities	4,643	4,853	28,880
% motor-vehicle occupants	93.3	91.7	84.1
% car occupants	88.8	82.7	74.6
Among car occupants (%):			
Males	65.1	74.2	61.8
Used seat belt	28.7	26.4	38.2
In car with air bag	17.4	21.4	23.6
Driver	59.7	68.1	75.6
Alcohol was involved	25.8	48.9	29.8
Friday/Saturday accident	35.3	36.0	33.4
Nighttime accident	52.8	61.7	36.5
Accident on Friday/Saturday night	20.9	23.9	13.8
By type of incident:			
Multivehicle	41.6	39.1	57.5
Single vehicle	43.6	46.4	31.9
Noncollision	14.8	14.5	10.6

reports, driver's-license and vehicle-registration data, death certificates, and hospital and emergency-room reports as well as other sources. Data are available beginning in 1975.

We begin the analysis by presenting, in table 3.1, the distribution of motor-vehicle deaths in 1998 for three age groups: teens sixteen to nineteen; young adults twenty to twenty-four; and adults twenty-five and older. This table provides a useful backdrop for establishing important stylized facts and for exploring what might constitute meaningful measures of teen traffic-fatality rates. Of the 4,643 motor-vehicle fatalities among teens in 1998, the vast majority are vehicle occupants, with almost 89 percent being fatalities among car occupants.[4] Nonoccupant deaths in all age categories are predominately among pedestrians. Adults have a much smaller fraction of car-occupant deaths than do younger people because a larger fraction of adults deaths occur in commercial trucks. Given the preponderance of teen deaths in cars, we present in the bottom portion of the table the fraction of all car-occupant deaths in particular groups. In all groups, the majority of deaths are among males, but this gender differential is higher among younger populations. There are a number of other intriguing results that also signal the relative prevalence of risk taking among teen drivers. First, teens have low belt-use rates, and they are more likely to be

4. We define *car occupants* as people in cars, vans, minivans, sport-utility vehicles, and light trucks.

Fig. 3.1 Motor-vehicle-fatality rate

in a car without an air bag relative to the older adults. Second, one-quarter of all teen deaths are alcohol related.[5] This rate is surprisingly only 4 percentage points lower than the rate for adults even though all states have adopted minimum legal drinking ages of twenty-one. For adults, three-quarters of car-occupant deaths are drivers. However, among teens, fewer than 60 percent are drivers, indicating that teens are substantially more likely to be passengers in fatal accidents. In the case of teens, most passenger fatalities occur in cars driven by other teens. The fraction of fatalities that happen on a Friday or Saturday is similar across age groups. However, teen traffic fatalities are more concentrated during the nighttime. Likewise, one-fifth of teen car-occupant fatalities happen on a Friday or Saturday night, compared to roughly one-sixth of adult deaths. Certain types of vehicle accidents are more likely to be caused by driver error than are others. For example, it is easier to assign driver blame in single-vehicle crashes and noncollision accidents like vehicle rollovers. Teens are much more likely to be involved in these types of crashes than are adults. About 60 percent of teen occupant deaths are single-vehicle crashes or noncollision accidents like rollovers, compared to just over 40 percent for adults.

In figure 3.1, we report the time series of motor-vehicle-accident rates for the three age groups over the period 1975–97. A fatality rate should

5. The NHTSA defines a traffic-related fatality as alcohol involved if anyone involved in the accident has a blood-alcohol concentration (BAC) of 0.01 or more. BAC measures the weight of alcohol in a given volume of blood (grams per deciliter) and can be identified through an evaluation of breath, blood, urine, or saliva. Since BAC data are not available for all participants in fatal accidents, the NHTSA imputes some data.

control for the underlying exposure of the population to risk. In this case, we use a simple measure of exposure, namely, fatalities per 100,000 people in the given age group. Population is a coarse measure of exposure to risk since driving intensity may vary considerably across age groups. But, given the lack of data on miles of travel by time and age, we start with this admittedly restrictive measure. The numbers in figure 3.1 demonstrate that the teen vehicle-fatality rate is roughly comparable to that for adults aged twenty to twenty-four and that both are about twice as large as the rate for adults aged twenty-five and older. The time-series pattern in all three series is similar, showing a large increase in rates during the late 1970s, a rapid decline in fatalities during the 1980s recession, a slight increase in rates through 1986, then a steady decline in rates until 1992. After 1992, fatality rates have been relatively constant. The long-term decline in teen fatality rates since the peak value in 1979 is stunning. Between 1979 and 1997, traffic-fatality rates for teens fell by 37 percent. Much of the drop occurred over the period 1986–92, when rates fell 25 percent. The drop in teen fatality rates is much larger than the drop for adults aged twenty-five and older, where fatality rates fell by 22 percent in the period 1979–97 and by 13 percent between 1986 and 1992. In figure 3.2, we report single-age fatality rates for teens aged sixteen to nineteen over the same period. The general time-series pattern is very similar to that reported in figure 3.1 above, with rates declining for all age groups after 1986. In general, these rates are monotonically higher for older drivers. However, this difference has converged over time with particularly strong reductions in traffic fatalities among older teens.

The motor-vehicle-fatality rate includes many type of victims, including drivers, occupants, passengers on public transportation, pedestrians, bik-

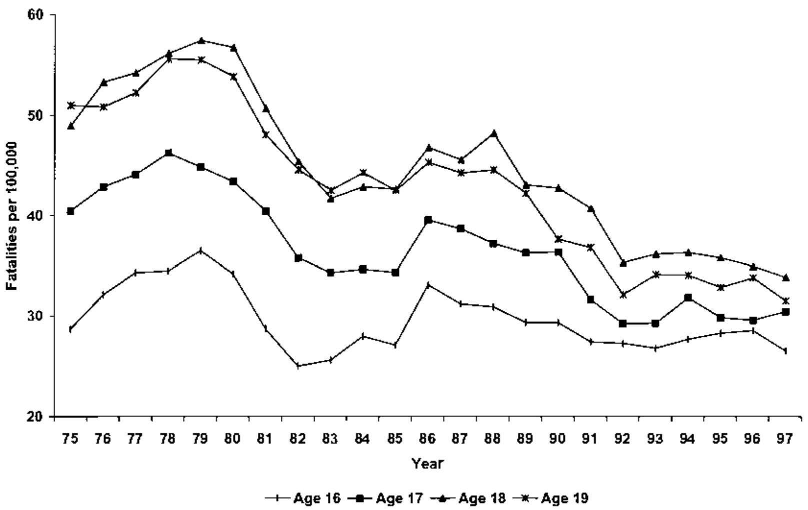

Fig. 3.2 Motor-vehicle-fatality rates for teens

ers, etc. The results shown in table 3.1 above illustrated that teen motor-vehicle fatalities are primarily from accidents involving the family car, but, in comparison to older adults, there are a higher fraction of nondriver-occupant deaths among teens. Therefore, a measure that may more accurately reflect risk taking by teens is the prevalence of fatalities in passenger vehicles. Using data from the FARS for the years 1975–97, we construct passenger-vehicle-fatality rates for each of the three age groups. In figures 3.3 and 3.4, we repeat the structure of the two previous graphs using

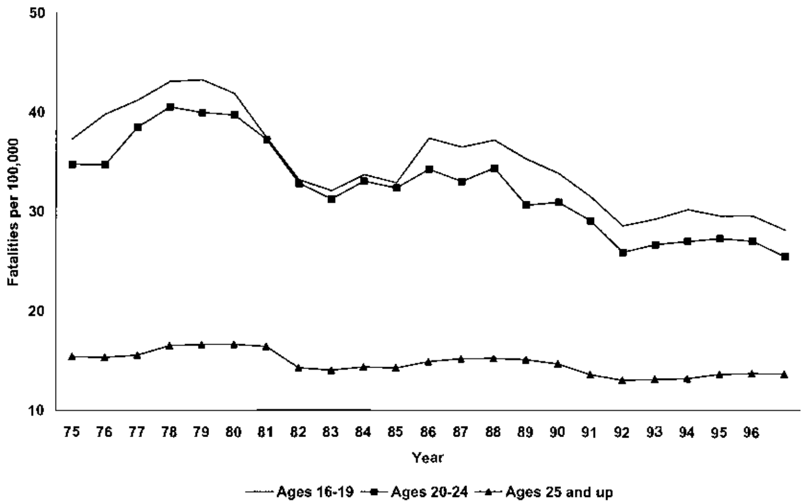

Fig. 3.3 Passenger-car-occupant-fatality rates

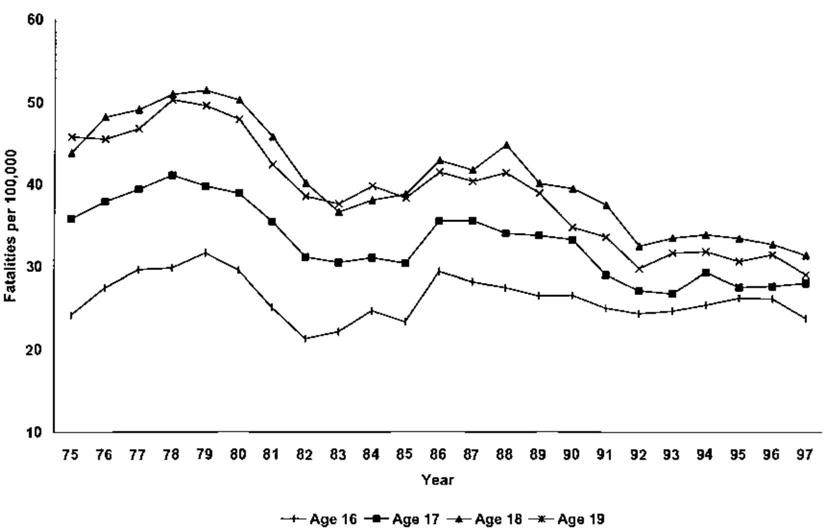

Fig. 3.4 Passenger-car-occupant-fatality rates among teens

passenger-vehicle-fatality rates as the outcome. Since teen fatalities are heavily concentrated among passenger-vehicle occupants, the trends and relative magnitudes of changes for this outcome are roughly comparable to the motor-vehicle deathrate numbers in figures 3.1 and 3.2 above. In contrast, the drop in occupant fatalities among adults twenty-five and older is less dramatic (17 percent) than that in the total vehicle fatality rate (22 percent).

As suggested earlier, denominating fatality rates with population is a coarse way in which to measure exposure to risks. The risks could vary considerably across groups if, for example, the types of roads, the types of travel, or the amount of travel varies across groups. Unfortunately, detailed data about these factors are sparse, and, therefore, we can view changes in fatality rates that are defined by different denominators only for particular years. More specifically, we can produce relatively detailed and age-specific estimates of car travel by relying on data from the National Personal Transportation Survey (NPTS).[6] The NPTS is a nationally representative survey of U.S. households. The NPTS is sponsored by the Federal Highway Administration and has been conducted in 1969, 1977, 1983, 1990, and 1995. In this chapter, we employ data from the three most recent surveys. Information is collected for all household members aged five and older. Data for children five to thirteen were reported by a household adult, and persons fourteen and older were interviewed directly. Information was collected about all trips taken by surveyed household members during a designated twenty-four-hour period (the "travel day" file) and about trips of seventy-five miles or more taken during the preceding fourteen-day period (the "travel period" file). The survey collected data on mode of transportation, trip purpose, distance, and time of trip. These values are used to construct aggregate estimates of annual travel. In 1995, data were collected from about forty-two thousand households. Roughly twenty-two thousand households were interviewed in 1990 and roughly sixty-four hundred in 1983.

From the day-trip data file, we calculated the distance of motor-vehicle trips in personal vehicles for all respondents. Using the sample weights, we then calculated the annual miles of car travel by age for the 1983, 1990, and 1995 surveys. We then constructed age-specific car-occupant-fatality rates for these years using vehicle miles of travel as the denominator. These results are reported in table 3.2. In the first columns, we report per capita vehicle miles of travel by age group for the three survey years. Notice that, for all three years of data, teens have much lower miles of car travel than do adults. In 1983, for example, adults twenty-five and older had 36 percent more per capita miles of travel than did teens. These results suggest

6. A detailed description of and data for the NPTS can be found at http://www.bts.gov/ntda/npts.

that conventional population-based fatality rates (e.g., fig. 3.3) vastly understate the difference in fatality risks across age groups. In 1983, for example, the ratio of age sixteen to nineteen to age twenty-five and older vehicle-occupant-fatality rates when rates are constructed using population is 2.2, but the ratio is just slightly over 3.0 when rates are constructed by vehicles of travel. The disparity in vehicle miles of travel across age groups fell considerably over the next twelve years. Between 1983 and 1995, per capita vehicle miles of travel increased from 5,861 to 11,498 for teens, a jump of 96 percent. In contrast, per capita miles of travel increased by only 69 percent for adults twenty-five and older. This implies that the population-denominated rates in figure 3.1 above understate the considerable gains in traffic safety among teens. To see this in more detail, in table 3.3 we report the change in fatality rates by age group for the periods 1983–95 and 1990–95. We report the change in rates for both the population- and the miles-denominated fatality rates. Notice that, using

Table 3.2 **Passenger-Vehicle-Occupant-Fatality Rates, 1983, 1990, and 1995**

Age Group	Annual per Person Car Miles of Travel	Fatalities per 100,000 People	Fatalities per Billion Car Miles of Travel
		1983	
16–19	5,861	32.06	54.22
20–24	9,773	31.21	31.62
25+	7,972	14.00	17.40
		1990	
16–19	8,218	33.78	40.74
20–24	10,177	30.85	30.01
25+	9,293	14.63	15.64
		1995	
16–19	11,498	29.48	25.43
20–24	12,656	27.20	21.29
25+	13,503	13.59	9.97

Sources: Fatalities are taken from the FARS. Occupant miles are taken from the 1983, 1990, and 1995 NPTS.

Table 3.3 **Percentage Changes in Passenger-Vehicle-Occupant-Fatality Rates**

	1983–95		1990–95	
Age Group	Fatalities per 100,000 People	Fatalities per Billion Car Miles of Travel	Fatalities per 100,000 People	Fatalities per Billion Car Miles of Travel
16–19	−8.0	−52.5	−12.7	−37.8
20–24	−12.8	−32.7	−11.8	−29.1
25+	−2.9	−42.7	−7.1	−36.3

population-denominated rates, there was only an 8 percent reduction in teen fatalities from 1983 to 1995 and a 12.7 percent reduction over the period 1990–95. Both these changes were substantially larger than the drop in rates for adults aged twenty-five and older. In contrast, the drop in rates is much more dramatic in both periods when one considers the large increase in vehicle miles traveled by teens. Over the period 1983–95, fatality rates denominated by miles fell by over 50 percent for teens and 43 percent for adults. Over the period 1990–95, the drop in fatality rates denominated by miles was similar for teens and older adults, in the 36–38 percent range. Because of the large increase in miles of travel over the period, the ratio of the teen miles-denominated fatality rate to the adult rate fell to 2.5 by 1995.

The trends in teen traffic fatalities also exhibit a distinctive heterogeneity with respect to gender, with most of the gains in traffic safety over this period concentrated among males. In figure 3.5, we report the percentage of car-occupant fatalities that are males by each age group. Notice that, for all age groups, we observe a large drop in the fraction male over the period 1982–97. For example, among teens, the fraction of fatalities that are male falls 11 percent between 1982 and 1997, from about three-quarters of all deaths to just over two-thirds. When we graph the male and female car-occupant-fatality rates by sex for teens (see fig. 3.6), we see that the drop is driven by a much larger reduction in the male deathrate. Between 1982 and 1997, male teen deathrates fell by 32 percent, about twice the rate for female teens.

There are a number of possible explanations for why teen car travel in-

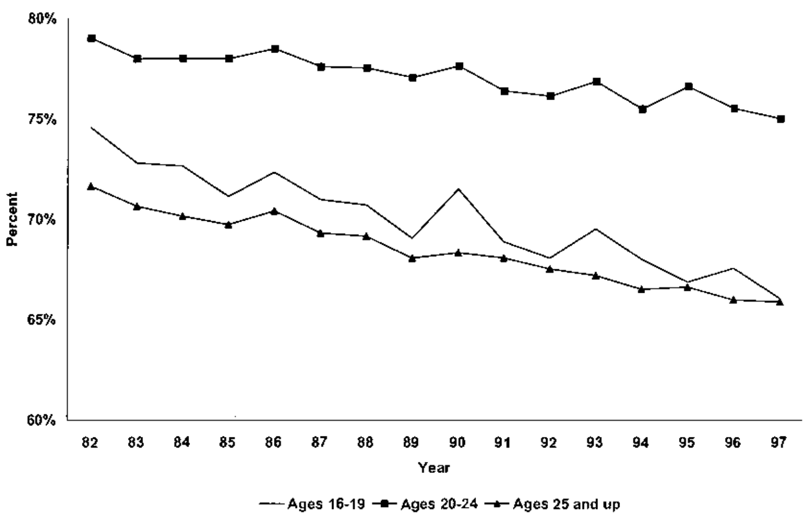

Fig. 3.5 Percentage of total motor-vehicle fatalities that are male

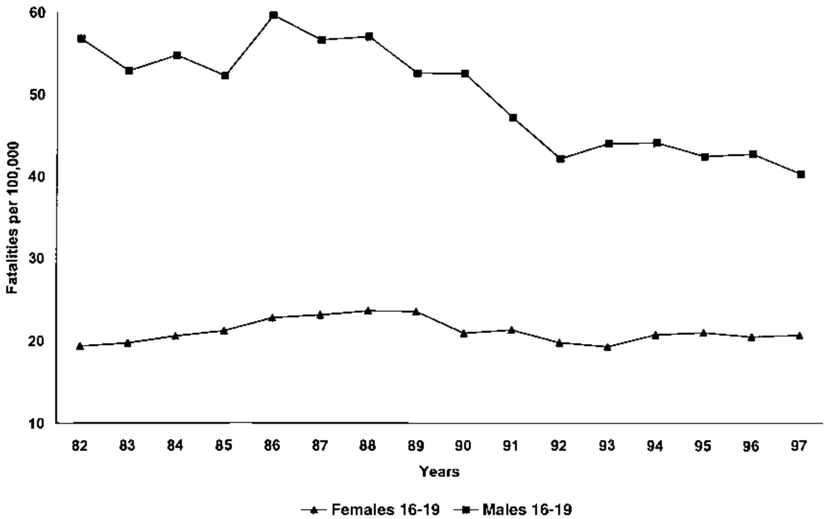

Fig. 3.6 Total motor-vehicle-fatality rates, male and female teens

creased so dramatically between 1983 and 1995. However, we should first note that car travel increased for all other age groups as well, so the increase among teens is part of a larger trend toward more car travel in society. Nonetheless, we can begin considering the increases in teen driving by first identifying a determinant that does not appear to explain the trends. There appears to have been no large change in the fraction of teens working or in teen labor income over this period. Using data from the 1984 and 1996 March Current Population Survey (CPS), we calculated a number of labor market variables for those aged seventeen to twenty. Since the March CPS provides labor market data for the previous year, these samples represent work for those aged sixteen to nineteen (roughly) in 1983 and 1995. Over these years, there was little change in teen work. The fraction of teens with labor income in these years was 68.3 and 68.2 percent, respectively. Likewise, real annual labor market earnings (in 1995 dollars) increased only slightly, from $3,910 in 1983 to $4,034 in 1995.

Part of the increase in car travel can potentially be explained by greater vehicle ownership in households with teens. Using data from the NPTS, we find that mean vehicles per household in households with teens increased from 2.28 in 1983 to 2.44 in 1995. More important, the fraction of households with more than one car increased from 69 to 79 percent, and the fraction with more than two cars increased from 42 to 48 percent. We should stress that, although these figures suggest that teens may have more opportunities to drive today, there is also the possibility that households may have increased vehicle ownership in response to the higher travel demands of other household members.

Some have suggested to us that the increased labor force participation of women may explain increased travel among teens. As women have entered the job market, driving patterns have changed, greatly increasing the number and composition of trips that women take (Spain 1997; McGuckin and Murakami 1999). Having a working mother may also influence the driving of teens, providing them with a greater need and/or more opportunity to drive. Data from the 1995 NPTS support the hypothesis that teens with working mothers drive more. From this survey, we constructed a sample of teens from the person data file. This file contains a composite measure of annual miles driven as well as detailed demographic information about respondents and their families. For teens who report that they are children of the household reference person, we merge into their observation an indicator that equals 1 when the mother works and 0 otherwise. Regressing annual miles driven on controls for household income, family size, age, race, ethnicity, sex, population size of the area where the household is located, and whether the mother works, we find that teens who have a working mother drive thirteen hundred miles more (t-statistic of 2.76) than other teens, which is about 20 percent of the sample mean of miles driven. Although the difference in annual driving miles across the two groups is large, the rise in labor force participation can explain only a small fraction of the increase in car travel. Data from the March CPS suggest that, among women aged thirty-five to sixty-five with school-age children in the family, the fraction with labor income increased by 10 percentage points, from 77 to 87 percent, between 1983 and 1995. This change in female labor force participation would explain only a 130-mile increase in driving over this period.

Another possible explanation for increased teen driving is the large drop in fuel prices over this period. Data from the Department of Energy indicate that nominal prices for a gallon of unleaded regular gasoline were \$1.24 in 1983 and \$1.15 in 1995.[7] Deflating these numbers by the consumer price index, the real price of a gallon of gasoline has fallen by almost 40 percent over this period. We suspect that the price elasticity of demand for gasoline is larger in absolute value for teens than for adults for two reasons. First, teens have lower incomes. More important, however, we suspect that teen car travel is more discretionary, and there is some evidence that discretionary car travel is more sensitive to price changes (Walls, Krupnick, and Hood 1993; Berkowitz et al. 1990).

3.1.2 Why Have Teen Traffic Fatality Rates Fallen since the 1980s?

The evidence presented here indicates that there have been substantive gains in teen traffic safety over the last two decades. When teen traffic fatalities are denominated by vehicle miles traveled, fatality rates have

7. See http://www.eia.doe.gov/pub/energy.overview/monthly.energy/mer9-4.

fallen by 50 percent since 1983, which exceeds the corresponding gain among adults over this period (table 3.3 above). This important trend could reflect two general influences: a reduction in the number of accidents and an increase in the survivability of crashes. This latter determinant can change for at least three reasons. First, the types of crashes may have changed if, for example, there are fewer high-speed crashes today than there were in previous years. Second, the crashworthiness of the automobiles driven by teens may have changed, enhancing the chances of crash survival. Finally, crash survivability can be enhanced through better medical care and the use of important occupant-safety devices such as seat belts and air bags. In this section, we present novel evidence suggesting that each of these factors has to varying degrees contributed to the downward trend in teen traffic fatalities.

Changing Crash Rates

Holding crash survivability constant, fatality rates should track the frequency of crashes. While there is some evidence that crash rates have declined, these changes may explain only part of the drop. More specifically, using data on the frequency of accidents from the National Automotive Sampling Survey (NASS), we find that crash rates have changed only modestly in recent years. The NASS is an annual sample of police accident reports that is sponsored by the NHTSA. The initial survey year for the NASS was 1988, so, unfortunately, we have a much smaller time series for accident rates than for fatalities. By 1998, the NASS reported data on about fifty thousand of the more than 6 million police-reported accidents. The structure of the NASS is similar to that of the FARS in that data are reported at the person, accident, and vehicle level.

In figure 3.7, we report the time series of accident rates for passenger-vehicle occupants by age groups for the period 1988–97. In this figure, accidents are per one thousand people. As with fatalities, teen rates are two to three times that of older adults. More important, accident rates follow a similar pattern as fatalities; that is, there was a sharp drop between 1988 and 1992, with a small increase in accidents since then. These results do suggest that some of the decline in fatalities can be attributed to a change in the frequency of accidents. However, crash rates have not fallen nearly as fast as fatalities. Between 1988 and 1992, for teens, fatality rates fell by 23 percent, but crash rates fell by only 11 percent.

The crashes represented by figure 3.7 are of various levels of severity, varying from simple "fender benders" to multivehicle accidents with fatalities. We would prefer to examine the time-series pattern for accident rates that are likely to produce injuries and fatalities. However, in this case, we cannot define severity on the basis of occupant injuries since vehicle crashworthiness may have changed over time. Instead, we can define accident rates on the basis of external damage to the vehicle. Specifically, we

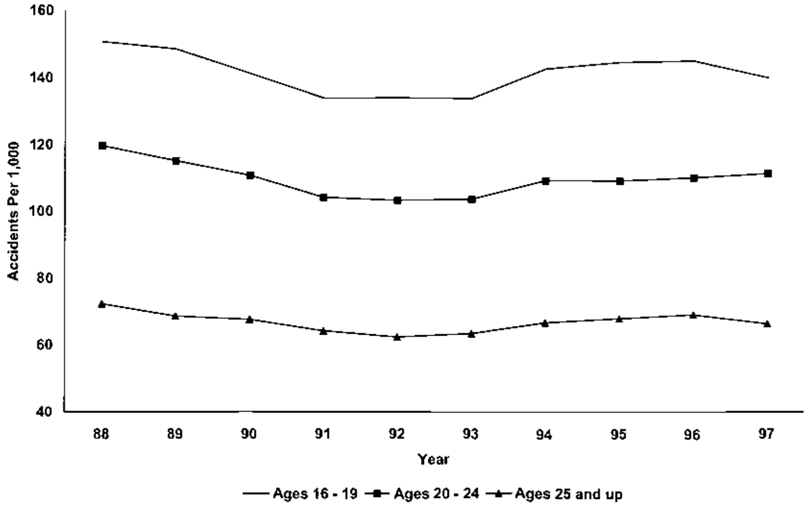

Fig. 3.7 Accident rates for passenger-car occupants

restrict our attention to accidents where the damage was great enough that the vehicle had to be towed from the accident scene.[8] In figure 3.8, we report the occupant crash rates for occupants who were in vehicles that were damaged enough to be towed away. The percentage drop in tow-away rates in the period 1988–92 is nearly identical to the drop in all crashes. Interestingly, however, there has been a large increase in tow-away crashes since 1992, with only a small increase in fatalities. The fact that the drop in accident and tow-away rates over the late 1980s and early 1990s is smaller than the drop in fatalities suggests that a change in crash rates can at best explain only part of the improvements in traffic safety. In the next section, we present evidence that crash survivability has also been enhanced.

These results do, however, beg the question why accident and fatality rates have fallen. Perhaps the most promising explanation involves the relation between teen alcohol use and traffic safety.[9] As is discussed in a later section, the widely recognized links between teen traffic accidents and alcohol use have motivated extensive policy making at the state and federal levels designed both to limit teens' access to alcohol and to deter drunk driving. There is a variety of direct medical evidence indicating that

8. Technically, we include all towed vehicles in the accident rate, including those that were towed for reasons other than drivability, such as the physical condition of the driver. These represent a small fraction of towed vehicles.

9. Changes in the prevalence of drunk driving may also have influenced crash rates as well as crash survivability through possible effects on crash severity and responsiveness to subsequent medical care.

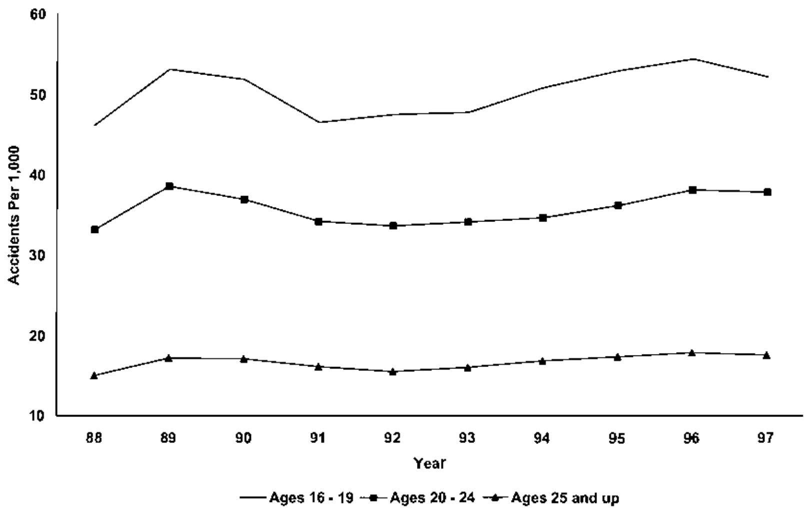

Fig. 3.8 Tow-away-accident rates for passenger-car occupants

alcohol use significantly impairs driver judgment as well as such critical motor skills as tracking, steering, and emergency responsiveness even at fairly low BACs (GAO 1999). Zador (1991) found, using FARS data, that the risk of fatal-crash involvement was substantially increased at BACs in the range of 0.05–0.09, particularly for young drivers.[10] More recently, Levitt and Porter (1999a) examined the fatality risk of drunk driving by adopting a unique empirical approach, one based on comparing the alcohol involvement of drivers in single-vehicle and two-car crashes. Their estimates suggest that drinking drivers are at least eight to nine times more likely than sober drivers to cause fatal crashes.[11]

However, Levitt and Porter (1999a) also recognized that the FARS data on BACs are not gathered for all participants in fatal crashes and that police reports of alcohol involvement may be incomplete.[12] Fortunately, we can construct a plausible proxy for alcohol-involved teen traffic fatalities by exploiting the distinct diurnal pattern in rates of alcohol involvement. The available data clearly indicate that alcohol involvement in fatal crashes is substantially higher at night. For example, using fatalities with identified BAC levels for teens over the period 1982–92, we graph in figure 3.9 the percentage of fatalities that have alcohol involvement by the time of day

10. In most states, it is "illegal per se" to drive with a BAC of 0.10 or more. Seventeen states have now set this limit at 0.08. Several other developed nations have also adopted regulations that make it illegal to drive with a BAC of 0.08 or lower.

11. Their estimates also point to the more limited fatality risk associated with young but sober drivers, which suggests the influence of other kinds of risk taking and/or inexperience.

12. They evaluate the robustness of their findings in part by replicating their results with data from states with high rates of BAC testing.

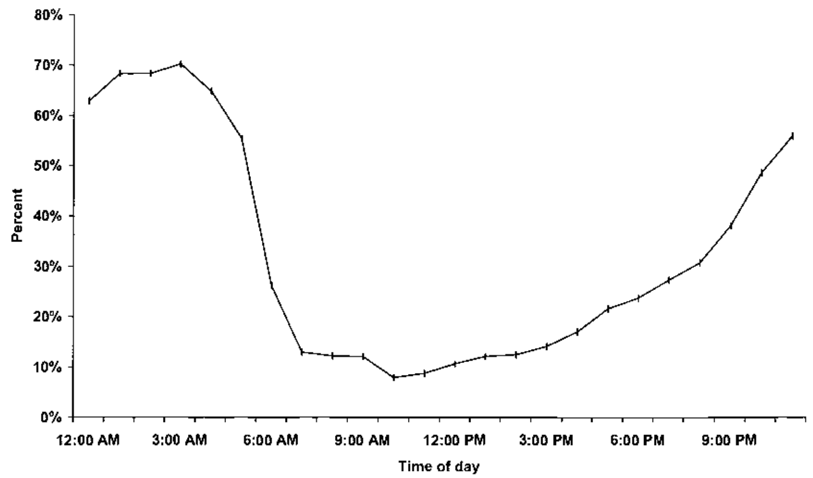

Fig. 3.9 Percentage alcohol involvement of motor-vehicle fatalities by time of day, FARS 1982–92, teens aged 15–19

when accidents happen. Notice that, for certain times of the day, alcohol-related fatalities represent as much as 70 percent of all motor-vehicle deaths. In contrast, between the hours of 6:00 A.M. and 6:00 P.M., alcohol is a cofactor in only about 15 percent of all crashes. Therefore, like other literature in this area, we use nighttime motor-vehicle fatalities as a proxy for the number of fatalities with alcohol involvement. Following the NHTSA's convention, we define *nighttime traffic fatalities* as those that occur between 6:00 P.M. and 5:59 A.M.

In figure 3.10, we present the nighttime motor-vehicle-fatality rate over the period 1975–97 for the three age groups. Notice that the drop in these alcohol-sensitive measures is fairly dramatic—between 1979 and 1997, this teen alcohol-sensitive fatality rate fell by almost 50 percent. In figure 3.11, we report age-specific nighttime fatality rates for teens. These figures suggest that the largest drop in fatality rates has been among eighteen- and nineteen-year-olds. The drop in alcohol-related fatalities can be traced in part to restricted access to alcohol and more aggressive drunk-driving legislation. Most notably, in 1977, thirty states had a minimum legal drinking age (MLDA) of eighteen. However, by the late 1980s, partly in response to federal pressure, all states had raised their MLDA to twenty-one. These legislative changes coincided with the large drop in fatalities during the 1980s (fig. 3.11). In the next section, we take a closer look at the effect that these and other alcohol and drunk-driving policies have had on teen motor-vehicle-fatality rates.

The effect that the drop in alcohol-related fatalities has had on aggregate fatality rates can be seen by looking at the time-series graph for daytime

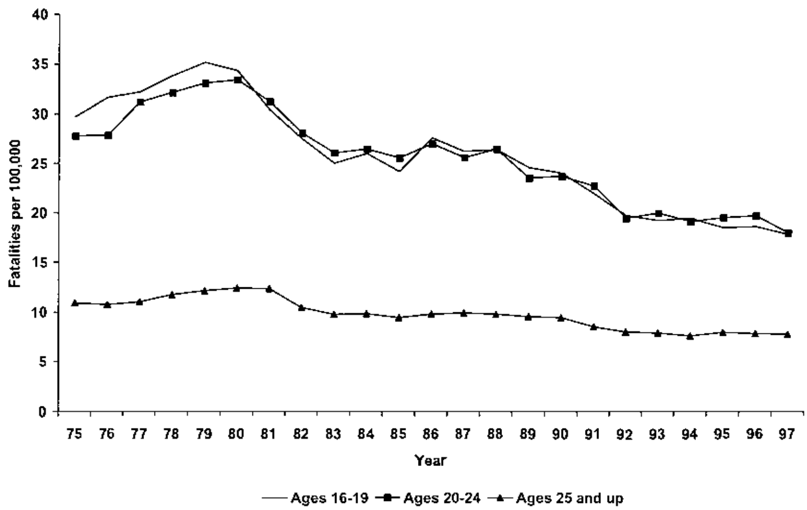

Fig. 3.10 Nighttime motor-vehicle-fatality rate

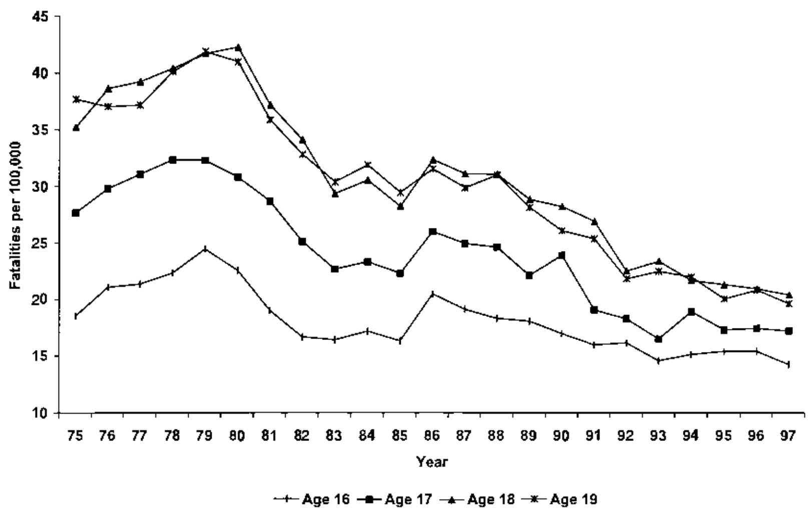

Fig. 3.11 Nighttime motor-vehicle-fatality rates for teens

fatality rates, shown in figure 3.12. Between 1979 and 1997, a time period when alcohol-related motor-vehicle fatalities are falling by 50 percent, daytime fatalities have stayed roughly constant. Since nighttime fatalities account for roughly 72 percent of all fatalities in 1979, these fatalities have fallen by 50 percent, and daytime fatalities have not fallen at all, it is not surprising that total motor-vehicle fatalities have fallen by almost (72 percent × 50 percent =) 36 percent over this period.

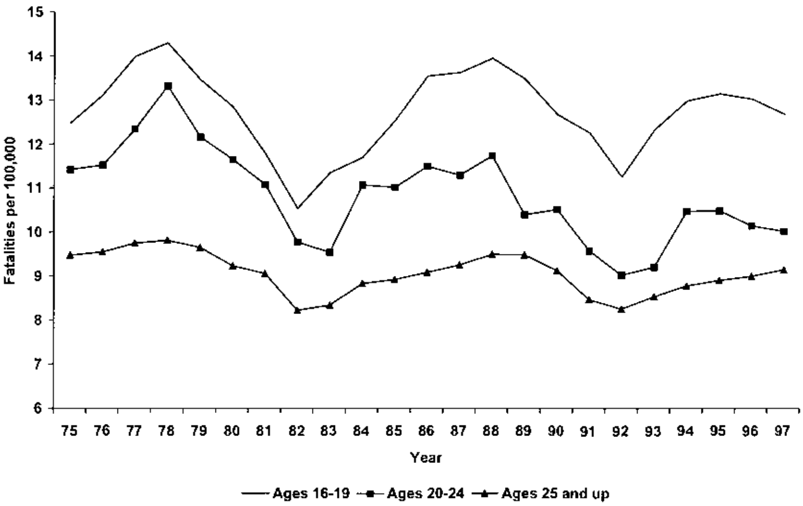

Fig. 3.12 Daytime motor-vehicle-fatality rate

Changes in Crash Survivability

It looks as though the drop in alcohol-related accidents may explain a large fraction of the long-run change in teen fatality rates. However, this important class of changes does not tell the whole story. In particular, note that alcohol-related fatalities, as measured by nighttime fatality rates, have fallen steadily since 1986. In contrast, aggregate fatality rates (both total and occupant, as measured in figs. 3.1 and 3.3 above) have been holding steady since 1992. Part of the reversal in the aggregate trend can be traced to an uptick in accidents. In figures 3.7 and 3.8 above, we saw that accident and tow-away-accident rates have actually increased by 5 and 10 percent, respectively, over the period 1992–97. However, part of the change in fatality rates may also have been driven by changes in crash survivability.

There have been four major trends that have altered the crashworthiness of automobiles. Between 1975 and 1985, new cars became much more fuel efficient, primarily by shedding vehicle weight. Over this time period, the curb weight of new cars sold fell by a thousand pounds (Kahane 1997). In a reversal of this trend, as real gas prices have fallen, the big automobile has returned, this time in the form of light trucks—pickups, sport-utility vehicles, and minivans. Between 1985 and 1993, the population of such light trucks increased by 50 percent (Kahane 1997). Today, light trucks represent one-third of registered vehicles (Gabler and Hollowell 1998). Light trucks are also 340 pounds heavier than the average new car. Larger vehicles, especially light trucks, are also much more crashworthy than lighter automobiles (Joksch, Massie, and Pichler 1998). In table 3.4, we present data from the NASS that identifies by age the fraction of occu-

Table 3.4 Characteristics of Passenger-Vehicle Occupants in Accidents, NASS

Category/ Age Group	1988	1992	1997
% Belt Use among Occupants in Accidents			
16–19	41.6	68.8	67.9
20–24	43.1	71.4	66.0
25+	38.4	77.4	70.7
% of All Occupants in Accidents in Light Trucks/Minivans/SUVs			
16–19	12.2	16.1	20.0
20–24	14.3	17.1	19.7
25+	13.8	18.7	22.2

pants in accidents who were drivers or passengers in light trucks. This fraction has doubled since 1988.

Another factor leading to improved survivability is enhanced trauma care. Regional trauma centers were established nearly twenty years ago to reduce injury-related mortality. By 1995, twenty-two states had regional trauma systems (Nathans et al. 2000). Evaluations suggest that the presence of regional trauma centers has reduced mortality among crash victims. Mullins and Mann (1999) found a 15–20 percent improved survival rate among the seriously injured treated at trauma centers. Nathans et al. (2000) found that states with regional trauma centers had a 9 percent lower automobile-accident-mortality rate than did states without such centers. Quantifying the benefits of these centers is not the focus of this paper, but there is some evidence in the FARS that enhanced medical care has improved the probability of survival among those who make it to a hospital. Consider the following example. Let D represent whether a crash victim dies and H represent whether he or she went to the hospital. We suspect that improved medical care has enhanced survivability or reduced the conditional probability prob($D|H$). Because the FARS contains only those involved in fatal accidents, we cannot estimate this probability directly. However, we can use the data in FARS by recognizing that, by Bayes's theorem, prob($D|H$) = prob($H|D$)prob(D)/prob(H). Notice that the probability of survival if a victim makes it to the hospital is proportional to the probability that we observed someone in a hospital given that he or she died. The intuition is straightforward. Suppose that, of a hundred crash victims, fifty die at the scene, and the remaining victims are transported to a hospital. If in-hospital-survival rates improve, then prob($H|D$) must fall. The 1980 FARS data indicate that 68 percent of fatalities were admitted to a hospital. This number fell considerably over the next eighteen years, dropping to 52 percent by 1997. These results are consistent with the hypothesis of improved medical care.

Another important trend that has clearly altered crash survivability substantively is the increased prevalence of seat-belt use (e.g., table 3.4).

Wearing a seat belt has been demonstrated to reduce significantly the fatality risk of crashes.[13] However, roadside and highway observations in the United States during the 1970s and early 1980s suggested that belt-use rates were only about 14 percent. Surprisingly, this rate had been relatively constant across prior years (Evans 1991). However, more recent observations suggest that belt use has risen nearly fivefold to 70 percent (NHTSA 1999a). As a later section demonstrates, a substantial proportion of these gains is directly due to the state-level adoption of mandatory seat-belt laws. At the beginning of 1984, no state required the use of a seat belt. However, since then, every state except New Hampshire has adopted some form of mandatory belt-use law (NHTSA 1999b). These laws were promoted in part by a federal regulation that would have delayed introduction of a proposed passive-restraint standard if two-thirds of the country were covered by mandatory belt-use laws. Since much of the surveillance data on belt use is based on direct roadside and highway observation, it is implausible to rely on that data to establish trends in youth-specific belt use. However, survey data do allow us to consider the age-specific trends in belt use. While any survey data are qualified by the potential biases inherent in self-reported health behaviors, they appear to track observed belt use as well as policy responses (Dee 1998).

The longest time series of belt use available is from the CDC's Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is an annual telephone-based survey designed to generate representative state-level data on the prevalence of important health behaviors among those aged eighteen or older (CDC 1998). The BRFSS began in 1984 by fielding surveys in fifteen states. By 1993, respondents in all fifty states were questioned. In figure 3.13, we plot the yearly belt-use rates for our three age groups. *Belt use* is defined as the percentage of BRFSS respondents who report always wearing a seat belt. In all years, teens have lower rates of belt use than do older drivers. However, all three age groups have dramatic increases in self-reported belt-use rates over this period. Use rates among teens increased by a factor of almost four, going from only 15 percent in 1984 to just under 57 percent in 1995. The percentage point increase in use was larger for adults, going from 23 to 68 percentage points, but this was only a threefold increase in use.

Unfortunately, the BRFSS surveys only adults eighteen and older. To obtain some evidence on belt use in a slightly younger population, we examine data from the Youth Risk Behavior Surveillance System (YRBSS), which is introduced in the next section. The YRBSS surveyed high school students in 1991, 1993, 1995, and 1997. Restricting our attention to the

13. Evidence on the technological efficacy of seat belts, the effects of mandatory seat-belt laws, and the possibility of compensating risk taking by drivers is discussed in detail in a later section.

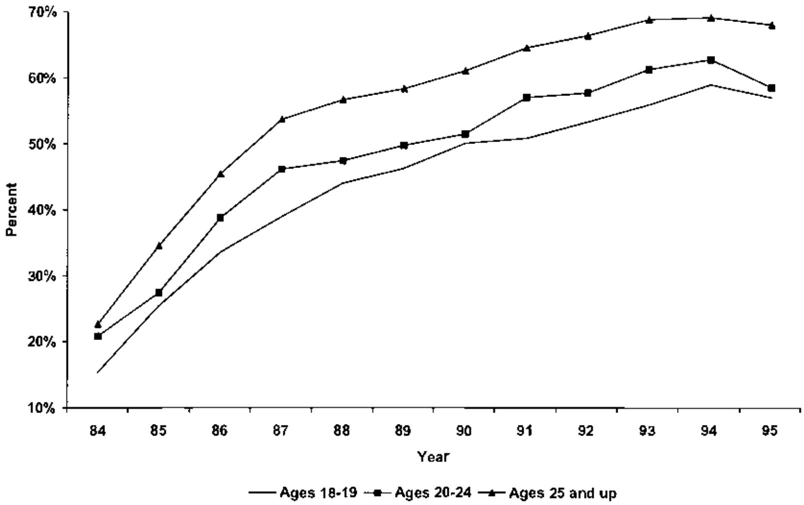

Fig. 3.13 Seat-belt use (all the time), BRFSS

driving-age population, we calculated belt-use rates (defined as the fraction who always wear a seat belt) for three age groups (sixteen, seventeen, and eighteen and older) for the four years of the survey. The use rates for sixteen-year-olds in the four survey years are 29.0, 31.9, 31.5, and 34.0 percent, respectively. The numbers for seventeen-year-olds (28.6, 34.8, 34.6, and 37.1 percent, respectively) and the eighteen and older group (27.2, 31.2, 35.2, and 34.5 percent, respectively) are similar to those for sixteen-year-olds. These data suggest that belt use is less common among these younger teens. However, during the 1990s, their belt use has been trending upward.

Another trend that is also likely to have improved crash survivability over this period is the increased installations of air bags. In 1984, the NHTSA required that automatic occupant-protection systems, such as air bags or automatic belts, be phased into passenger cars during 1987–90. All vehicles manufactured after 1 September 1993 were required to have automatic protection for the driver and right-front passenger. The Intermodal Surface Transportation Efficiency Act (ISTEA), passed by Congress in 1991, required all passenger cars manufactured after 1 September 1997 and light trucks manufactured after 1 September 1998 to have driver and passenger air bags plus manual lap-shoulder belts. However, since belt use has increased so sharply over this period and belts are substantially more effective at reducing fatality risk, it is unlikely that the adoption of air bags is as empirically relevant. Levitt and Porter (1999b) find that conventional estimates have overstated the efficacy of air bags. They estimate that air bags reduce fatality risk by between 9 percent (partial frontal collisions) and 16 percent (direct frontal collisions) but that seat belts reduce fatality risk by 60 percent. The Insurance Institute for Highway Safety estimates that roughly 46 percent of cars and light trucks on the road today have driver-side air bags and that one-third of these cars have passenger-side air bags.[14]

3.2 Who Are the Risky Teen Drivers?

The numbers given in table 3.1 above illustrate that the vast majority of teen motor-vehicle fatalities occur among males. Are there other observed characteristics that would allow one to predict who will be the risk takers? To address this question, we evaluated data from the national school-based YRBSS. The YRBSS is a nationally representative survey of roughly sixteen thousand high school students from 150 schools. The survey is sponsored by the CDC and has been fielded every two years since 1991. The purpose of the survey is to track priority health-risk behaviors of high schoolers over time. In our work, we present estimates from the 1997 YRBSS.[15]

From the YRBSS, we can construct three variables that indicate teen risk taking in the car. The first variable equals 1 for those who report always wearing a seat belt, the second equals 1 for those who drove after drinking in the past thirty days, and the third equals 1 for those who rode in a car in the past thirty days with a driver who had been drinking. With these variables, we estimate a simple probit that predicts a response of yes to these questions. For our analysis, we use data for sixteen- to eighteen-year-olds, deleting data for fifteen-year-olds since most cannot drive. Although the YRBSS contains detailed data on risky behavior, the data set has limited information on individual characteristics. We can include as covariates information on age, race, sex, parents' education, and urbanicity. Given the variation across states in traffic-safety laws, we also include in each model a full set of state dummy variables.

The results of these simple probits are included in table 3.5. The sample means for each outcome are reported in the final row of the table. We report the marginal effects, which represent the change in the probability of the event happening given a change in the covariate. So, for example, females are 10.3 percentage points more likely to wear a safety belt, which represents about a 35 percent higher use rate relative to the mean. Females are also much less likely to drive after drinking or to ride in a car with a drinking driver. Blacks and Hispanics are both less likely to wear seat belts but also less likely to be associated with drunk driving. The only strong effects of age are that younger drivers are less likely to drive drunk but also slightly less likely to wear a seat belt. Parents' education is a strong

14. See http://www.highwaysafety.org/safety_facts/airbags.htm.
15. Results from the three other YRBSS data sets were similar.

Table 3.5 Probit Estimates of Traffic-Safety-Choice Models, 1997 YRBSS, 16–18-Year-Olds, Probit Marginal Effects

	Traffic-Safety Choice (1 = yes, 0 = no)		
Covariate	Always Wear Seat Belt?	Drove after Drinking in Past 30 Days?	Rode in Car Driven by Someone Under the Influence in Past 30 Days?
Female	.103	−.113	−.078
	(.010)	(.008)	(.010)
Black	−.174	−.119	−.045
	(.018)	(.016)	(.017)
Hispanic	−.058	−.028	−.027
	(.019)	(.016)	(.018)
Other race	−.113	−.059	−.033
	(.014)	(.012)	(.014)
Age 16	−.038	−.104	−.043
	(.013)	(.011)	(.013)
Age 17	.006	.000	.031
	(.013)	(.010)	(.012)
Parents' education not reported	−.092	−.049	−.036
	(.024)	(.021)	(.023)
Highest parents' education is high school dropout	−.193	.028	.032
	(.022)	(.017)	(.020)
Highest parents' education is high school graduate	−.100	−.005	−.00
	(.015)	(.012)	(.014)
Highest parents' education is some college	−.043	−.030	−.018
	(.012)	(.011)	(.012)
Live in urban area	.109	−.135	−.121
	(.021)	(.017)	(.020)
Live in suburban area	.123	−.111	−.127
	(.021)	(.016)	(.020)
Mean of dependent variable	.352	.206	.385

Note: All models include state fixed effects. Standard errors are reported in parentheses.

predictor of belt use, with use monotonically increasing with parents' education. Interestingly, there is little correlation with parents' education and the two drinking-and-driving variables. Suburban and urban respondents look similar, and both are much more likely than rural residents to wear seat belts and not drink and drive.

One important characteristic that is strongly associated with teens' risk taking behind the wheel is their actions concerning other risky behaviors. Teens' decisions not to wear a seat belt or drive drunk appear to follow a pattern of risk taking along many dimensions—teens who take risks in the car appear to take risks in other aspects of life as well. In the first column of table 3.6, we report a number of questions from the 1997 YRBSS that measure, with a discrete yes-or-no variable, students' responses to ques-

Table 3.6 **Difference in Means by Traffic-Safety Indicator (yes-no), 1997 YRBSS, 16–19-Year-Olds**

Health Habit (1=yes, 0=no)	Males Obs.	Males Sample Mean	Males Always/Mostly Wear Seat Belt?	Males Rode in Car with Drinking Driver?	Males Drove Car After Drinking?	Females Obs.	Females Sample Mean	Females Always/Mostly Wear Seat Belt?	Females Rode in Car with Drinking Driver?	Females Drove Car after Drinking?
Smoked cigarette in past 30 days?	7,293	.378	−.227	.351	.434	7,581	.347	−.144	.318	.514
			(.011)	(.011)	(.013)			(.012)	(.011)	(.016)
Use bicycle helmet?	5,889	.335	.030	−.041	−.134	4,946	.114	−.033	.007	−.036
			(.013)	(.013)	(.016)			(.010)	(.010)	(.014)
Had at least 1 drink in past 30 days?	7,523	.340	−.212	.457	.648	7,829	.248	−.088	.354	.641
			(.011)	(.010)	(.011)			(.010)	(.009)	(.013)
Had 5 or more drinks in a row in past 30 days?	7,690	.279	−.182	.418	.644	8,007	.174	−.057	.293	.550
			(.010)	(.009)	(.010)			(.009)	(.008)	(.012)
In a physical fight in past year?	7,738	.455	−.159	.197	.204	8,038	.258	−.171	.147	.127
			(.011)	(.011)	(.014)			(.010)	(.010)	(.015)
Smoked pot in last 30 days?	7,716	.302	−.205	.318	.374	8,008	.215	−.083	.264	.376
			(.010)	(.010)	(.012)			(.010)	(.009)	(.013)
Used a condom last time had sex?	4,261	.647	.110	−.086	−.072	3,956	.539	.020	−.079	−.089
			(.015)	(.015)	(.016)			(.016)	(.016)	(.020)
Ate fruit yesterday?	7,770	.666	.085	.007	−.035	8,056	.614	.154	−.038	−.075
			(.011)	(.011)	(.013)			(.012)	(.011)	(.017)
Ate vegetables/salad yesterday?	7,771	.638	.100	.022	−.019	8,061	.629	.074	−.005	.008
			(.011)	(.011)	(.013)			(.012)	(.011)	(.017)
Ate burger/hot dog/sausage yesterday?	7,771	.482	−.103	.130	.083	8,055	.332	−.036	.028	−.012
			(.011)	(.012)	(.014)			(.011)	(.011)	(.016)
Ate fries/potato chips yesterday?	7,769	.604	−.083	.066	.066	8,054	.509	−.091	.053	.050
			(.011)	(.011)	(.014)			(.012)	(.012)	(.017)
Any aerobic exercise in past week?	7,754	.882	.046	.001	−.016	8,046	.758	.105	−.022	.034
			(.007)	(.008)	(.009)			(.010)	(.010)	(.015)
Any strength exercise in past week?	7,760	.776	.013	.019	.005	8,048	.671	.120	−.025	.025
			(.010)	(.010)	(.012)			(.011)	(.011)	(.016)

Note: Standard errors are reported in parentheses.

tions about a number of activities that pose health risks. For each health habit, we report the number of valid observations and the sample mean. We next report the difference in means for the particular health habit on the basis of whether a respondent reports always wearing a seat belt or riding in or driving a car after drinking. These numbers are reported for males and females. So, in the first row, 37.8 percent of males report smoking in the past thirty days. This smoking rate is 22.7 percentage points lower for those who always wear a seat belt, 35 percentage points higher among those who rode with a drinking driver, and 43 percentage points higher for those who drove after drinking. For males, knowing whether you are a risky driver indicates that you have twice the average chance of smoking!

The results in the rest of the table are striking. Risky drivers (those not wearing seat belts and those riding/driving after drinking) are less likely to wear a bicycle helmet, more likely to have been drinking in the past thirty days, more likely to have been in a fight in the past year, more likely to smoke marijuana, more likely to have had unprotected sex, more likely to have had fatty foods like burgers and fries, less likely to eat fruits and vegetables, and less likely to exercise! The differences in means are in most cases slightly smaller for females, but, for some of the variables (e.g., smoking), the estimates are comparable.

3.3 Which Policies Have Improved Teen Traffic Safety?

The evidence presented in the previous sections of this paper has underscored the dramatic level of lethal risk faced by teens in cars as well as important stylized facts about the character of these risks. However, this evidence also indicated that, over the past twenty years, there have been impressive gains in teen traffic safety, both in absolute terms and relative to adult traffic-related risks. This evidence also suggested that these gains have been driven both by a reduction in the number of accidents and by increases in the probability of surviving a crash. However, these striking conclusions beg further questions about what factors might constitute the root causes of these impressive improvements. The extensive literature on traffic safety has attributed much of these gains to the broad and aggressive new regulation over this period of key behaviors related to traffic safety. This section presents a critical overview of this evidence. First, we discuss the theoretical and empirical evidence linking the adoption and enforcement of mandatory seat-belt laws to the observed improvements in the prevalence of belt use among teens (fig. 3.13 above). Then we discuss the more general evidence on the efficacy of key traffic-safety regulations, in part, by presenting reduced-form evaluations of how state-level policies have influenced the number of teen traffic fatalities. This discussion focuses, in particular, on four classes of state-level policies: policies that influence youth access to alcohol, policies directed at the specific and general deterrence of drunk driving,[16] mandatory seat-belt laws, and highway speed limits.

3.3.1 Seat-Belt Use

Evidence from both technological evaluations and actual crashes suggests that seat belts are highly effective at reducing the fatality risk associated with a crash. Early estimates indicated that this risk reduction was roughly 50 percent (Evans 1986; NHTSA 1984). However, in a recent study, Levitt and Porter (1999b) conclude that such estimates may be biased downward because of sample selectivity and that the actual risk reduction associated with seat-belt use is 60 percent. Regardless, it was in part a growing awareness of such dramatic lifesaving benefits that motivated the widespread adoption of state laws mandating their use. Beginning with New York in late 1984, every state but New Hampshire has adopted a mandatory seat-belt law.[17] However, these laws were accompanied by differing levels of enforcement. More specifically, most states (currently thirty-eight) adopted "secondary" enforcement, which allows only a citation for a seat-belt violation if the driver has been stopped for another infraction. In the eleven states with "primary" enforcement, a seat-belt violation alone is sufficient cause for a citation.

The technological efficacy of seat belts suggests that the widespread adoption of mandatory seat-belt laws may have generated substantive gains in traffic safety. However, there are at least two reasons to suspect that these gains may have been sharply attenuated. One is the possibility of "selective recruitment"—a smaller response in belt use among those most likely to be involved in accidents (young drivers, males, those who drink). A second reason is the possibility of risk-compensating behavior. Peltzman (1975) argued that the lifesaving benefits of such safety requirements as seat-belt laws may be reduced if drivers subsequently increase their risk taking behind the wheel. A casual reading of the U.S. experience with seat-belt laws suggests that this may actually have occurred. More specifically, naive evaluations that compare belt-use rates before and after a seat-belt law suggest that such laws increased use by roughly 28 percentage points (Campbell and Campbell 1988). If seat belts reduce fatality risks by 50 percent, this increase in belt use should be accompanied by a decrease in traffic fatalities of roughly 14 percent in the absence of a compensating behavioral response. However, most studies suggest that fatalities fell by only about 8 percent (Evans and Graham 1991). Nonetheless, Dee (1998) argues that the U.S. experience with seat-belt laws did not

16. General deterrence is an attempt to reduce drunk driving in the general population. Specific deterrence is an attempt to punish known offenders so that they do not offend again.

17. Two states (Massachusetts and Nebraska) adopted, rescinded, and later reinstated such laws.

Table 3.7 OLS and Probit Estimates of Impact of Mandatory Seat-Belt Laws on Seat-Belt Use

			OLS Coefficient or Probit Marginal Effect		
				Model (2)	
Data Set and Sample	Sample Size	Mean Belt Usage	Model (1): Mandatory Seat-Belt Law	Mandatory Seat-Belt Law, Primary Enforcement	Mandatory Seat-Belt Law, Secondary Enforcement
NHTSA 19 City Survey (1985–91)	126	.422	.172 (.019)	.351 (.043)	.158 (.018)
1984–93 BRFSS:					
All respondents	577,422	.541	.183 (.003)	.260 (.006)	.172 (.003)
Balanced panel of 15 states	239,779	.504	.144 (.004)	.212 (.011)	.141 (.004)
25+	513,557	.549	.190 (.003)	.247 (.006)	.179 (.003)
20–24	47,244	.488	.137 (.010)	.233 (.023)	.126 (.010)
18–19	16,621	.438	.147 (.017)	.249 (.040)	.136 (.019)
18–19 males	7,953	.383	.105 (.024)	.209 (.058)	.091 (.027)
18–19 females	8,668	.489	.188 (.024)	.286 (.053)	.176 (.026)

Note: All models include year and state or city fixed effects. The BRFSS models also include covariates for gender, race/ethnicity, age, and age squared. Standard errors are reported in parentheses. For further details, see Dee (1998).

induce a dramatic increase in risk taking by drivers.[18] The flaw in the prior reasoning is that it does not seem that seat-belt laws actually increased belt use by 28 percentage points. Such estimates (which are typically based on interrupted time-series analysis) appear to confound the long-term trend toward increased belt use with the adoption of the state laws, overstating those laws' effects dramatically. Dee (1998) concludes that mandatory seat-belt laws increased belt use by only about 18 percent—a magnitude consistent with the observed reduction in fatalities and a number that suggests that compensating risk taking is of minor importance. However, Dee (1998) does find evidence of selective recruitment: a smaller response in belt use among the young and, in particular, young male drivers.

Table 3.7 summarizes this evidence by presenting estimates of how man-

18. Evans and Graham (1991) also present evidence consistent with this claim: the adoption of mandatory seat-belt laws was not associated with increases in pedestrian or cyclist deaths related to traffic accidents.

datory seat-belt laws and their enforcement levels influenced belt use. This evidence draws on two distinct data sources. The first source is pooled city-level data from the 1985–91 19 City Surveys, which employed observation techniques to gather information (e.g., NHTSA 1989). While these aggregate data do not allow us to address the selective-recruitment hypothesis by focusing on heterogeneous responses in particular subgroups, they do have the virtue of being observed as opposed to self-reported. Pooling seven years of data over eighteen cities leaves a data set with 126 observations.[19] With this data set, we estimate a simple analysis-of-covariance model in which we regress the fraction belt use on a series of city and year fixed effects and the belt-use intervention dummy variables, which equal 1 in years when the laws were in effect and 0 otherwise. These estimates, reported in the first row of table 3.7, suggest that mandatory seat-belt laws increased use by about 17 percentage points and that these effects were plausibly heterogeneous with regard to enforcement levels.[20] The importance of mandatory belt-use laws in explaining increased use rates is also illustrated by the experience in Massachusetts. A secondary-enforcement belt-use law went into effect in Massachusetts on 1 January 1986, but the law was repealed in a statewide referendum just eleven months later. Observation studies found that belt use increased from 20 percent before the law went into effect to 37 percent after. However, belt use quickly fell back down to 25 percent after the law was repealed (Hingson et al. 1988).

To examine the effect of belt-use laws on teen use of seat belts, we must move away from the observational data and utilize individual self-reports of belt use. For this exercise, we use the BRFSS data introduced above. We pool the BRFSS data over the period 1984–93, constructing a sample of 577,422 respondents (Dee 1998). *Belt use* was defined by a binary indicator equal to 1 for respondents who claimed to use a seat belt "always." For this sample, we estimate simple linear-probability models, controlling for basic demographic characteristics, state and year effects, plus the belt-use intervention indicator variables. The remaining results in table 3.7 present estimates of how mandatory seat-belt laws influenced this belt-use measure for all respondents as well as for specific age and gender groups. Overall, evaluations based on the BRFSS data are similar to those based on observation data. Mandatory seat-belt laws increased belt use by roughly 18 percentage points with a plausible heterogeneity with respect to the level of enforcement. As we noted above, the BRFSS contained data

19. The eighteen cities are Atlanta, Baltimore, Birmingham, Boston, Chicago, Dallas, Houston, Los Angeles, Miami, Minneapolis/St. Paul, New Orleans, New York, Phoenix, Pittsburgh, Providence, San Diego, San Francisco, and Seattle. Data from Fargo/Moorhead were excluded since this area crossed state lines.

20. However, since Houston and Dallas are the only represented cities with primary enforcement over this period, these results may not be fully generalizable to the experiences across the country (Dee 1998).

from only fifteen states in 1984 and expanded to include data for fifty states by 1993. We examined whether this change in sample composition is influencing our basic results. Evaluations based only on data from the fifteen states surveyed in all ten years return similar results. The evidence from evaluations based on subsets of the BRFSS respondents points to the existence of some selective recruitment. Younger respondents and young males in particular were less likely to increase their belt use in response to mandatory seat-belt laws and their enforcement levels sharply influenced belt use among teens and may, therefore, have been an important source of recent improvements in teen traffic safety. The reduced-form models presented in the next section provide more direct evidence on this question by evaluating the influence of these regulations on the number of traffic fatalities.

3.3.2 Traffic Fatalities

This section discusses the reduced-form evidence linking a variety of state policies to reductions in teen traffic fatalities.

Prior Literature

One widely recognized determinant of the recent reductions in teen traffic fatalities is the nationwide movement calling for an MLDA of twenty-one. In the late 1960s and 1970s, many states had lowered their MLDA in response to a general sentiment toward the enfranchisement of young adults as well as considerable doubt about the efficacy of prohibiting alcohol. By 1977, thirty states had an MLDA of only eighteen. However, there was a growing realization that relaxed access to alcohol may have increased the number of teen traffic fatalities. Partly in response to this realization as well as strong financial pressure by the federal government, all states increased their MLDA to twenty-one by the late 1980s. Several studies have established a clear link between the state-specific timing of movements to higher MLDAs and reductions in traffic fatalities (e.g., Cook and Tauchen 1984; Evans et al. 1991; Chaloupka et al. 1993; Ruhm 1996; Dee 1999). Similarly, some studies have also concluded that there are traffic-safety benefits of another regulation that can limit access to alcohol: excise taxes on beer (Chaloupka et al. 1993; Evans et al. 1991; Ruhm 1996). However, recent evidence, which is discussed in more detail here, has suggested that these links may be spurious (Dee 1999; Mast et al. 1999).

Another important set of policies that may have influenced the distinctive recent trends in youth traffic fatalities is those aimed at the deterrence of drunk driving. Policies designed to reduce drunk driving have proliferated over the last twenty years in response to increased public awareness and indignation. One important type of state-level drunk-driving law was the kind that made it “illegal per se” to drive with a specific BAC. All states except Massachusetts and South Carolina currently have such an explicit limit. Most states initially established their BAC limit at 0.10 or more. However, an increasing number of states (now nineteen) have established a stricter definition at a BAC of 0.08. Federal efforts to compel all states to adopt 0.08 BAC laws have foundered recently, in part because of controversies over the efficacy of such laws at the state level (GAO 1999; Dee, in press). Another major drunk-driving policy that has sometimes been adopted simultaneously with an explicit BAC level is a regulation allowing "administrative license revocations." This policy, which has been adopted in forty-one states, allows state licensing agencies to suspend or revoke the driver's license of an allegedly drunk driver prior to any court action.[21] All states have now also adopted "zero-tolerance" laws that make it illegal per se for underage drivers to have a positive BAC regardless of its value. Other drunk-driving policies include "dram-shop" statutes (or case law) that allow injured parties to sue the servers of alcohol and regulations that mandate jail time for first-time DUI offenders. Recent reviews of the efficacy of such drunk-driving policies (e.g., DeJong and Hingson 1998; Hingson 1996; Zador et al. 1989) uniformly conclude that all these policies have been highly effective. However, this evidence should be interpreted with some caution since the research methodologies vary widely across studies. Ruhm (1996) addresses the efficacy of several drunk-driving and alcohol-related policies and finds that inferences regarding their effects can be sensitive to the omission of state and year fixed effects that purge the unobserved and potentially confounding determinants that vary across states and over time. However, Ruhm (1996) does find that administrative license revocations were somewhat effective in reducing traffic fatalities among youths. This evidence is developed further here by examining evidence on the hypothesized interactive effects of administrative license revocations and other policies that establish specific BAC limits at which it is illegal to drive.

A third set of policies evaluated in this context is the mandatory seatbelt laws discussed earlier. Given the evidence that these laws substantially increased belt use among young drivers, we would expect to find significant fatality reductions in the absence of a compensatory increase in risk taking. Since the available evidence suggests that the enforcement level of these laws is relevant, those distinctions are allowed. The fourth set of policies evaluated here reflects the changes in each state's maximum speed limit. In response to the Arab oil embargo, a national maximum speed limit (NMSL) of fifty-five miles per hour (MPH) was established in the early 1970s. In 1987, these regulations were relaxed, and states were allowed to raise their speed limits to sixty-five MPH on portions of the rural interstate system (and in that year alone, thirty-eight states did so). In

21. The constitutionality of these regulations has been unsuccessfully challenged in several states.

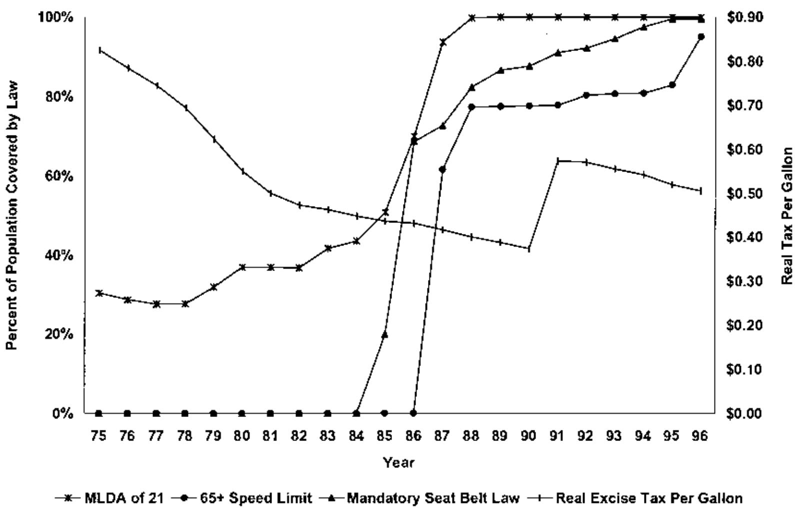

Fig. 3.14 Key state traffic-safety policies by year

1995, the federal regulation of speed limits was eliminated, and most states raised their maximum speed limit above sixty-five MPH.[22] The prior empirical evidence on the effects of higher speed limits is mixed. Lave and Elias (1994) suggest that the movement in the late 1980s to sixty-five-MPH speed limits actually reduced overall fatalities by redirecting traffic away from more dangerous secondary roads and influencing patterns of police enforcement. However, this conclusion has been challenged in recent studies (e.g., Farmer et al. 1999) that also considered the effects of more recent movements to speed limits above sixty-five MPH. The evaluations presented here provide further evidence on this question.

In figure 3.14, we report the time-series of the percentage of the population covered by four traffic-safety policies: mandatory belt-use laws, an MLDA of twenty-one, the beer tax, and a speed limit of sixty-five. Notice the steep increase in the fraction covered by belt use since 1984 and the sharp drop in those covered by an MLDA of eighteen. The beer tax is drifting downward until a federal tax hike in 1991; then it drifts downward slowly again. The time-series pattern for this variable is determined mainly by the changes in the price index. Over this period, few states are changing their nominal excise tax on beer, and inflation is eroding its real value over time.

In figure 3.15, we report for a shorter period the percentage of people covered by laws aimed at the specific and the general deterrence of drunk driving. Notice that, over this short period, coverage rates for most laws

22. During the day in portions of Montana, there is no posted speed limit for cars.

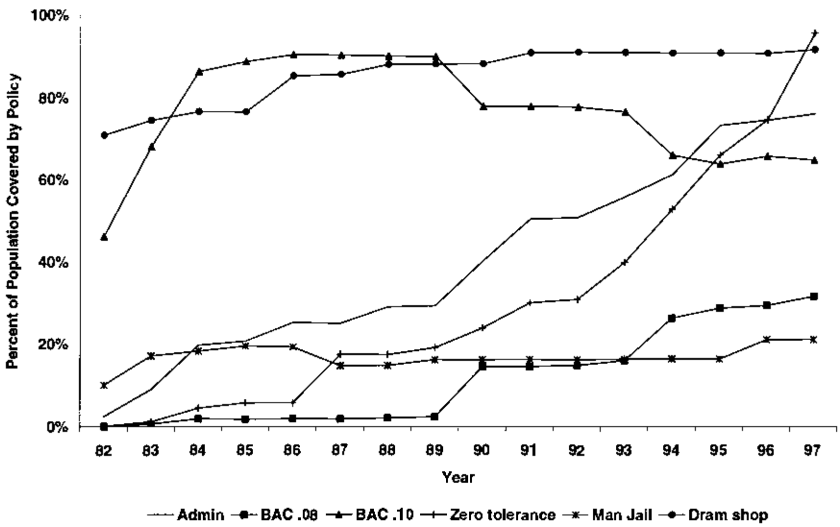

Fig. 3.15 Key alcohol-control policies by year

are increasing dramatically. The lone exception is the BAC 0.10 laws, which are declining somewhat as states shift to an "illegal per se" BAC limit of 0.08. In both figure 3.14 and figure 3.15, there are a significant number of laws that are coming into effect during our period of analysis. Subsequently, in any model that analyzes the within-state changes in fatality rates over time, we should be able to detect whether these programs reduced fatalities.

The models presented here also include controls for state-specific macroeconomic trends (unemployment rate, real state personal income per capita). Prior evidence (e.g., Evans and Graham 1988) has indicated that traffic fatalities are procyclic, possibly reflecting the increased risk associated with road congestion as well as the associated variation in patterns of alcohol use and drunk driving. To control for changes in safety that are common to all states (e.g., the crashworthiness of cars, declining drinking and driving owing to nonlegislative factors), we also include in all models a set of year effects.

Certain state policies that are omitted from these evaluations also deserve special mention. For example, several states require driver education as a condition for getting a license. Unfortunately, the available evidence (NHTSA 1994) suggests that these programs are not effective. However, a number of recent studies have emphasized the possible traffic-safety benefits of "graduated-licensing" systems for beginning drivers.[23] Such regula-

23. Foss and Evenson (1999) review the evaluation results from graduated-licensing systems in New Zealand and related studies on curfew restrictions and conclude that graduated licensing is likely to be successful.

tions require that new drivers acquire experience in low-risk settings before moving on to more complex driving environments. These systems vary in their details (e.g., supervision requirements, driving curfews) but generally consist of three distinct stages: a learning period, during which direct supervision is required; an intermediate period, which may allow for unsupervised driving in low-risk situations; and full licensure (IIHS 1999). In recent years, these regulations have been widely adopted in the United States. More specifically, since July 1996, twenty-four states have implemented some form of graduated licensing (IIHS 1999). Unfortunately, these experiences are too recent to evaluate with the currently available FARS data.

However, age-specific regulations like driver licensing and MLDAs raise more profound questions about their overall efficacy that have not been extensively explored in the current literature. Alcohol use and driving (while either drunk or sober) are both activities where experiential learning is likely to be important. The relevance of learning by doing to such activities raises the possibility that the lifetime efficacy of MLDAs and licensing-age policies may be attenuated. More specifically, policies that keep young adults away from alcohol and car travel may to some degree simply shift the attendant mortality risks to an older age, where learning by doing occurs. Both Males (1986) and Asch and Levy (1987) present some evidence in support of this view with regard to the MLDA. These studies can be criticized on methodological grounds.[24] Nonetheless, this issue suggests an important direction for future research on MLDAs and driver-licensing policies.

Data and Specifications

The evaluations presented here are based on state-level counts of teen traffic fatalities over the period 1977–97 that were drawn from FARS. In order to evaluate response heterogeneity as well as inform the plausibility of these inferences, ten distinct measures of teen traffic fatalities are employed. These ten measures are based on five different fatality types defined over two age groups: sixteen- to seventeen-year-olds and eighteen- to nineteen-year-olds. The five different fatality types are passenger-vehicle fatalities, total fatalities from nighttime accidents (6:00 P.M. to 5:59 A.M.), total fatalities from daytime accidents (6:00 A.M. to 5:59 P.M.), and total fatalities by gender. The unweighted state-year means for these counts are reported in table 3.8. The daytime measure is particularly useful in this context since it provides the basis for a compelling counterfactual that evaluates the reliability of conventional inferences regarding policies related to alcohol and drunk driving. More specifically, as stated earlier, alcohol involvement in fatal accidents is substantially higher at nighttime

24. For example, the Asch and Levy (1987) study is based on a single cross section of state-level data.

Table 3.8 State-Level Panel Data on Teen Traffic-Fatality Counts, 1977–97 FARS

	Mean		% Obs. ≤ 10 Fatalities		% Obs. ≤ 25 Fatalities	
Fatality Type	16–17	18–19	16–17	18–19	16–17	18–19
Passenger vehicles	46.3	64.0	15.5	9.1	34.9	27.1
Nighttime	29.2	44.1	24.9	16.5	55.9	39.1
Daytime	16.8	19.4	41.2	34.6	77.9	76.3
Male	31.1	47.4	23.8	15.0	54.1	36.5
Female	15.2	16.5	45.1	41.0	84.1	82.3

than during the day. Given this important stylized fact, we would expect the estimated effects of alcohol and drunk-driving policies to be sharply attenuated, if not nonexistent, in models for daytime counts. However, if such policies generate relatively large effects in daytime models, we could conclude that the model is generating specious inferences.[25]

Most reduced-form econometric specifications for panel data on traffic fatalities model the fatality rate denominated by population size or number of miles traveled. However, the evaluations presented here are based on an alternative approach. Specifically, since the fatality counts examined here are constructed relatively finely by age and other observed characteristics, employing a conventional fatality rate could substantially reduce the signal-to-noise ratio. Table 3.8 presents some limited information on the distribution of fatality counts that illustrates the nature of this concern. A substantial fraction of the state-year observations have fewer than ten or twenty-five fatalities in a year. This problem is particularly acute for modeling traffic fatalities among females as well as those that occur during the day. Because of this concern, the evaluation results presented here are based on count-data models that explicitly recognize that all the dependent variables are nonnegative integers. Within this framework, the natural log of the relevant population is treated instead as an additional regressor. However, since the prior literature has emphasized the need to control for unobserved state-specific effects, conventional count-data techniques cannot be employed. More specifically, conventional count-data models do not generate consistent estimates when cross-sectional fixed effects are introduced because of the "incidental-parameter" problem. Therefore, we adopt the conditional-maximum-likelihood approach for negative binomial models, which was developed Hausman, Hall, and Griliches (1984) to study the development of patents in a panel of firms.[26] The estimates

25. The power of this ad hoc counterfactual to identify specification error should not be overdrawn. We may find plausible results in daytime models despite the presence of specification error. And, even when this approach clearly suggests specification error, it provides at best limited guidance as to its nature.

26. The negative binomial model is less restrictive than a Poisson regression since it accommodates the presence of overdispersion in the counts.

generated by these models can be interpreted as the proportionate change in the given fatality count.

Results

The first set of results reported in table 3.9 presents evidence on how mandatory seat-belt laws, MLDAs, a sixty-five-MPH speed limit, and the macroeconomic variables influence passenger-vehicle fatalities. In this table, we report estimates for all fatalities by age and sex groupings. These models are based only on data from the period 1977–92. The sample is truncated in this fashion since nearly all the within-state variation in two key policies (mandatory seat-belt laws and the MLDA) had ended by the early 1990s.

In table 3.9, the estimated coefficients in the first row suggest that a seat-belt law with primary enforcement significantly reduced passenger-vehicle fatalities among sixteen- to seventeen-year-olds by nearly 8 percent and among eighteen- to nineteen-year-olds by almost 10 percent. In general, these effects are smaller in states that had only secondary enforcement for their seat-belt laws and substantially larger among female teens. These estimates are consistent with associated increases in belt use (table 3.7 above) and the technological efficacy of seat belts and suggest that risk-compensating behavior has not dramatically attenuated the lifesaving benefits of these laws. The coefficients on the MLDA variables suggest that a lower MLDA (i.e., easier access to alcohol) was associated with significantly higher counts of traffic fatalities among eighteen- to nineteen-year-olds. Males aged eighteen to nineteen are more affected by the MLDA than are females, which is to be expected given the higher alcohol use among males. These large and statistically significant increases were in most cases plausibly concentrated among nighttime as opposed to daytime fatalities and, interestingly, were also concentrated among male teens. In contrast, the evidence linking the MLDA variation to traffic fatalities among sixteen- to seventeen-year-olds is at best limited.[27] Other results in table 3.9 indicate that the initial movement to sixty-five-MPH speed limits did not significantly influence teen traffic fatalities but that these outcomes do consistently vary inversely with the state unemployment rate.

To provide some estimate of how much of the secular decline in per capita mortality rates can be attributed to these law changes, we conducted a simple simulation. To avoid the incidental-parameters problem, we estimated a conditional maximum-likelihood model in which we conditioned on the total number of deaths in a state over a fixed period of time. Because in our simulation we will want to examine how total fatalities change when regulations are changed, this econometric model does not lend itself well to these types of simulations. Therefore, we reestimated the basic

27. Cook and Tauchen (1984) reported similarly imprecise links between MLDA exposure and traffic fatalities among sixteen- to seventeen-year-olds.

Table 3.9 **Conditional Maximum-Likelihood Estimates of Fixed-Effects Negative Binomial Models for Teen Motor-Vehicle Fatalities, 1977–92 FARS**

		Fatality Counts—Passenger Vehicles					
		All		Male		Female	
Independent Variable	Mean	16–17	18–19	16–17	18–19	16–17	18–19
Mandatory seat-belt law, primary enforcement	.107	−.078	−.096	−.090	−.068	−.058	−.171
		(.031)	(.029)	(.037)	(.032)	(.055)	(.049)
Mandatory seat-belt law, secondary enforcement	.199	−.043	−.070	−.057	−.062	−.020	−.090
		(.029)	(.028)	(.034)	(.031)	(.050)	(.045)
MLDA of 18	.206	−.043	.046	−.049	.056	−.027	.024
		(.027)	(.025)	(.031)	(.028)	(.048)	(.042)
MLDA of 19	.156	.036	.052	.034	.063	.039	.025
		(.026)	(.024)	(.031)	(.027)	(.046)	(.040)
MLDA of 20	.051	.034	.033	−.007	.088	.122	−.147
		(.051)	(.048)	(.059)	(.052)	(.091)	(.087)
65-MPH speed limit	.306	.046	.025	.020	.018	.077	.041
		(.040)	(.036)	(.047)	(.039)	(.069)	(.061)
State unemployment rate	6.67	−.020	−.023	−.024	−.026	−.011	−.011
		(.006)	(.006)	(.007)	(.007)	(.011)	(.010)
Real per capita personal income (00,000)	1.23	−.029	−.272	−.059	−.189	.127	−.149
		(.141)	(.133)	(.166)	(.146)	(.252)	(.227)

Note: Standard errors are reported in parentheses. There are 768 observations in each model (48 states over 16 years). Each model includes state and year fixed effects and the natural log of the population for the given age and/or gender.

models from table 3.9 with a negative binomial maximum-likelihood model, inserting a complete set of dummies. The coefficients on the regulation dummy variables were nearly identical to the results from conditional maximum-likelihood estimations. We use this second set of negative binomial estimates in the simulations. Using these parameter values, we can estimate, for each state and year, the expected number of deaths given the state's observed characteristics and the set of regulations. Summing these predicted values in a given year and dividing by population will produce a predicted estimate of the national fatality rate, which in practice is a very accurate estimate. Next, we reconstruct this estimate for 1992, assuming that the laws present in 1979 never changed, that is, assuming that belt-use laws were never adopted and that those states with an MLDA under twenty-one stayed at these levels through 1992.

Results from this simulation for passenger-vehicle fatalities among eighteen- to nineteen-year-olds are presented in table 3.10. In the first row of the table, we report the actual percentage change in fatalities that we observe between 1979 and 1992. In the next row, we present the predicted change that would have happened had no belt-use laws been adopted. For eighteen- to nineteen-year-olds, without a belt-use law, fatalities would have fallen only 32.6 percent, meaning that ([38.4 − 32.6]/38.4 or) 15 percent of the drop can be attributed to belt-use laws. Had MLDA laws stayed at their 1980 values, the fatalities would have fallen by 36 percent, meaning that MLDA law changes can explain only 6.3 percent of the reduction in fatalities. Finally, the passage of belt-use laws and MLDA hikes can explain only 19.5 percent of the reduction in the fatality rate. The effect of the laws is not necessarily additive since this is a highly nonlinear model.

In table 3.11, we report model estimates for our alcohol-sensitive measure (nighttime fatalities) and daytime fatalities. In these models, we also add the real beer tax as an alcohol-specific intervention. The results presented in this table suggest that, as expected, the effect of MLDAs of eighteen and nineteen is larger in the alcohol-specific regressions compared

Table 3.10 Percentage of Drop in 18–19-Year-Old Passenger-Vehicle-Fatality Rate Explained by State Interventions

	% Change in Fatality Rate, 1979–92	% of Change Explained by Law Changes
Actual change	−38.4	
Predicted change with no adoption of belt-use laws	−32.6	15.0
Predicted change with no increases to an MLDA of 21	−36.0	6.4
Predicted change with no adoption of belt-use laws and no increases to an MLDA of 21	−30.9	19.5

Table 3.11 Conditional Maximum-Likelihood Estimates of Fixed-Effects Negative Binomial Models for Teen Motor-Vehicle Fatalities, 1977–92 FARS

		Passenger-Vehicle Fatalities			
		Nighttime		Daytime	
Independent Variable	Mean	16–17	18–19	16–17	18–19
Mandatory seat-belt law, primary enforcement	.107	−.059 (.038)	−.081 (.034)	−.073 (.049)	−.062 (.047)
Mandatory seat-belt law, secondary enforcement	.199	−.055 (.036)	−.063 (.032)	.015 (.045)	−.037 (.044)
MLDA of 18	.206	.018 (.034)	.113 (.030)	−.078 (.045)	.024 (.044)
MLDA of 19	.156	.034 (.032)	.069 (.028)	.069 (.042)	.071 (.040)
MLDA of 20	.051	.031 (.031)	.046 (.055)	.059 (.082)	.008 (.083)
Real state and federal excise taxes on beer	.519	−.448 (.154)	−.697 (.141)	−.540 (.190)	−.530 (.186)
65-MPH speed limit	.306	−.010 (.048)	−.006 (.041)	.092 (.063)	.002 (.060)
State unemployment rate	6.67	−.010 (.008)	−.012 (.007)	−.030 (.010)	−.044 (.010)
Real per capita personal income (00,000)	1.23	−.038 (.171)	−.292 (.152)	.227 (.226)	.140 (.223)

Note: Standard errors are reported in parentheses. There are 768 observations in each model (48 states over 16 years). Each model includes state and year fixed effects and the natural log of the population for the given age.

to the samples shown in table 3.9 above. This suggests that the daytime/nighttime counterfactual does function properly. The beer-tax results in table 3.11 deserve special mention. Prior studies have documented strong links between beer taxes, abusive teen drinking, and traffic fatalities. The results presented in table 3.11 replicate this reduced-form evidence by implying that increases in beer taxes would significantly reduce the number of teen traffic fatalities. However, several recent studies have suggested that these links may be spurious (e.g., Dee, in press; Mast et al. 1999). In part, this is because the direct links between beer taxes and the prevalence of teen alcohol use have typically been based on cross-sectional identification strategies and are not robust to the inclusion of state fixed effects (Dee 1999). But the reduced-form link between beer taxes and teen traffic fatalities has proved robust even in two-way fixed-effects specifications (e.g., Ruhm 1996). However, there are at least two reasons to be skeptical about the validity of such inferences. One is that the estimated tax effects are implausibly large. For example, the estimated tax elasticity of nighttime traffic fatalities among sixteen- to seventeen-year-olds is roughly -0.23 (i.e., $-.448 \times .519$). However, since beer taxes are only a fraction (roughly 10 percent) of the price of beer, this tax elasticity implies a substantially and implausibly larger price elasticity (roughly −2.3).[28] A second and perhaps more compelling type of evidence of the validity is based on comparing the models of daytime and nighttime fatalities. The estimated tax effects are quite large and statistically significant in the models of daytime fatalities even though the rate of alcohol involvement in these fatalities is just a fraction of what it is at night. One explanation for why beer taxes appear implausibly effective in such models is that these tax variables proxy for the unobserved trends specific to each state. The within-state variation in nominal beer taxes is fairly limited, and the overall time-series profile in real taxes is smoothly declining in most states owing to price inflation.[29] Regardless, a conservative interpretation of this evidence is that we should be substantially less sanguine than most of the prior literature suggests about the possible lifesaving benefits of higher beer taxes. In part, this is because we simply have not had sufficient state-level experiences with such tax changes to allow us to evaluate their effects.

The remaining tables present evaluations of the key drunk-driving policies discussed earlier. These evaluations are based on data from the period 1982–97, when much of the relevant policy variation occurred.[30] These evaluations include regressors defined as the interaction of administrative license revocations with each of the three BAC variables: illegal per se at 0.08 BAC; illegal per se at 0.10 or higher BAC; and zero-tolerance laws. In the absence of these interaction terms, most drunk-driving policies appear ineffective (e.g., Ruhm 1996). However, the recent debate over 0.08 BAC laws has underscored the claim that such laws are effective largely through their interaction with administrative license revocations (GAO 1999).[31] Furthermore, as a practical matter, the sample variation is sometimes defined only for such interactions. In particular, in the case of 0.08 BAC laws, the timing of their adoption was typically quite close to that of a regulation allowing administrative license revocations (Dee, in press). Tables 3.12 and 3.13 present the results of these evaluations for all ten fatality counts. These results suggest that illegal per se laws may generate large reductions in traffic fatalities through their interaction with administrative license revocations. For example, these results imply that the combination of a 0.08

28. Another reason to be skeptical of the implied price elasticity is that not all teen traffic fatalities are alcohol related, implying that the effects of the tax on drunk driving by teens are even larger.

29. The beer-tax estimates are sensitive to including state-specific trends as regressors (e.g., Dee 1999). However, since this often removes much of the available sample variation, the implied sensitivity is not clearly as meaningful as the results of the counterfactual estimations.

30. Nonetheless, the MLDA, seat-belt law, and macroeconomic regressors are also included. The beer-tax variable is omitted.

31. Since 1970, the NHTSA has advocated this sort of "systems approach" to reducing drunk driving, one based on a combination of laws, enforcement, and public education.

Table 3.12 **Conditional Maximum-Likelihood Estimates of Fixed-Effects Negative Binomial Models for Teen Motor-Vehicle Fatalities, 1982–97 FARS**

		Fatality Counts—Passenger Vehicles					
		All		Nighttime		Daytime	
Independent Variable	Mean	16–17	18–19	16–17	18–19	16–17	18–19
Illegal per se at 0.08 BAC	.105	.025	.096	−.032	.118	.119	.103
		(.127)	(.112)	(.162)	(.129)	(.185)	(.181)
× administrative license revocation	.101	.164	−.254	.262	−.278	.006	−.292
		(.152)	(.134)	(.193)	(.158)	(.224)	(.217)
Illegal per se at 0.10 or higher BAC	.753	.030	−.047	−.037	−.054	.167	−.004
		(.040)	(.035)	(.049)	(.039)	(.064)	(.063)
× administrative license revocation	.376	.212	−.133	.233	−.136	.131	−.198
		(.088)	(.078)	(.111)	(.092)	(.135)	(.128)
Zero-tolerance law	.269	−.037	−.016	.001	−.026	−.088	−.004
		(.033)	(.030)	(.042)	(.035)	(.047)	(.049)
× administrative license revocation	.212	−.10	−.069	−.056	−.055	.051	−.104
		(.041)	(.038)	(.053)	(.045)	(.061)	(.061)
Administrative license revocation	.494	−.211	.136	−.196	.129	−.182	.229
		(.091)	(.081)	(.115)	(.096)	(.140)	(.133)
Dram-shop statute or case law	.764	.010	.041	.007	.051	.039	.033
		(.038)	(.035)	(.048)	(.039)	(.058)	(.059)
Mandatory jail time for first DUI offense	.284	−.011	.071	.010	.110	−.036	−.008
		(.038)	(.035)	(.048)	(.040)	(.055)	(.058)
65-MPH speed limit	.526	.031	.005	.033	−.021	.013	.061
		(.036)	(.032)	(.045)	(.037)	(.055)	(.055)
70+-MPH speed limit	.061	.135	.039	.106	−.008	.160	.134
		(.060)	(.056)	(.077)	(.067)	(.087)	(.092)

Note: Standard errors are reported in parentheses. There are 768 observations in each model (48 states over 16 years). Each model includes state and year fixed effects, the natural log of the population for the given age and/or gender, two seat-belt-law variables, three MLDA variables, the state unemployment rate, and the real state personal income per capita.

Table 3.13 **Conditional Maximum-Likelihood Estimates of Fixed-Effects Negative Binomial Models for Teen Motor-Vehicle Fatalities, 1982–97 FARS**

	Fatality Counts—Passenger Vehicles			
	Male		Female	
Independent Variable	16–17	18–19	16–17	18–19
Illegal per se at 0.08 BAC	.050	.050	−.036	.222
	(.156)	(.123)	(.210)	(.195)
× administrative license revocation	.109	−.204	.285	−.412
	(.187)	(.150)	(.252)	(.234)
Illegal per se at 0.10 or higher BAC	.066	−.056	−.039	−.009
	(.048)	(.039)	(.070)	(.064)
× administrative license revocation	.154	−.136	.320	−.181
	(.108)	(.089)	(.148)	(.138)
Zero-tolerance law	−.012	−.031	−.086	.013
	(.040)	(.034)	(.054)	(.052)
× administrative license revocation	−.051	−.105	.065	.030
	(.051)	(.043)	(.067)	(.065)
Administrative license revocation	−.108	.157	−.400	.134
	(.112)	(.092)	(.153)	(.143)
Dram-shop statute or case law	.018	.022	−.012	.096
	(.047)	(.039)	(.064)	(.061)
Mandatory jail time for first DUI offense	.040	.057	−.107	.093
	(.046)	(.039)	(.062)	(.060)
65-MPH speed limit	.012	−.017	.068	.075
	(.044)	(.036)	(.061)	(.058)
70+-MPH speed limit	.107	−.036	.187	.221
	(.075)	(.064)	(.099)	(.097)

Note: Standard errors are reported in parentheses. There are 768 observations in each model (48 states over 16 years). Each model includes state and year fixed effects, the natural log of the population for the given age and/or gender, two seat-belt-law variables, three MLDA variables, the state unemployment rate, and the real state personal income per capita.

BAC law and administrative license revocations reduced passenger-vehicle fatalities among eighteen- to nineteen-year-olds by 25 percent. It should be noted that, although these estimated effects are large, they are only marginally significant. However, these effects are plausibly concentrated in reductions of nighttime and not daytime fatalities. The results reported in table 3.13 also suggest that these interactions were relatively more effective for females than for males. The evidence from tables 3.12 and 3.13 also suggests that zero-tolerance laws were typically ineffective either alone or in concert with administrative license revocations. However, it should be noted that these results may reflect a relative lack of enforcement.[32]

The other results reported in tables 3.12 and 3.13 provide little support

32. GAO (1999) notes that, in California, more underage drivers were prosecuted under that state's 0.08 BAC law than under its zero-tolerance law.

for the hypothesis that either of the other drunk-driving policies (dram-shop case law or statutes, mandatory jail time for DUI offenders) or sixty-five-MPH speed limits had any detectable effects. It is, however, not entirely surprising that the initial movement to a sixty-five-MPH speed limit had no detectable effect among teens since these limits were restricted to rural interstate roads, where such fatalities are rare. Interestingly, these evaluations do suggest that the movement to maximum speed limits above sixty-five MPH did significantly increase counts of some teen traffic fatalities. In particular, these large increases (12–20 percent) were concentrated among the younger (sixteen- to seventeen-year-old) teens and among females.

3.4 Conclusions

Unfortunately for most parents, life begins for many teenagers when they get their driver's license. Teenagers travel upward of ten thousand miles in an automobile per year, many of those behind the wheel as a driver. As we illustrated here, parents have good reason to be alarmed. Driving is an inherently risky activity, and teens' inexperience and risk taking make the problem even worse. Teen fatality rates are two to three times those for adults aged twenty-five and older.

Teens are, on average, more aggressive drivers, are less likely to use safety equipment such as seat belts, and are about as likely to drive drunk as adults—even though no teens can legally drink. It is hard to disentangle whether a high teen fatality rate is due to risk taking or inexperience because both variables change with age. Teen traffic fatalities are, however, more a function of such driver behaviors than are fatalities among other age groups. Teens have a high frequency of accidents where driver error or risk taking is the clear cause, such as single-vehicle crashes and vehicle rollovers. This pattern of potential risk taking is consistent with other behaviors that we see among teens. The teens who do not wear their seat belts or who drive after drinking are those teens who take other health risks, like smoking, drinking, using drugs, and fighting.

The situation has, however, improved considerably over the last twenty years. When denominated by population, teen traffic fatalities have fallen by about 37 percent since 1979. This decline is probably an underestimate of the true improvements in traffic safety since teens are driving much more today than they have in past years. Most of the decline seems to be due to large reductions in alcohol-related fatalities. However, there have also been substantive increases in occupant protection, owing primarily to an increase in belt use and a move to heavier, more crashworthy automobiles.

Even with these important gains, traffic fatalities are still the leading cause of mortality among teens and, by implication, a major concern for health policy. However, there is cause for optimism. The U.S. experience over the past twenty years has clearly demonstrated that traffic safety is one area where government regulations can change important behaviors. For example, the state-specific movement away from MLDAs of eighteen has been associated with a drop in teen occupant fatalities of at least 5 percent. Furthermore, the widespread adoption of mandatory seat-belt laws at the state level has substantially increased belt use among teens, resulting in a 7–10 percent drop in teen occupant fatalities. More aggressive enforcement of seat-belt laws could possibly generate further gains. Additionally, these results suggest that drunk-driving policies like administrative license revocations may work in tandem with illegal per se laws that establish explicit BAC limits to reduce alcohol-related fatalities among teens. However, there is one possible and largely unexplored caveat to this evidence of the lifesaving benefits of certain government regulations. These benefits may be somewhat attenuated over the life cycle if traffic-safety policies simply shift to older teens and young adults the experiential learning that occurs in risky settings. These benefits may also be somewhat limited because teens who take driving risks are substantially more likely to be risk takers in other contexts as well.

References

Asch, P., and D. T. Levy. 1987. Does the minimum drinking age affect traffic fatalities? *Journal of Policy Analysis and Management* 6, no. 2:180–92.

Berkowitz, M. K., et al. 1990. Disaggregate analysis of the demand for gasoline. *Canadian Journal of Economics* 23, no. 2:253–75.

Campbell, B. J., and F. Campbell. 1988. Injury reduction and belt use associated with occupant restraint laws. In *Preventing automobile injury: New findings from evaluation research,* ed. J. D. Graham. Dover, Mass.: Auburn House.

Centers for Disease Control (CDC). 1998. *Behavioral risk factor surveillance system's user guide.* Atlanta: U.S. Department of Health and Human Services.

Chaloupka, F. J., et al. 1993. Alcohol-control policies and motor-vehicle fatalities. *Journal of Legal Studies* 22, no. 1:161–86.

Cook, P. J., and G. Tauchen. 1984. The effect of minimum drinking age legislation on youthful auto fatalities, 1970–1977. *Journal of Legal Studies* 13:169–90.

Dee, T. S. 1998. Reconsidering the effects of seat belt laws and their enforcement status. *Accident Analysis and Prevention* 30, no. 1:1–10.

———. 1999. State alcohol policies, teen drinking, and traffic fatalities. *Journal of Public Economics* 72, no. 2:289–315.

———. In press. Does setting limits save lives? The case of 0.08 BAC laws. *Journal of Policy Analysis and Management.*

DeJong, W., and R. Hingson. 1998. Strategies to reduce driving under the influence of alcohol. *Annual Review of Public Health* 19:359–78.

Evans, L. 1986. The effectiveness of safety belts in preventing fatalities. *Accident Analysis and Prevention* 18, no. 3:229–41.

———. 1991. *Traffic safety and the driver.* New York: Van Nostrand Reinhold.
Evans, W. N., and J. D. Graham. 1988. Traffic safety and the business cycle. *Alcohol, Drugs, and Driving* 4, no. 1:31–38.
———. 1991. Risk reduction or risk compensation? The case of mandatory safety-belt use laws. *Journal of Risk and Uncertainty* 4, no. 1:61–73.
Evans, W. N., et al. 1991. General deterrence of drunk driving: Evaluation of recent American policies. *Risk Analysis* 11, no. 2:279–89.
Farmer, C. M., et al. 1999. Changes in motor vehicle occupant fatalities after repeal of the national maximum speed limit. *Accident Analysis and Prevention* 31, no. 5:537–43.
Foss, R. D., and K. R. Evenson. 1999. Effectiveness of graduated driver licensing in reducing motor vehicle crashes. *American Journal of Preventive Medicine* 16, no. 18:47–56.
Gabler, H. C., and W. T. Hollowell. 1998. The aggressivity of light trucks and vans in traffic crashes. Paper no. 980908. Warrendale: Society of Automotive Engineers, February. Paper available at http://www-nrd.nhtsa.dot.gov/include/nrd10/aggressivity/documents/980908/980908.htm.
General Accounting Office (GAO). 1999. Highway safety: Effectiveness of state .08 blood alcohol laws. Washington, D.C.
Hausman, J., B. H. Hall, and Z. Griliches. 1984. Econometric models for count data with an application to the patents-R&D relationship. *Econometrica* 52, no. 4:909–38.
Hingson, R. 1996. Prevention of drinking and driving. *Alcohol Health and Research World* 20, no. 4:219–26.
Hingson, R., S. Moelock Levenson, T. Heeren, T. Nagione, C. Rodgers, T. Schiavone, and R. P. Hertz. 1988. Repeal of the Massachusetts seat belt law. *American Journal of Public Health* 78, no. 5:548–52.
Horne, J., and L. Reyner. 1995. Sleep related vehicle accidents. *British Medical Journal* 310, no. 6979:565–67.
Insurance Institute for Highway Safety (IIHS). 1999. *Graduated licensing: A blueprint for North America.* Arlington, Va.
Joksch, H., D. Massie, R. Pichler. 1998. *Vehicle aggressivity: Fleet characteristics using traffic collision data.* Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.
Kahane, C. J. 1997. Relationships between vehicle size and fatality risk in model year 1985–93 passenger cars and light trucks. Report no. DOT HS 808 570. Washington, D.C.: National Highway and Traffic Safety Administration, January.
Lave, C., and P. Elias. 1994. Did the 65-MPH speed limit save lives? *Accident Analysis and Prevention* 26, no. 1:49–62.
Levitt, S. D., and J. Porter. 1999a. Estimating the effect of alcohol on driver risk using only fatal accident statistics. Working Paper no. 6944. Cambridge, Mass.: National Bureau of Economic Research.
———. 1999b. Sample selection in the estimation of air bags and seat belt effectiveness. Working Paper no. 7210. Cambridge, Mass.: National Bureau of Economic Research.
Males, M. A. 1986. The minimum purchase age for alcohol and young-driver fatal crashes: A long-term view. *Journal of Legal Studies* 15:181–211.
Mast, B. D., et al. 1999. Beer taxation and alcohol-related traffic fatalities. *Southern Economic Journal* 66, no. 2:214–49.
McGuckin, N., and E. Murakami. 1999. Examining trip-chaining behavior: A comparison of travel by men and women. Washington, D.C.: Federal Highway Administration, U.S. Department of Transportation.

Mullins, R. J., and N. C. Mann. 1999. Population-based research assessing the effectiveness of trauma systems. *Journal of Trauma* 47, no. 3, suppl.:559–566.

Nathans, A. B., G. J. Jurkovich, F. P. Rivara, and R. V. Maier. 2000. Effectiveness of state trauma systems in reducing injury-related mortality: A national evaluation. *Journal of Trauma* 48, no. 1:25–30.

National Highway Traffic Safety Administration (NHTSA). 1984. *Regulatory impact analysis of FMVSS 208: Occupant crash protection.* Washington, D.C.: U.S. Department of Transportation.

———. 1989. *Restraint usage in the traffic population: 1988 report.* Washington, D.C.: U.S. Department of Transportation.

———. 1994. *Research agenda for an improved novice driver education program.* Washington, D.C.: U.S. Department of Transportation.

———. 1999a. *Observed belt use in 1998.* Washington, D.C.: U.S. Department of Transportation.

———. 1999b. *Traffic safety facts, 1998.* Washington, D.C.: U.S. Department of Transportation.

Pack, A., et al. 1995. Characteristics of crashes attributed to the driver having fallen asleep. *Accident Analysis and Prevention* 27, no. 6:769–75.

Peltzman, S. 1975. The effects of automobile safety regulation. *Journal of Political Economy* 83, no. 4 (August): 677–726.

Ruhm, C. J. 1996. Alcohol policies and highway vehicle fatalities. *Journal of Health Economics* 14, no. 5:583–603.

Spain, D. 1997. Societal trends: The aging baby boom and women's increased independence. Washington, D.C.: Federal Highway Administration, U.S. Department of Transportation.

Walls, M. A., A. J. Krupnick, and H. C. Hood. 1993. Estimating the demands for vehicle-miles-traveled using household survey data: Results from the 1990 Nationwide Personal Transportation Survey. Discussion Paper no. ENR93-25. Washington, D.C.: Resources for the Future, Energy and Natural Resources Division.

Zador, P. L. 1991. Alcohol-related relative risk of fatal driver injuries in relation to driver age and sex. *Journal of Studies on Alcohol* 52, no. 4:302–10.

Zador, P. L., et al. 1989. Fatal crash involvement and laws against alcohol-impaired driving. *Journal of Public Health Policy* 10, no. 4:467–84.