

Technical Report Documentation Page

1. Report No. UMTRI-86-40	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Effectiveness of Michigan's Mandatory Child Restraint Law: Three Year Follow-Up		5. Report Date August 1986	6. Performing Organization Code UMTRI-86-40
		8. Performing Organization Report No.	
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9. Performing Organization Name and Address The University of Michigan Transportation Research Institute Ann Arbor, Michigan 48109-2150		11. Contract or Grant No. MDE-86-010A	
		13. Type of Report and Period Covered Final: 01/01/86 to 09/30/86	
12. Sponsoring Agency Name and Address Michigan Office of Highway Safety Planning 111 South Capitol Avenue Lansing, Michigan 48913		14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract On April 1, 1982, Michigan implemented a law mandating the use of child restraint devices for children under age 4 traveling in automobiles. This study measured the effects of that law on restraint use and injury rates among young children. Major dimensions of the study design include: (1) examination of multiple comparison age groups; (2) controls for exposure to risk of crash injury through analyses of injury rates based on population, number of crashed vehicles, and vehicle miles traveled; and (3) controls for longitudinal patterns in injury rates using Box-Jenkins intervention models. Data on all police-reported crash-involved motorists in Michigan between January 1978 and December 1984 were examined. Major findings for the 33-month post-law period include: <ul style="list-style-type: none"> • 307% increase in proportion of crash-involved children restrained; • 27.4% reduction in the number of children injured in traffic crashes; • 26.6% reduction in the rate of injured children per million population; • 27.5% reduction in the rate of occupants injured per crashed vehicle; • 26.4% reduction in the rate of children injured per vehicle mile traveled; • 29.1% reduction in the number of children injured as a percent of injured occupants of all ages. These injury reductions were largely due to declines in moderate injuries; severe injuries did not decline significantly after the child restraint law was implemented.			
17. Key Words Motor-vehicle crashes, injuries, occupant restraint, mandatory child restraint laws, time-series analysis		18. Distribution Statement Unlimited	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 88	22. Price

This report was prepared in cooperation with the Michigan Office of Highway Safety Planning and the U.S. Department of Transportation, National Highway Traffic Safety Administration. Support of these organizations is gratefully acknowledged.

Findings, conclusions, and recommendations in this report are solely the authors' and do not necessarily reflect the views of the Michigan Office of Highway Safety Planning, the National Highway Traffic Safety Administration, or The University of Michigan Transportation Research Institute.

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Acknowledgments

Assistance of Charles P. Compton with data file management is gratefully acknowledged.

1 INTRODUCTION

On April 1, 1982, Michigan implemented a law requiring use of child safety seats or seatbelts for motor-vehicle occupants under the age of 4. An initial evaluation of the effects of that law on numbers of young children injured in motor-vehicle crashes in its first nine months was completed in 1984 (Wagenaar, 1984a). Results revealed significant immediate increases in the proportion of children restrained and decreases in number of children injured in traffic crashes. A follow-up study completed in 1985 found that the immediate effects of the law were maintained through December 1983, 21 months after the law first took effect (Wagenaar and Webster, 1985). Results indicated that the law was followed by a 25% decrease in number of young children injured. The current study updates the results with data through December 1984, 33 months after the child restraint law first took effect.

1.1 Recent Additions to the Literature

Recent studies of the effectiveness of child passenger restraint laws that were not included in the two previous reports in this series (Wagenaar, 1984a; Wagenaar and Webster, 1985) are briefly reviewed here.

Agran, Dunkle, and Winn (1986) examined the impact of California's Child Passenger Protection Act by analysis of the injuries of children taken to hospital emergency rooms. California's law, effective in 1983, required children under 4 years of age to be restrained. Two years of pre-law data (1981-82) were compared with two years of post-law data (1983-84). Children over 4 years old were used as the control population. For those covered by the law (under age 4) restraint use increased from 26% in the pre-law years to 50% in the post-law years. In addition, the proportion of children under age 4 determined to be medically **uninjured** after being seen in the emergency room increased from 30% in the pre-law period to 42% in the post-law period. There was no significant change from pre-law to post-law periods in the total number of those under age 4 severely or critically injured, although head injuries were down significantly by 16%. Utilization of hospital emergency rooms for children under age 4 in noncrash automobile-related injuries (e.g., sudden stops, swerves, loss of balance, falling out of the vehicle) decreased significantly from 17% to only 7% after the child protection law became effective.

New York State's Mandatory Occupant Restraint Law was implemented December 1, 1984 with full enforcement beginning January 1, 1985. The law expanded mandatory restraint to all front-seat occupants and to all children under 10 years of age, regardless of seating position. Earlier legislation had required only children under 7 years of age to be restrained. Rood and Kraichy (1986) conducted observational surveys of restraint use by children under 10 years of age in October 1984, before the law took effect; in April 1985, four months after the law took effect; and in September 1985, nine months after implementation. Results indicated 42% of all children under age 10 were wearing safety restraints in the pre-law period, 61% were restrained

in the first post-law wave, and 57% were restrained during the second post-law survey wave. Restraint use was highest in all three surveys for children 3 years of age and under; this group increased from 71% in the pre-law period to 82% in the first post-law survey; use remained at 82% during the second post-law wave. The use rate for children 4-6 years old was 27% before the new law, 54% in the first post-law survey, and 46% by the second post-law survey. The pre-law rate for children 8-9 years of age was 20%, rising to 48% in the first post-law wave and then declining to 34% by the second post-law survey.

The North Carolina Child Passenger Protection Law requires children under 2 years of age traveling with their parents to be restrained. Children under age 1 must be in a child safety seat, those between 1 and 2 in a safety seat or seatbelt. According to data analyzed by Hall (1985), restraint use among crash-involved children under age 2 increased from 30% just prior to the effective date of the law (July 1, 1982) to 70% at the end of 1984. Following implementation of the law, restrained children were 88% less likely to be killed and 56% less likely to be seriously injured than before the law. An estimated 55 serious injuries were prevented and 22 lives were saved in the first 29 months following implementation. Although not covered specifically by the new law, 2- and 3-year-old children increased their restraint use from 12% before the law to 37% in November 1984. Older children, however, did not benefit from the Child Protection Law. During 1984, use among 0-1 year olds covered by the law was 60%, but only 34% for 2-3 year olds. Furthermore, the use rate was only 21% among 4-5 year olds and 15% among 6-12 year olds.

Decker and others (1984) examined overall child restraint use rates and child crash involvement data for the years 1978-83 and more detailed data for 1982-83, the fifth and sixth years following the implementation of the Tennessee Child Passenger Protection Act. The Act requires use of child restraint devices for children younger than 4 years. From 1978 to 1983 the use of child restraint devices rose from 8% to 30% and the number of deaths among children younger than 4 years declined more than 50%. Data presented suggests that a strong negative correlation exists between the number of citations issued for noncompliance and the number of fatalities occurring over the six years since the law went into effect.

Using results from direct observation surveys, Hatfield and others (1986) compared restraint use before the Texas child passenger safety law (1984) with data after the law (1985) for 11 cities in Texas. The results discussed here apply only to one-child-per-vehicle observations. Over the eleven cities, the proportion of child occupants restrained increased from 24% to 46%, a gain of 92%. Both pre-law and post-law use rates varied considerably from city to city; post-law rates for child occupants ranged from 15.6% in Brownsville to 59.3% in Austin. In the 11 cities, 78% of child restraint devices (CRDs) in use were reportedly used correctly in 1984 whereas only 71% were reportedly used correctly in 1985. The study also compared restraint use at day-care center observation sites to shopping center sites. Pre-law day-care site use was 28%, rising to 48.2% after the law. Shopping center use increased from 22% to 44.7%.

Montague (1984) compared crash data for the year preceding implementation of the Virginia Child Safety Seat Law (1982) with data from the year the law was implemented (1983). The overall population-adjusted casualty rate for persons of all ages killed or injured in enclosed vehicles in Virginia increased 15.7% from 1982 to 1983, while decreasing 16.5% for children

0-4 years of age.¹ Casualty rates adjusted for vehicle miles traveled indicated an increase for all ages of 8.7%, but a reduction of 21.5% for children 0-4 years of age. Restraint use (including both seatbelts and safety seats) among injured children rose from 20% pre-law to 38% post-law, and use of child safety seats increased from 14% to 24%. In addition, more children were riding in rear-seat positions after the law (from 31% in 1982 to 41% in 1983).

Stoke (1985) examined child restraint use data from two surveys, 6 and 18 months following implementation of the Child Safety Seat Law in Virginia on January 1, 1983. In the first post-law survey, 76% of children up to 4 years old in the right-front passenger seat were restrained, while 66.8% of children in other locations were restrained. In the second post-law survey 78.6% of children in right-front passenger seats and 66.7% of children in other seat locations were restrained.

Lowne and others (1984) compared child restraint use in the United Kingdom the year prior to introducing child restraint legislation with the year the law was implemented (1982 versus 1983). The United Kingdom law requires children under 1 year of age to be restrained in an approved safety seat, and those age 1 to 14 to be restrained by an approved safety seat or seatbelt. They found an increase from 25% to 45% in the proportion of infants (under 1 year old) and young children (age 1-4) traveling in rear seats, and an increase in restraint use among infants traveling in the rear seat. There was also a sizable increase (from 12% to 24%) in the proportion of older children (age 10-14) restrained in the front seat. Fatal and serious injuries were down considerably for children age 10-14 traveling in the front seat (from 88 in 1982 to 41 in 1983) while the number of younger children injured was not affected by the law.

Lawless and Siani (1984) reviewed studies of 6 states and 19 cities regarding child restraint use among children affected by child safety seat laws. They found child restraint use rates as high as 47% after compulsory use was implemented. They noted that states and localities with major education programs for the law enforcement community appear to have higher rates of compliance with child restraint laws.

Finally, Wagenaar, Webster, and Maybee (in press) examined the effect of child restraint laws in 11 states on child traffic fatalities. Fatalities from 1976 through 1978 were examined using a time-series design. Statistical power analyses revealed that because of the small number of cases of child fatalities, a reduction of 20% to 25% was required to reach statistical significance. Fatality reductions of that magnitude were not found.

1.2 Summary of Recent Literature

Recent studies published since our earlier reviews of this literature (Wagenaar, 1984a; Wagenaar and Webster, 1985) confirm conclusions based on previous studies. Significant increases in the proportion of young children traveling restrained typically follow implementation of legislation mandating child restraint use. In some areas, the laws have spillover effects in increasing the rate of restraint use among children not specifically covered by

1. The law only covered children under age 4, but due to data availability, analyses were conducted on the 0-4 age group, resulting in an underestimate of the effect of the law.

the laws. However, even with laws requiring use, half or more child occupants still ride unrestrained in many jurisdictions. Finally, studies to date that examined crash injuries and fatalities have not uniformly found reductions associated with the laws. Where effects are found, the size of the estimated effects varies considerably according to jurisdiction studied and methods used.

2 METHODS

This section reviews methods used to measure restraint use and crash-related injury trends in Michigan and to assess the effects of Michigan's mandatory child restraint law. It includes a discussion of the basic design and analytic approach, data collection and processing procedures, and statistical techniques used. The presentation is brief, with extensions and additions from the earlier projects noted. A more detailed discussion of the methods used can be found in Wagenaar (1984a).

2.1 Research Design

There are three basic dimensions of the study design worth noting. First, a monthly **time-series** design was used to control for numerous factors influencing the number of crash injuries reflected in multiyear trends, cycles, or other regularities. The same 51-month baseline as the initial study was used. There were 33 months of post-law data were available, compared to 21 months of post-law data examined in the 1985 report (Wagenaar and Webster, 1985) and only 9 months of post-law data examined in the 1984 report (Wagenaar, 1984a).

Second, **multiple age groups** were used for comparison to increase confidence that observed changes in reported restraint use or injuries were in fact due to the child restraint law, not other coincidental factors. Age-group categories were identical to the 1985 study. It should be noted that in the initial study (Wagenaar, 1984a) infants under age 1 were examined separately from toddlers age 1-3. Because those results indicated limited utility in separate analyses of infants under age 1 (due to the relatively small number of cases), all children covered by the law were analyzed as a single age group in subsequent studies (i.e., age 0-3).

Third, the extended 33-month period of post-law data permitted more sensitive analyses of the **differential effects** of the child restraint law than was possible in previous studies. In addition to analyses of the effects of the law on the number of children injured in various seating positions and in crashed vehicles with varying levels of damage, the legal impact was measured for various areas of the state stratified by population density and poverty level. These analyses were designed to provide information on potential target groups for future efforts to increase restraint use and decrease injuries.

2.2 Data Collection

Information on occupants involved in motor-vehicle crashes used for this project was obtained from the Michigan State Police. Records were available for all traffic crashes that occurred in the State of Michigan and were reported to local or state police agencies. Individual records were developed for each crash, vehicle, and occupant (or pedestrian). Detailed information was available for all crashes, vehicles, and **injured** occupants. However, the only information available for uninjured occupants was whether they were using a restraint at the time

of the crash. Information on age, sex and other characteristics for uninjured occupants other than drivers is not recorded by police officers investigating traffic crashes in Michigan.

The complete data files contain records on approximately three-quarters of a million crash-involved occupants per year. Files for the years 1978 through 1984 were used to calculate the number of crash-involved occupants per month for numerous subgroups of interest. Monthly time-series variables were constructed one year at a time by generating bivariate frequency tables containing the number of occupants stratified by (1) year, (2) month, and (3) a variable or combination of variables of interest (e.g., young injured children in right-front seat positions in a vehicle experiencing extensive damage). The separate monthly time series for each year were combined to produce the 84-month-long time series required for a careful assessment of recent restraint use and injury trends, and evaluation of the effects of Michigan's child restraint law. Specific variables and code values used to construct the time series are summarized here. For a complete description of each variable, see the codebooks for these data (prepared and published by The University of Michigan Transportation Research Institute). Variable numbers and code values corresponding to the 1982 codebook are enclosed in parentheses for easy reference (The University of Michigan Transportation Research Institute, 1983). For example, "V1:1-2" refers to variable number one, code values one and two as documented in the 1982 Michigan codebook.

Cases included in all time series were first filtered to include only passenger cars and light trucks (V104:1-7). These global filters were employed to limit the data analyzed to the target population of recent restraint use efforts. Restraint use by occupants of buses and motor homes, for example, is a separate issue and not the focus of this study. Passengers on farm equipment, construction equipment, or motorcycles are also not subject to the provisions of mandatory restraint use laws. Similarly, Michigan's child restraint law applies only to Michigan residents; therefore, the time series were filtered to include only occupants of vehicles with a driver possessing a Michigan driver license (V151:1-2). Nonresidents were not exposed to the major public information and education efforts that accompanied implementation of the law. This focus on the relevant target group increased the accuracy of the assessment of the effects of recent restraint use efforts.

The following monthly (V2) time-series variables were constructed for the period January 1978 through December 1983:

- A. Total number of crashed vehicles per month for each of eight levels of vehicle damage as measured by the Traffic Accident Damage (TAD) scale (V118).
- B. Total number of injured occupants per month by:
 - (1) ages 0 through 3 (V206:0-3)
 - (2) ages 4 through 15 (V206:4-15)
 - (3) ages 16 through 17 (V206:16-17)
 - (4) ages 18 through 24 (V206:18-24)
 - (5) ages 25 through 34 (V206:25-34)
 - (6) ages 35 through 54 (V206:35-54)
 - (7) ages 55 and over (V206:55-98)
- C. Total number of injured 0-3 year old occupants per month by:

- (1) occupant position front-center (V203:1)
- (2) occupant position front-right (V203:2)
- (3) occupant position rear-left (V203:3)
- (4) occupant position rear-center (V203:4)
- (5) occupant position rear-right (V203:5)
- (6) occupant position other (V203:6-9)

D. Total number of injured occupants per month by age groups in B above and by:

- (1) restraints used (V204:2,5)
- (2) restraints not used (V204:1,3,6)²

E. Total number of injured occupants per month by age groups in B above and by:

- (1) fatal injury severity (V210:1) and minor vehicle damage (V118:1-2)
- (2) incapacitating injury severity (V210:2) and minor vehicle damage (V118:1-2)
- (3) nonincapacitating injury severity (V210:3) and minor vehicle damage (V118:1-2)
- (4) possible injury severity (V210:4) and minor vehicle damage (V118:1-2)
- (5) fatal injury severity (V210:1) and moderate vehicle damage (V118:3-4)
- (6) incapacitating injury severity (V210:2) and moderate vehicle damage (V118:3-4)
- (7) nonincapacitating injury severity (V210:3) and moderate vehicle damage (V118:3-4)
- (8) possible injury severity (V210:4) and moderate vehicle damage (V118:3-4)
- (9) fatal injury severity (V210:1) and severe vehicle damage (V118:5-8)
- (10) incapacitating injury severity (V210:2) and severe vehicle damage (V118:5-8)
- (11) nonincapacitating injury severity (V210:3) and severe vehicle damage (V118:5-8)
- (12) possible injury severity (V210:4) and severe vehicle damage (V118:5-8)³

F. Number of 0-3 year olds injured divided by total estimated vehicle miles traveled (rate of child injuries per billion VMT)

G. Number of injured 0-3 year olds per month by county of crash (V12: 83 Michigan counties).

H. Total number of injured occupants per month by age groups in B above divided by total number of crashed passenger cars and light trucks driven by Michigan residents (rate of injuries per 10,000 crashed vehicles)

I. Total number of injured occupants per month by age groups in B above divided by total number of people in that age group residing in the State of Michigan.

Resident population for Michigan by age for 1978-84 was obtained from the U.S. Bureau of the Census (U.S. Department of Commerce, 1986). Population estimates for

2. Due to a change in the crash report format, restraint use coding from 1975 to 1981 was: (1) restraints used, V204:2,4; (2) restraints not used, V204:1,3,5.

3. The categories of fatal, incapacitating, nonincapacitating, and possible injury correspond to the standard K,A,B,C injury scale used in many police crash reporting systems.

individual ages were not available; ages 0-2 and 3-4 were grouped. To estimate population figures for the 0-3 age group, the number of live births (Michigan Department of Public Health, 1985) four years prior to a given year was subtracted from the sum of age groups 0-2 and 3-4 for that year. 1985 Michigan resident population figures for each age group were derived through extrapolation from trends in the previous seven years. The resulting annual population estimates were then used to linearly interpolate monthly population figures for the entire January 1978 through December 1984 period.

The child injury time series could not be used to assess the effects of the mandatory child restraint law separately for each county because of the small number of cases within each county. However, county-specific time series were grouped for analyses of the impact of the law across areas of varying population density and socioeconomic status.

2.3 Statistical Methods

The number of crash-involved occupants per month was examined for an extended period for each of the categories included in the research design. A long series of observations was required to assess the degree to which restraint use and injury frequencies from 1982 to 1984 (after child restraints became mandatory) were different from the level expected, given regular patterns over the previous 4-year period. Examination of both the raw plots of injuries and the series smoothed with simple 12-month moving averages provided preliminary evidence concerning effects of the legal change. The moving average also revealed whether long-term baseline trends were present in each series. The figures shown in Section 3 include such a moving average trend line, which for any time point equals the average of the actual values for that month, the preceding six months, and the subsequent five months.

The main objective of the analyses was to estimate shifts in each injury and restraint use time series associated with the legal intervention in April 1982. The Box-Jenkins and Box-Tiao (Box and Tiao, 1975; Box and Jenkins, 1976) intervention analysis methods were used to control for long-term trends and seasonal cycles and to estimate such shifts beginning the first month after the law took effect. The methods combine baseline modeling techniques with intervention impact models. The time-series (Auto-Regressive Integrated Moving Average) models are developed iteratively, repeatedly going through cycles of specifying a model, estimating it, and evaluating its adequacy. The Box-Jenkins approach is a versatile time-series modeling strategy that can model a wide variety of trend, seasonal, and other recurring patterns.

On a conceptual level, the analytic strategy involves explaining as much of the variance in restraint use or occupant injuries as possible on the basis of the past history of restraint use or injuries, before attributing any of the variance to another variable, such as passage of a law making restraint use compulsory. Comparative studies have found that, in most cases, the Box-Jenkins methods more accurately account for regularities in time series (as reflected in lower residual error variances) than alternative analytic strategies (Reid, cited in Kendall, 1976; Newbold and Granger, 1974; Vigderhous, 1977). The intervention analysis approach was particularly appropriate for this study, since the objective was to identify significant shifts in restraint use and injury rates associated with the child restraint law,

independent of observed regularities in the history of each variable. Without these methods, incorrect conclusions might be made. For example, a change in injuries might be fully attributed to a specific intervention, when in fact it is entirely consistent with a pre-existing multiyear cycle in injuries. In short, controlling for baseline trends and cycles with time-series models produces more accurate estimates of the effects of restraint-use legislation.

3 RESULTS

Michigan's mandatory child restraint law took effect on April 1, 1982. The law requires children under the age of 4 to be properly restrained in an approved child restraint device. Children age 1 to 3 may be restrained by a conventional adult seatbelt, provided they are traveling in the rear seat. A major public information and education (PI&E) program designed to increase awareness of the new law and increase the rate of proper use of child restraints began in January 1982 (Office of Highway Safety Planning, 1981). Effects of these two distinct interventions, the PI&E efforts only (January-March 1982) and the child restraint law with continuing PI&E efforts (April 1982 to present) were assessed by time-series intervention models. For each outcome measure, four intervention models were developed and tested:

1. Effects of PI&E program occurring January 1 to March 31, 1982, before the child restraint law was implemented;
2. Effects of the child restraint law from April 1, 1982 through December 31, 1983;
3. Effects of the child restraint law from January through December 1984;
4. Aggregate effects of the child restraint law from April 1982 through December 1984.

This report focuses on comparisons of the short-term effects of the law (in 1982 and 1983) with the longer term effects (through 1984). A chart of each outcome measure is shown and results of time-series modeling are summarized in a condensed table. When examining the plots, note that the solid line represents a moving average trend line, which is useful for discerning overall trends. Also note carefully differences in the vertical axis scale across plots. Understanding the scale used is important for discerning the magnitude of discontinuities associated with the child restraint law. All legal impact estimates are based on carefully developed Box-Jenkins time-series models developed for each dependent variable (Box and Jenkins, 1976). All final models met the multiple criteria for model adequacy, such as significant noise model parameters, insignificant residual autocorrelations, and lack of high correlations among the parameters. Estimated intervention effects are summarized here as the percent change of the postintervention period from the levels expected, given baseline patterns. Finally, t-ratios for each impact estimate are provided; a t-ratio smaller than 1.67 indicates that the estimated pre-law to post-law change is not statistically significant at the 0.05 level.

3.1 Effects of the Child Restraint Law on Restraint Use

The rate of restraint use among injured children under 4 years old is depicted in Figure 3.1. Restraint use within this age group increased gradually from 1979 through 1981. Restraint use before the PI&E program and mandatory child restraint law were implemented averaged about 12%. During the January-March 1982 PI&E program, restraint use increased 35.1%. The dramatic increase occurred immediately after the child restraint law took effect, with restraint use

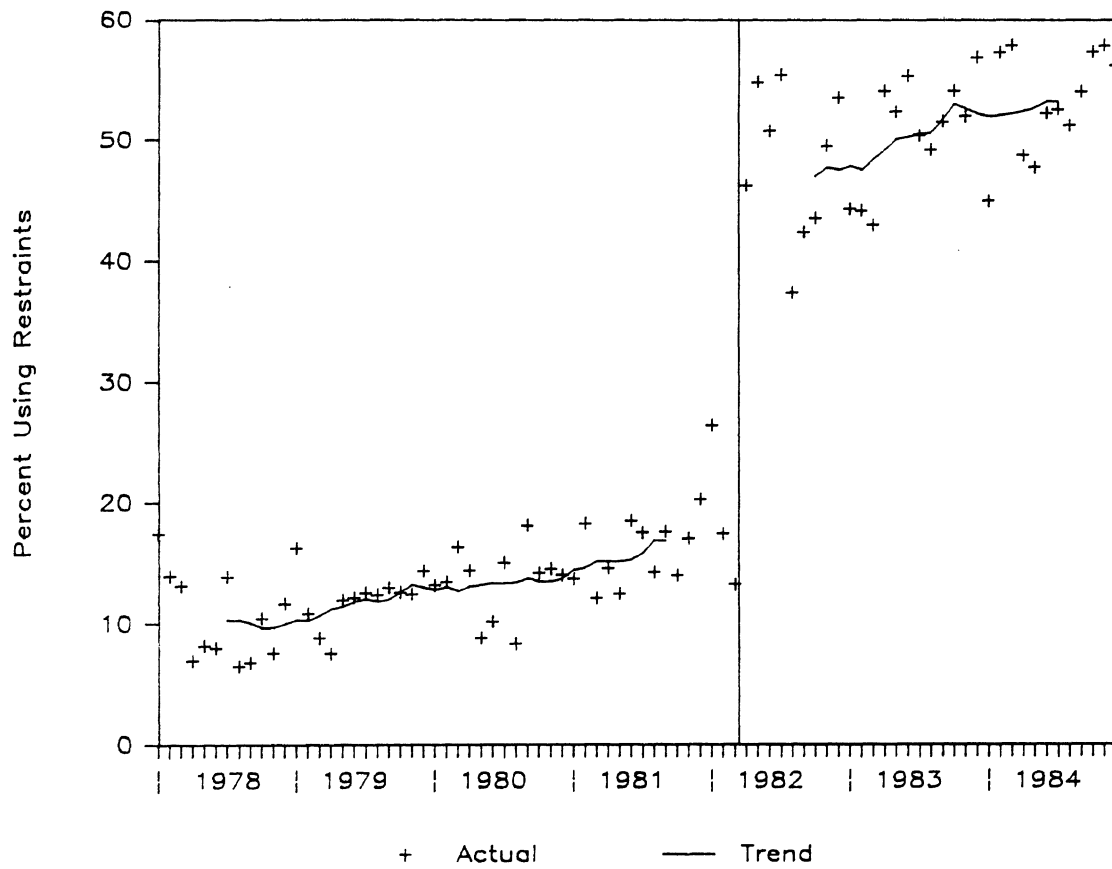


Figure 3.1 Restraint Use Among Injured Occupants Age 0-3

	Percent Change	t-Ratio
Effect of PI & E, January-March 1982	35.1	1.72
Effect of law, April 1982-December 1983*	303.1	14.80
Effect of law, January 1984-December 1984	314.1	12.47
Effect of law, April 1982-December 1984	307.1	16.96

Baseline time-series model: ARIMA (1,0,0) (0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

during the April 1982 to December 1983 period 303% higher than it was during the 1978-81 baseline period. Because restraint use increased slightly in 1984, the estimated effect of the law over the entire 1982-84 period was slightly higher (307%) than the estimated effect for 1982-83 (303%).

Restraint use rates among motor-vehicle occupants of other ages were also examined to identify possible spillover effects of the child restraint law and to ensure that significant increases in restraint use observed among young children were not simply a reflection of other factors influencing motor-vehicle occupants of all ages. From 1978 through 1981, restraint use among occupants age 4 to 15 averaged about 5% to 6%, with little variation from month to month (Figure 3.2). A sharp increase in restraint use can be seen in early 1982 with introduction of the child restraint law. The upward trend continued over the following 33 months. Time-series analyses revealed that the PI&E program was associated with a 58% increase in restraint use (6% to 9%), while implementation of the child restraint law was associated with a 132% increase in restraint use among children age 4 to 15 during April 1982 to December 1983, and a 224% increase during 1984. Restraint use among 4-15 year olds during the entire April 1982 to December 1984 period averaged 162% higher than the 1978-81 baseline period. Even though the rate of increase in this age group appears large, it reflects a much smaller percentage point increase than the under 4 age group (i.e., an increase from 6% to 16% for 4-15 year olds versus an increase from 12% to 53% for 0-3 year olds).

Restraint use among 16-17 year old occupants remained constant between 1978 and 1982, and increased 35% during the April 1982 to December 1983 period (Figure 3.3). In 1984, belt use among 16-17 year olds was 83.5% higher than 1978-81. While these changes are clearly statistically significant, they represent very small absolute changes in restraint use compared to changes observed among 0-3 year olds.

The pattern of restraint use of occupants age 18-24 (Figure 3.4) varies little from that of 16 and 17 year olds. Use rates averaged about 8% from 1978 through 1981, with little variation. A statistically significant 34% increase in belt use occurred in 1982-83, and use in 1984 was 86% higher than in 1978-81. Again, because of the low baseline rate, these increases represent small absolute changes in the rate of restraint use when compared to the changes found among 0-3 year olds.

Belt use among 25-34 year old occupants decreased very slightly between 1978 and 1981, and gradually increased 1982 through 1984 (Figure 3.5). Results of time-series modeling, however, indicated that the increases in belt use during January-March 1982, when the PI&E program was active, and after April 1982, when the child restraint law took effect, were not statistically significant.

The pattern of restraint use for occupants age 35-54 (Figure 3.6) was similar to that for the 25-34 age group. Only in 1984 was the belt-use rate significantly higher than 1978-81. The entire 1982-84 period was not significantly different from the baseline 1978-81 period.

Seatbelt use among crash-involved motorists age 55 and over has increased slightly in recent years (Figure 3.7). Use in 1982-83 was 15% higher than 1978-81, and use in 1984 was

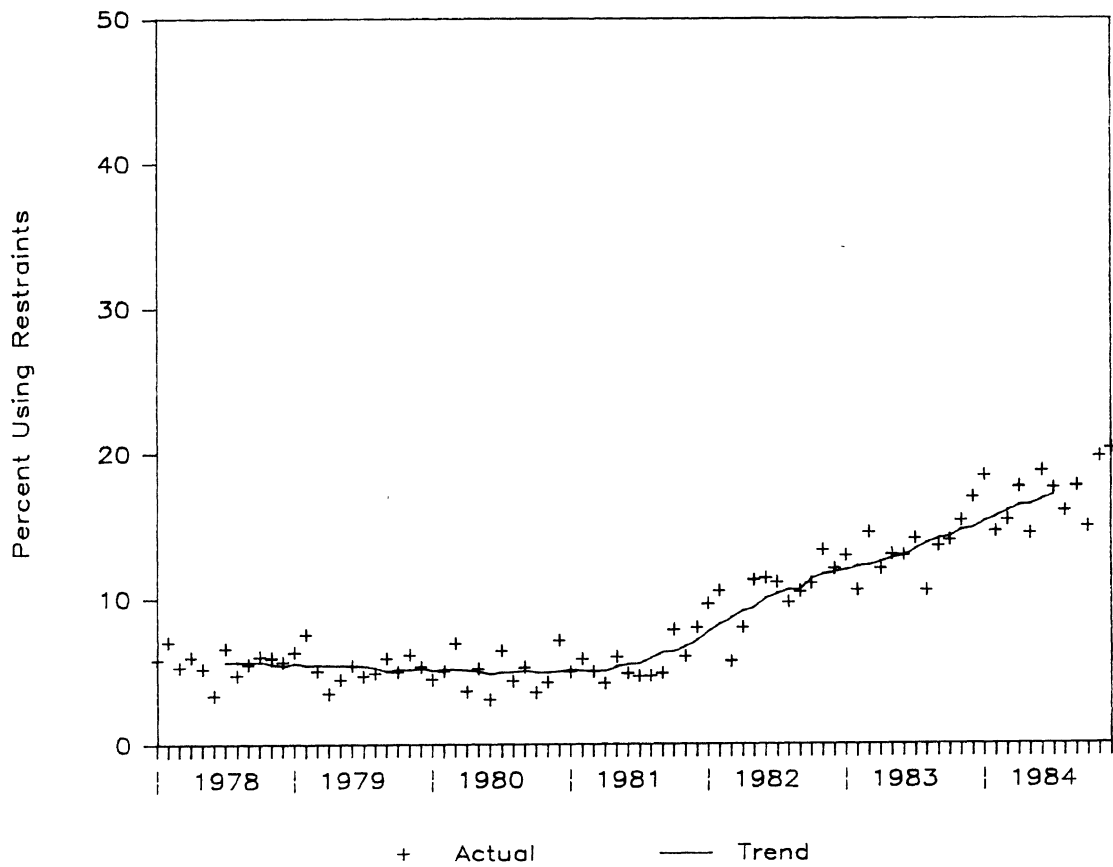


Figure 3.2 Restraint Use Among Injured Occupants Age 4-15

	Percent Change	t-Ratio
Effect of PI & E, January-March 1982	58.2	3.86
Effect of law, April 1982-December 1983*	131.5	16.06
Effect of law, January 1984-December 1984	224.1	18.23
Effect of law, April 1982-December 1984	161.6	19.00

Baseline time-series model: ARIMA (0,0,0) (0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

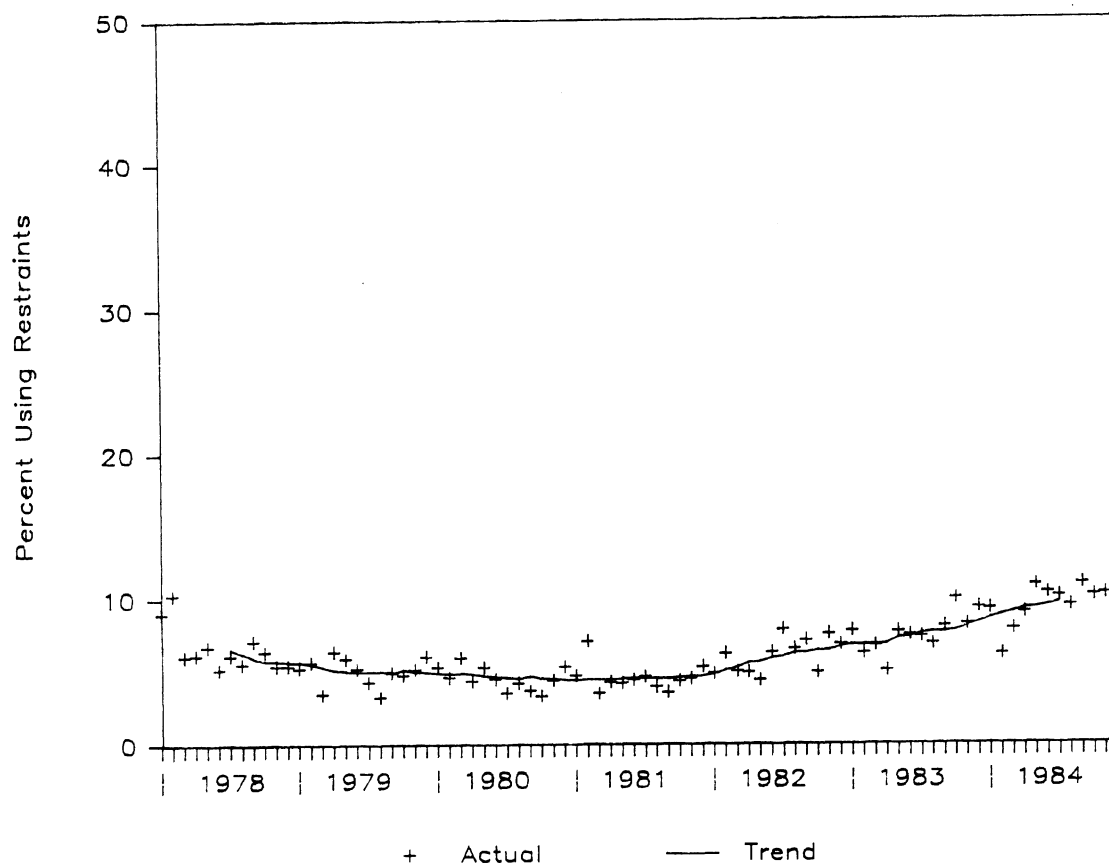


Figure 3.3 Restraint Use Among Injured Occupants Age 16-17

	Percent Change	t-Ratio
Effect of PI & E, January-March 1982	7.6 [†]	0.47
Effect of law, April 1982-December 1983*	34.9	3.31
Effect of law, January 1984-December 1984	83.5	5.57
Effect of law, April 1982-December 1984	48.4	3.91

Baseline time-series model: ARIMA (1,0,0) (0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

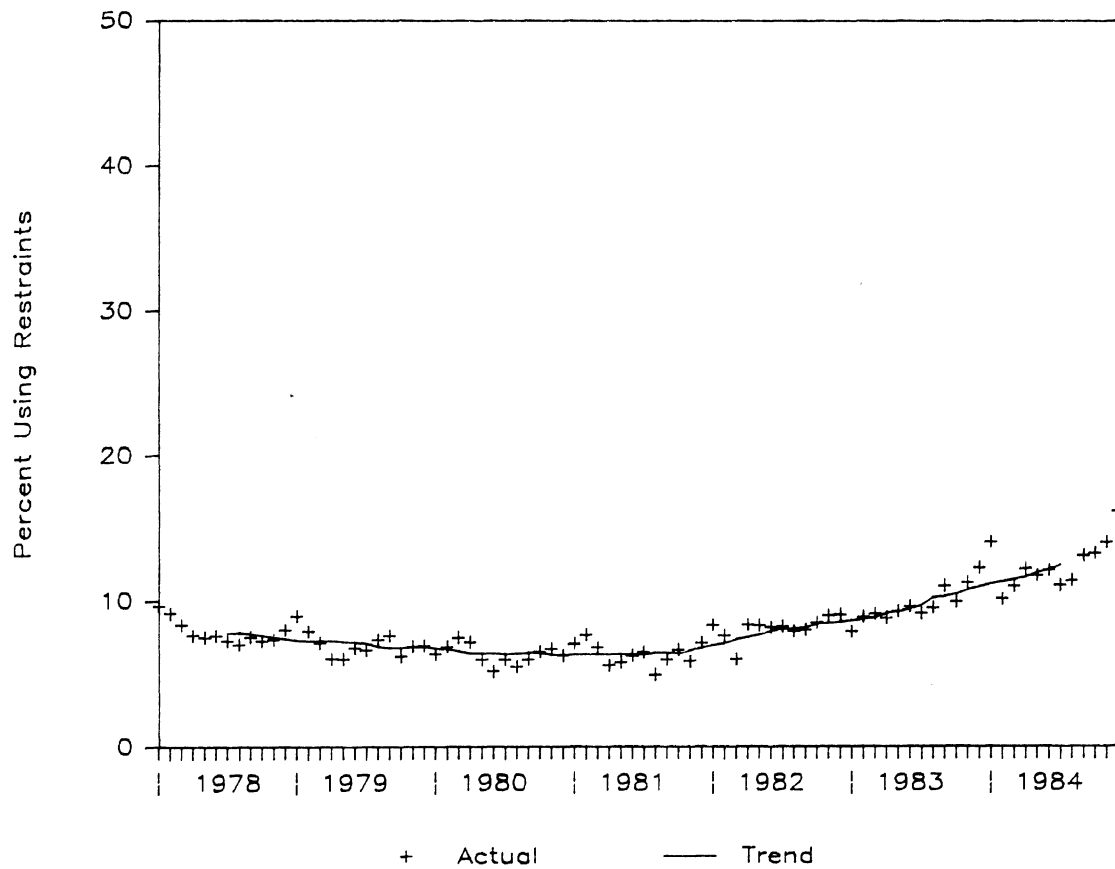


Figure 3.4 Restraint Use Among Injured Occupants Age 18-24

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-4.0 [†]	0.53
Effect of law, April 1982-December 1983 [*]	34.0	5.58
Effect of law, January 1984-December 1984	86.0	9.79
Effect of law, April 1982-December 1984	50.7	7.42

Baseline time-series model: ARIMA (0,0,2) (0,0,0)₁₂

^{*} Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

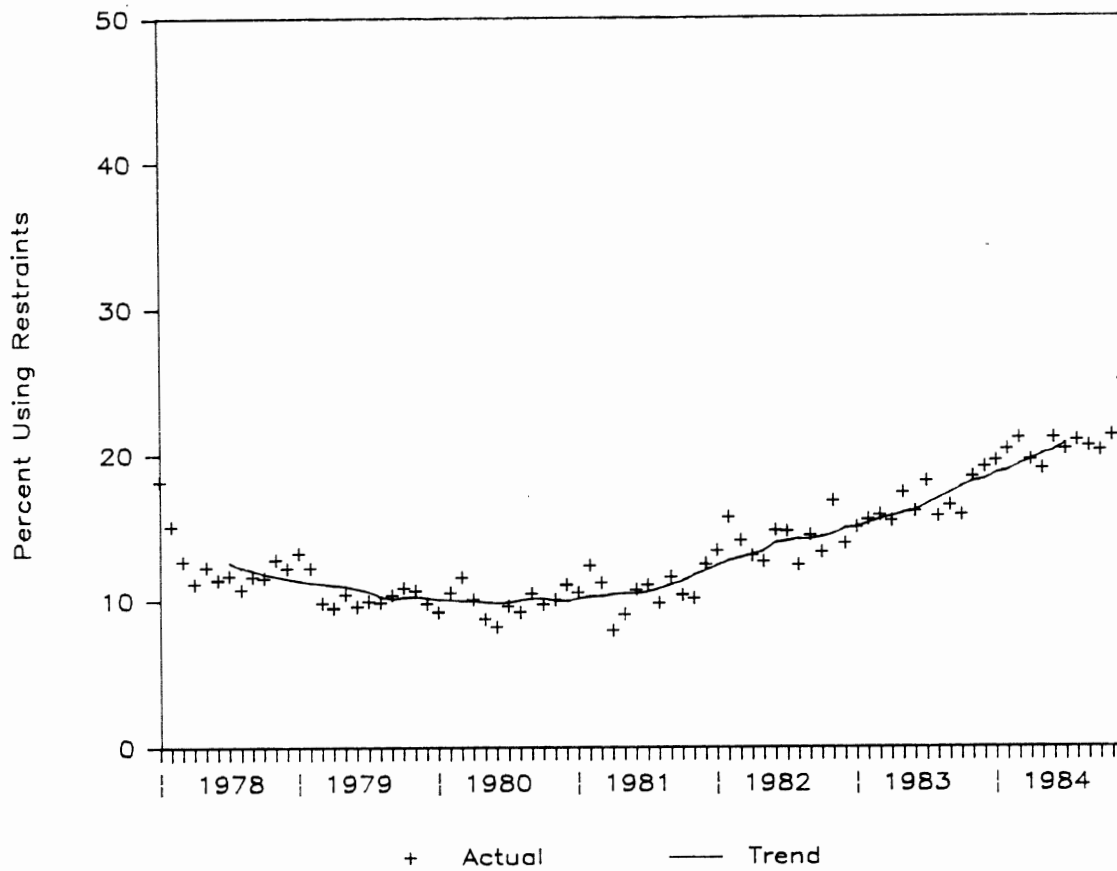


Figure 3.5 Restraint Use Among Injured Occupants Age 25-34

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	5.4 [†]	0.52
Effect of law, April 1982-December 1983*	9.1 [†]	0.60
Effect of law, January 1984-December 1984	8.7 [†]	0.49
Effect of law, April 1982-December 1984	9.0 [†]	0.60

Baseline time-series model: ARIMA (0,1,0) (0,0,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

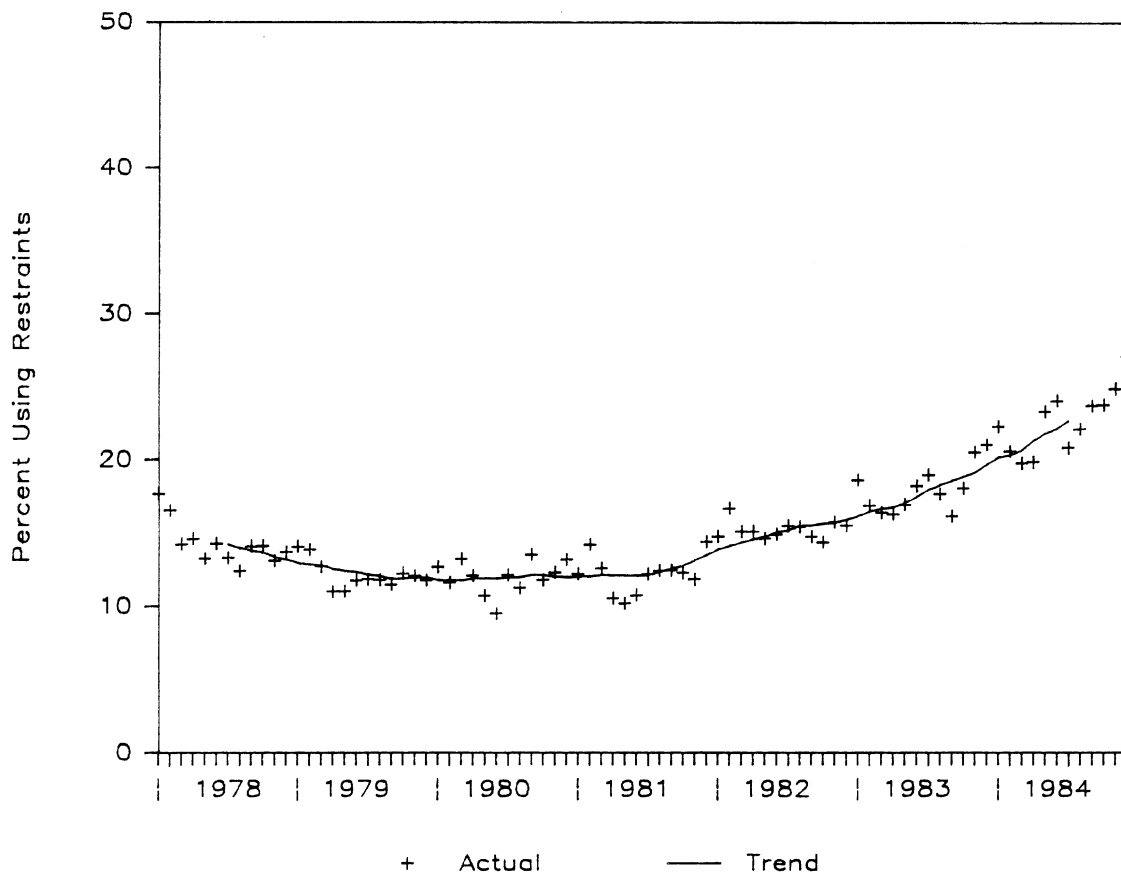


Figure 3.6 Restraint Use Among Injured Occupants Age 35-54

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	12.3 [†]	1.37
Effect of law, April 1982-December 1983*	12.5 [†]	1.19
Effect of law, January 1984-December 1984	25.1	1.72
Effect of law, April 1982-December 1984	10.8 [†]	0.99

Baseline time-series model: ARIMA (0,1,3) (0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

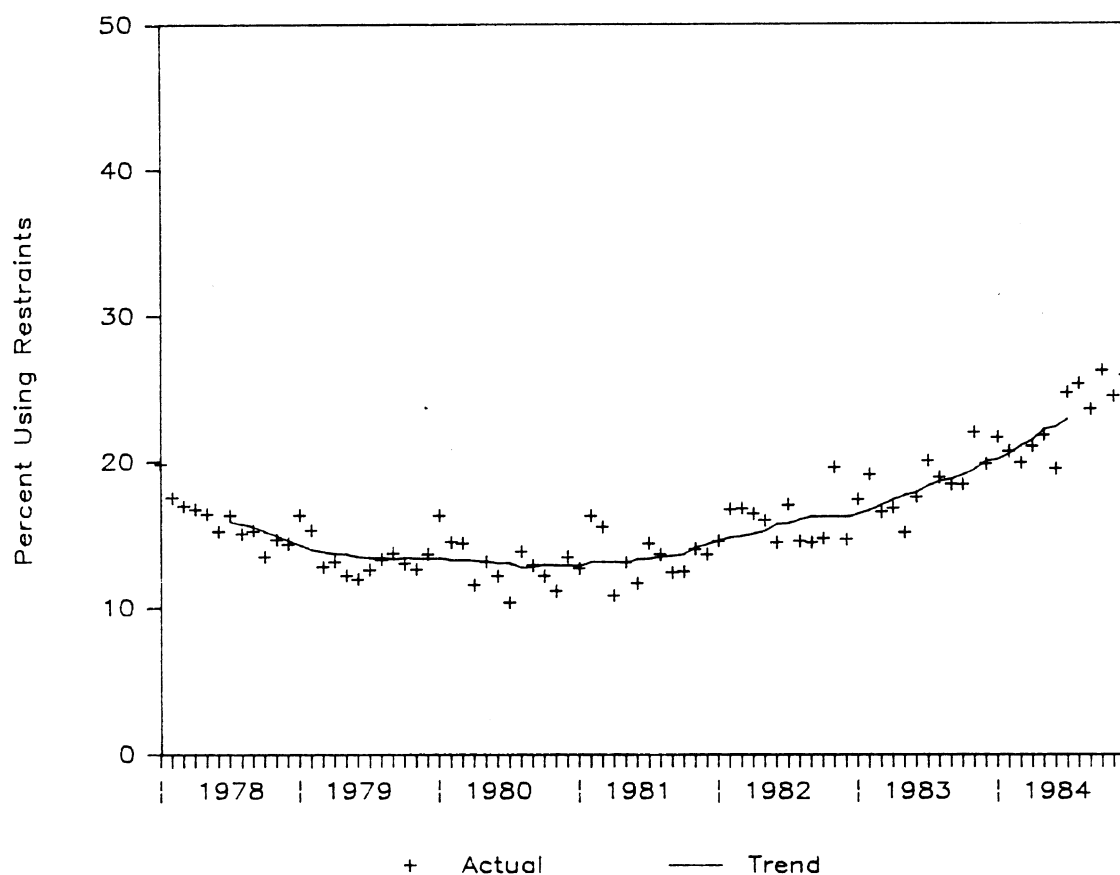


Figure 3.7 Restraint Use Among Injured Occupants Age 55 and Over

	Percent Change	t-Ratio
Effect of PI & E, January-March 1982	8.2 [†]	1.16
Effect of law, April 1982-December 1983*	15.0	1.70
Effect of law, January 1984-December 1984	19.4	1.71
Effect of law, April 1982-December 1984	15.9	1.79

Baseline time-series model: ARIMA (0,1,1) (0,0,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

19.4% higher. While these increases are statistically significant, a 19% increase in a baseline belt-use rate of only 14% means that belt use increased a mere 3 percentage points.

Results presented thus far indicate that the child restraint law and the PI&E program had a positive effect on police-reported child restraint use. There were dramatic increases in reported restraint use among young children, and only small increases in reported belt use among adult motor-vehicle occupants. Furthermore, results indicate that restraint use for most age groups increased in 1984. However, these findings do not clearly establish the beneficial effects of the child restraint law because of questions about the measurement of restraint use. If the use of a restraint is not obvious to a police officer investigating a crash, the officer may rely on the self-report of the drivers involved. One effect of the child restraint law may have been to increase the number of crashed drivers who report that their child was restrained when in fact the child had not been, since reporting that a child under age 4 was not restrained is admitting a violation of law.⁴

Finally, the Michigan police crash-report form was changed in January 1982 to include a separate category for child restraint device use (added to existing belt-use codes). The addition of child seat codes to the form, along with increased education and public information efforts, may have increased awareness of child restraints among police officers, and therefore may have caused an increase in police-reported child seat use, independent of any change in actual use rates. To avoid inferences based only on measurement of restraint use, this study focused on the effects of the law on the ultimate outcome of interest, namely the number of children injured in crashes.

3.2 Effects of the Child Restraint Law on Number of Children Injured

The number of injured crash-involved occupants under age 4 is depicted in Figure 3.8.⁵ The number of children injured in this age group declined from 1978 through the beginning of 1983, but drifted upward in late 1983 and 1984. A similar pattern can be found for occupants in the other age groups (Figures 3.9 through 3.14).

Results of the time-series analyses shown in Figure 3.8 reveal a 24.4% decline (from 180 to 136 per month) in the number of children under age 4 injured in crashes during the PI&E-only period and a 27% decline (from 180 to 131 per month) the first 21 months the child restraint law was implemented. In 1984, the number of 0-3 year old injured occupants was 29.8% lower than would have been expected without the child restraint law. The estimated effect of the law over the entire 33-month post-law period was a 27.4% reduction in child injuries. In short, the estimated effect of the child restraint law on the frequency of children injured in motor-vehicle crashes changed little with the addition of the 1984 data.

4. Such an effect would bias these estimates of restraint use based on crash data upward. Direct observation of restraint use at a probability sample of 240 intersections throughout Michigan in December 1984 found 61% of 0-3 year olds restrained (Wagenaar and Wiviott, 1985), only a few percentage points higher than the 56% rate among crash-involved children. Crash-involved populations typically have lower restraint use rates than the populations of noncrash-involved motorists.

5. All estimates of injury reductions associated with the child restraint law reported here are based on the **number of motor-vehicle occupants injured**. As indicated in Section 2.2, all analyses are based on counts of injured occupants; while many occupants in crashes sustain multiple injuries, each injury was not counted separately.

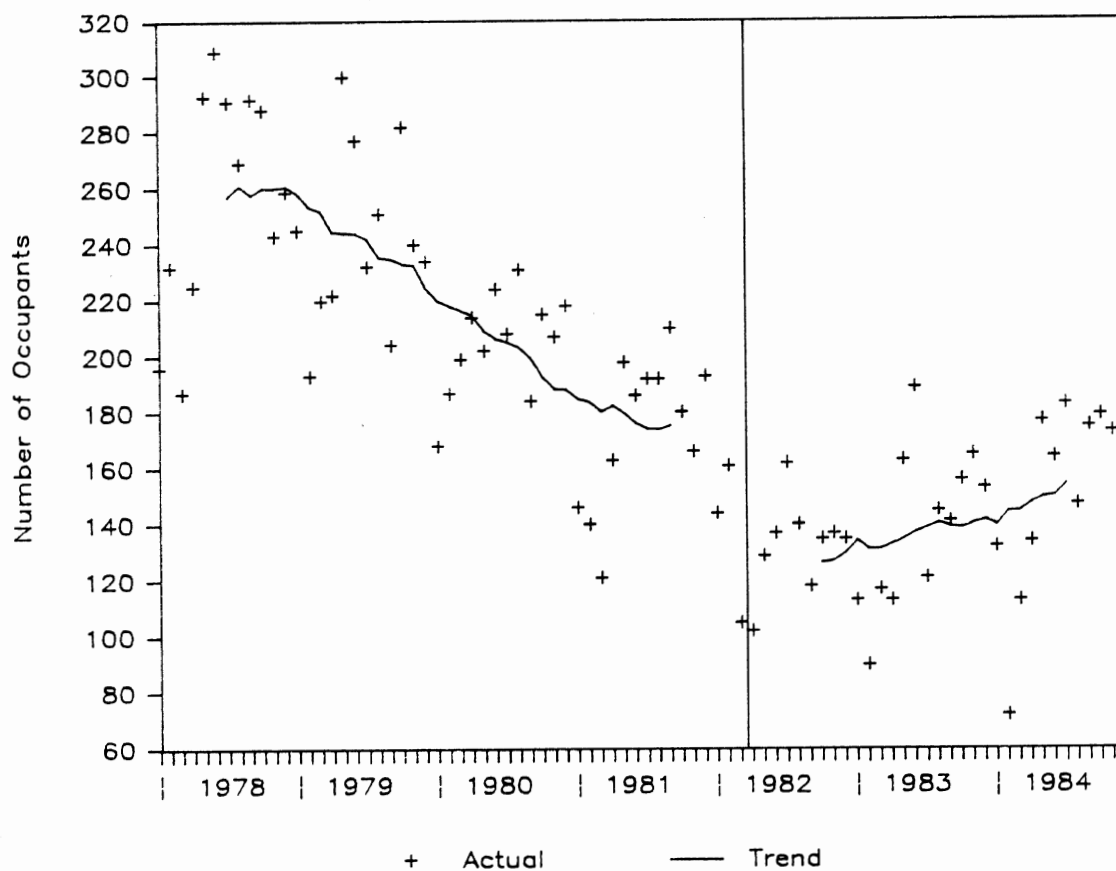


Figure 3.8 Number of Injured Occupants Age 0-3

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-24.4	1.79
Effect of law, April 1982-December 1983*	-27.0	2.11
Effect of law, January 1984-December 1984	-29.8	1.89
Effect of law, April 1982-December 1984	-27.4	2.21

Baseline time-series model: ARIMA (0,1,3) (0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

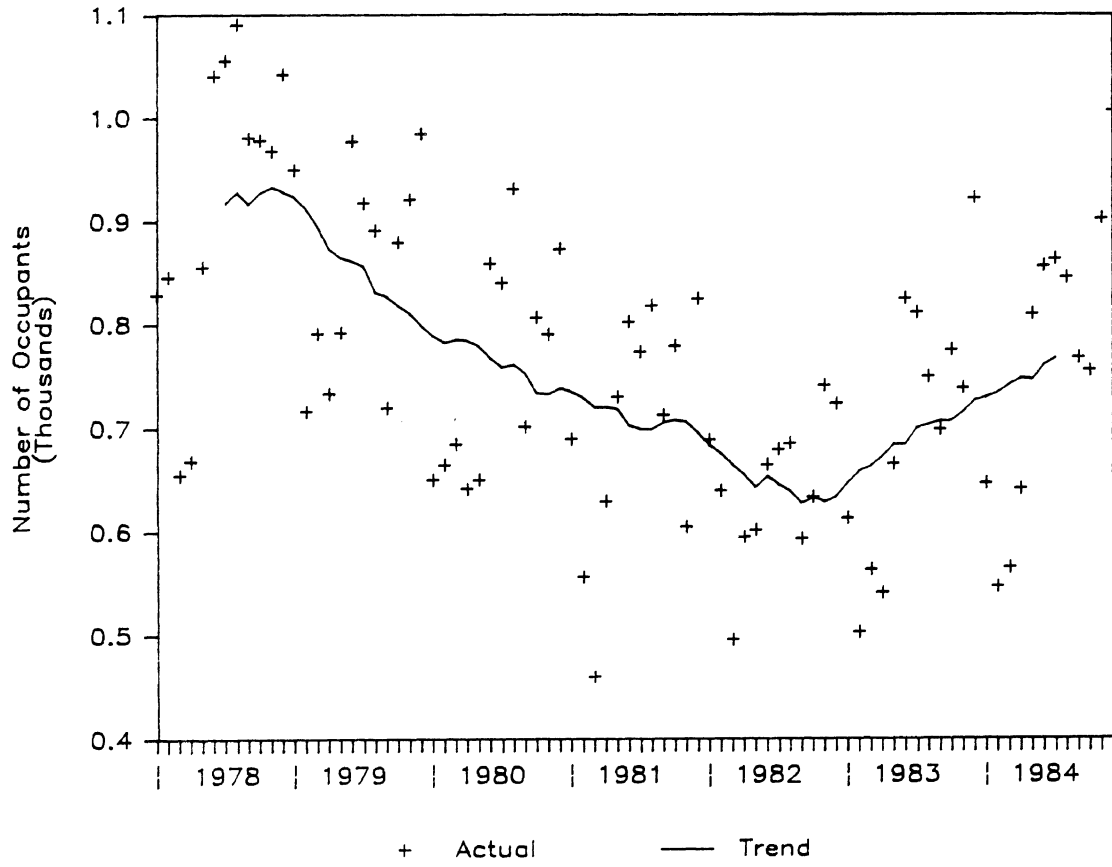


Figure 3.9 Number of Injured Occupants Age 4-15

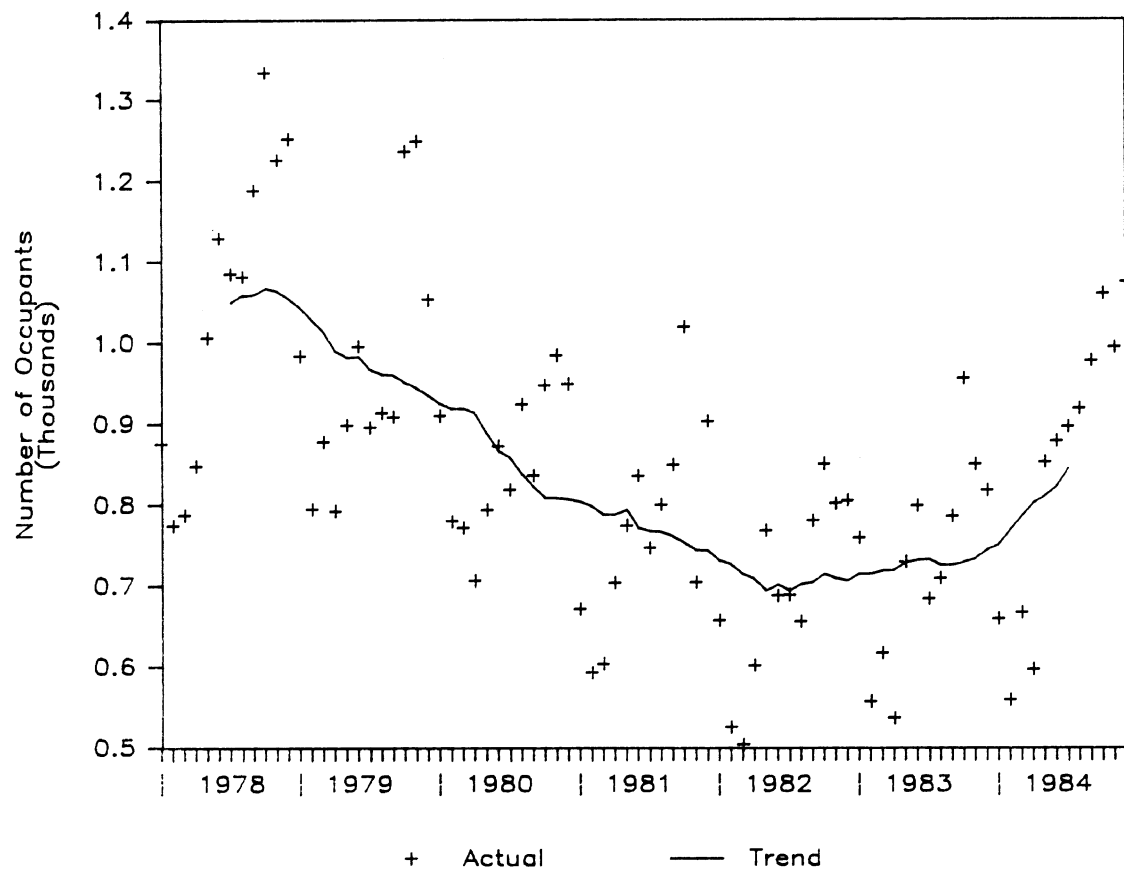


Figure 3.10 Number of Injured Occupants Age 16-17

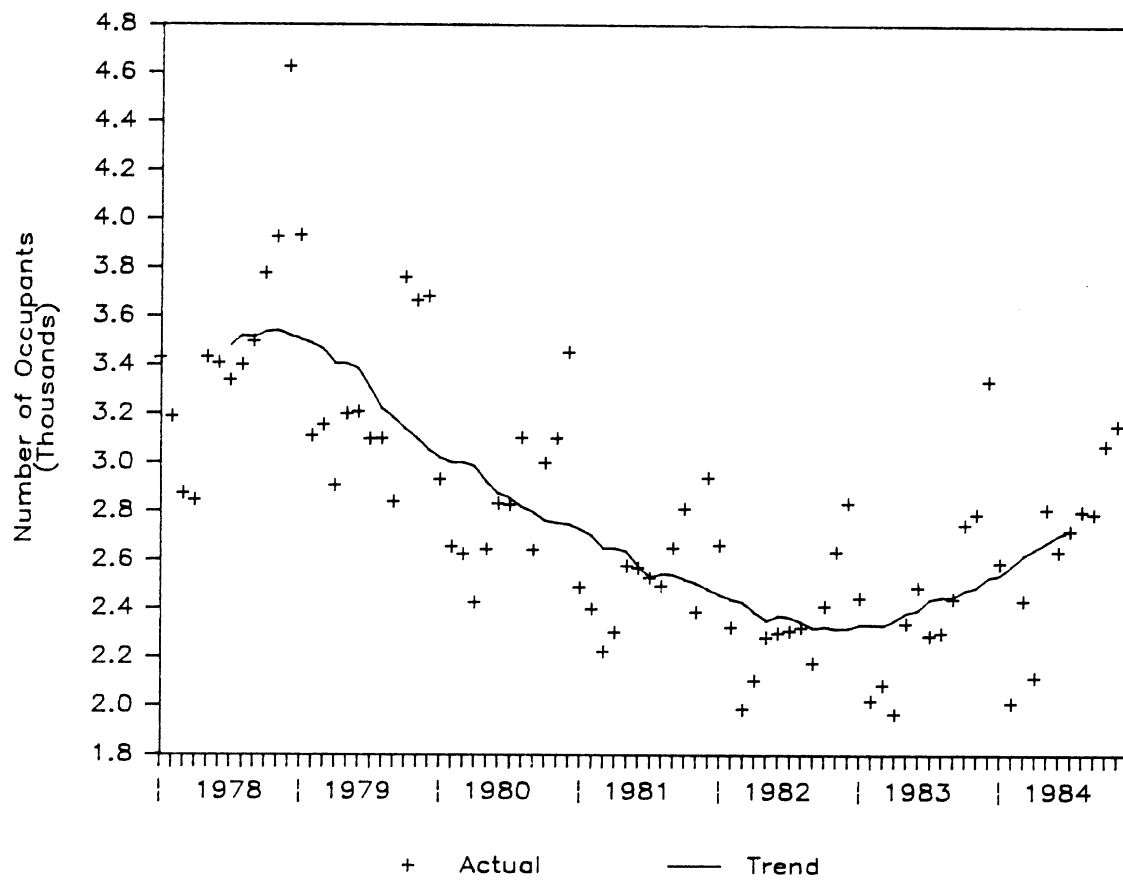


Figure 3.11 Number of Injured Occupants Age 18-24

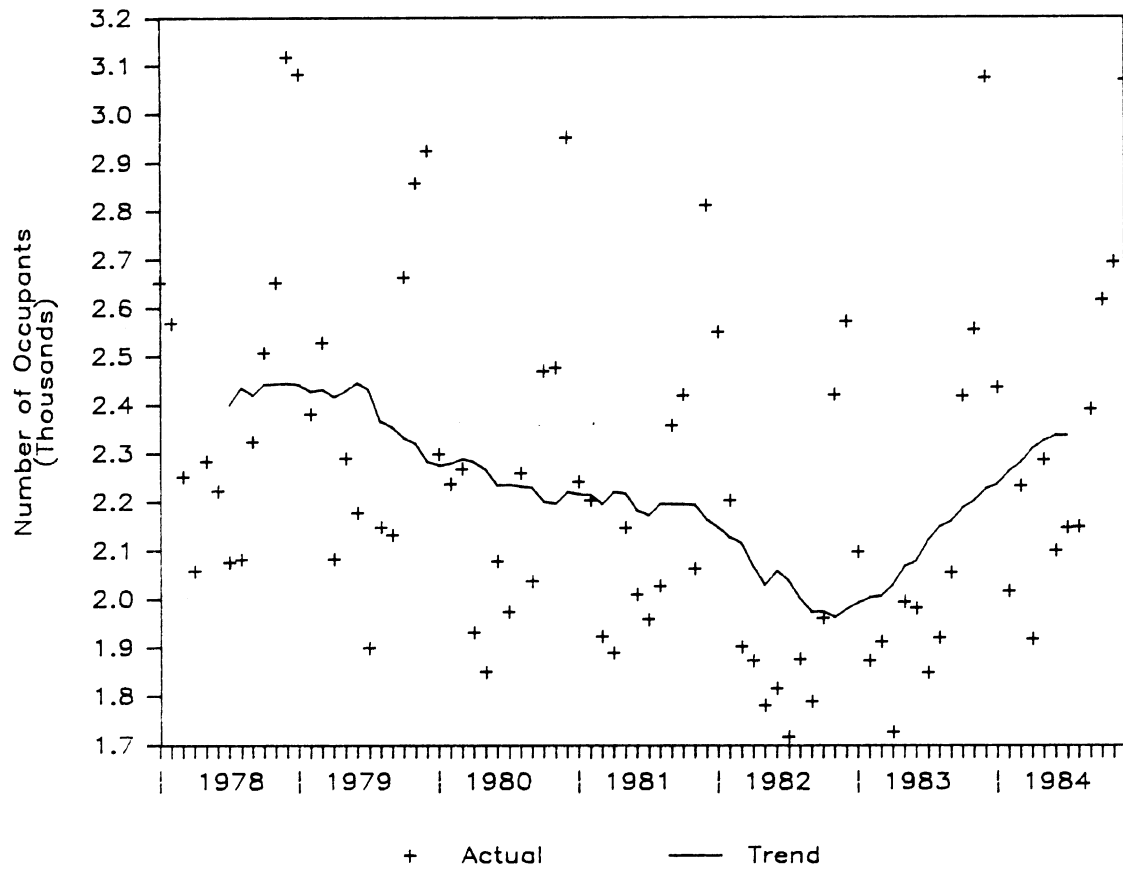


Figure 3.12 Number of Injured Occupants Age 25-34

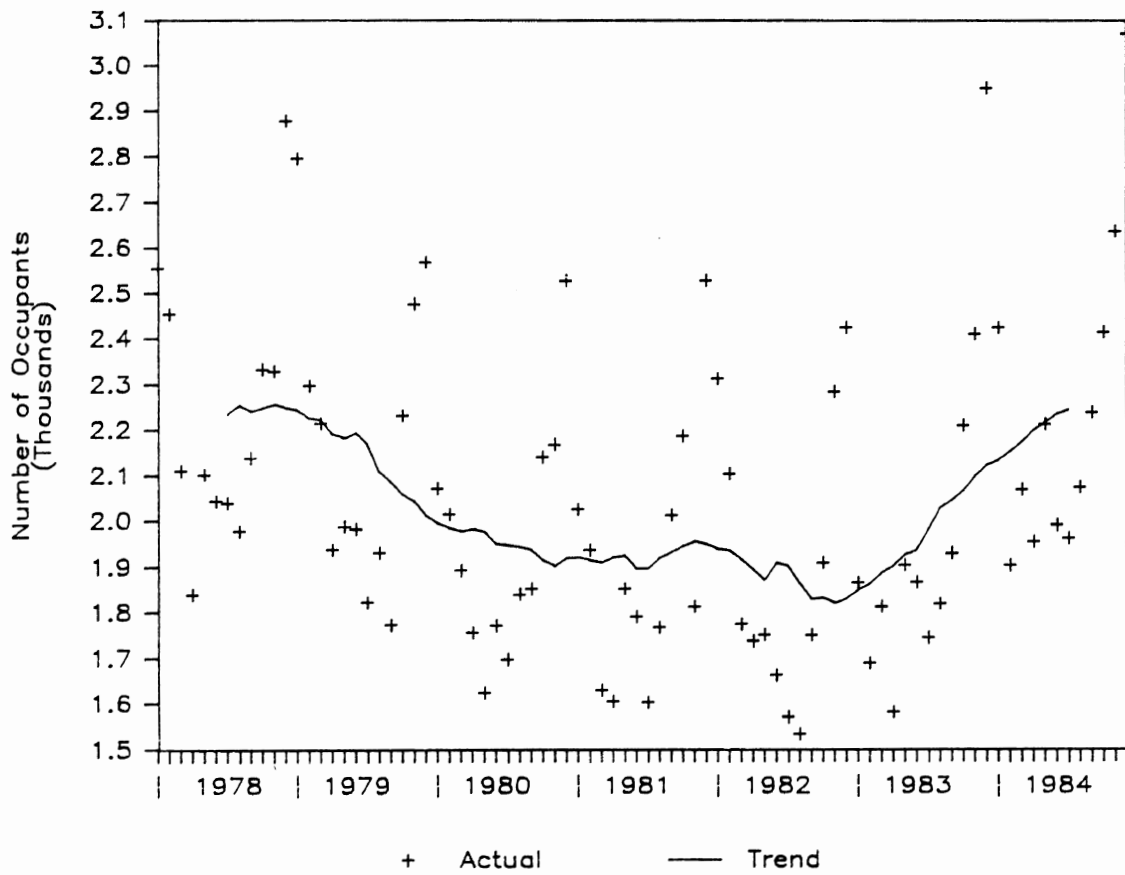


Figure 3.13 Number of Injured Occupants Age 35-54

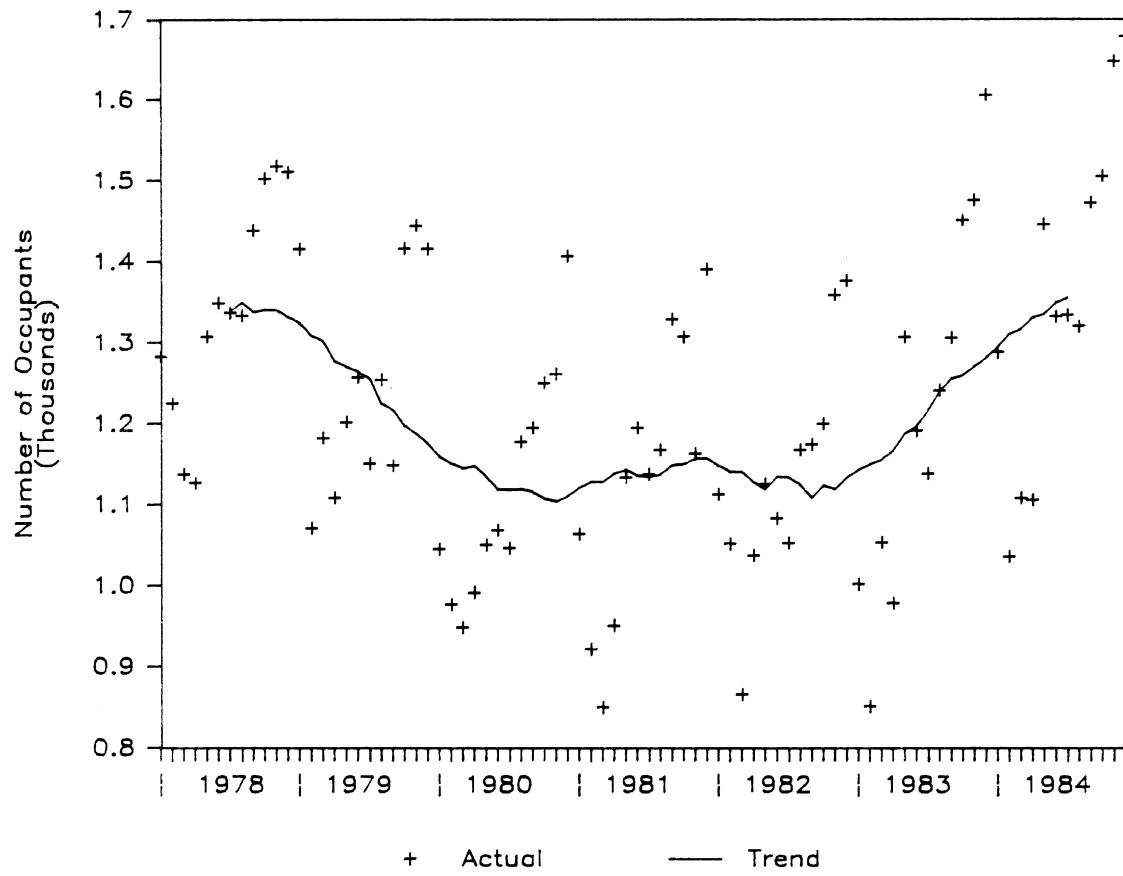


Figure 3.14 Number of Injured Occupants Age 55 and Over

The number of injured motor-vehicle occupants of other ages was examined and compared with the pattern seen in the target population. One way to assess whether the child restraint law was indeed responsible for the reduction in children injured during the post-law period is to compare patterns across age groups. Since only children under age 4 were covered by the law, effects of the law should be more dramatic in this age group than among older occupants. Figure 3.9 displays how the number of injured occupants age 4-15 have varied in recent years. Although the overall pattern is similar to that of younger children, the decline beginning in April 1982 is much smaller, and the increased number of injuries during 1983 and 1984 is more pronounced than for 0-3 year olds. By 1984, injuries among 4-15 year olds returned to the level observed in 1981, while injuries among 0-3 year olds remained substantially below 1981 levels.

Figure 3.10 shows that the number of injured occupants 16-17 years old declined more gradually between 1978 and 1982 than the 0-3 or 4-15 age groups. The increase in 1983 was also less dramatic, but by 1984 16-17 year olds reached the level seen in 1980 and 1981. Figure 3.11 shows a similar pattern of injuries among 18-24 year old occupants. The number of injured occupants in the 25-34 age group illustrated in Figure 3.12 reveals a more pronounced drop in 1982 than any of the other age groups not covered by the child restraint law. However, in subsequent years there was a noticeable increase in the number of 25-34 year olds injured; by 1984, the frequency of injured occupants returned to the levels seen during 1979 and 1980. The number of injuries among occupants 35-54 years old (Figure 3.13) and occupants age 55 and over (Figure 3.14) show a similar pattern of decline during 1978-81 and increase in 1983 and 1984.

The number of people in Michigan within each age group examined changes slightly from year to year as birth rates change and the population ages. To ensure that observed reductions in the number of children injured were not due to a reduction in the number of children in the 0-3 age group, rates of crash injuries per million population were also examined (Figures 3.15 through 3.21). A careful comparison of the child injury **rate** per million population (Figure 3.15) with the **frequency** of injuries (Figure 3.8) reveals that the post-law moving average trend line for the rate is slightly but consistently higher than the post-law trend line for the frequency. This observation is confirmed by the time-series results, which show a 27.4% decline in the **frequency** of child injuries during the post-law period, and a 26.6% decline in the **rate** of child injuries. This difference is due to a small decline in the number of young children in Michigan in 1982 and 1983 compared to 1980 and 1981. The main point is that the estimated effect of the child restraint law changes only a little when population levels are taken into account.

An important factor to note from this examination of injury trends for the seven age groups is that **all** age groups experienced an increase in the number and rate of injured motor-vehicle occupants in 1983 and 1984. The increased number of injured children under age 4, therefore, does not represent a diminishing effect of the child restraint law. Instead, the modest rise in the number of 0-3 year olds injured in 1983 and 1984 is consistent with the increased exposure to risk of injury among all age groups as reflected in an increase in the number of vehicle miles traveled. Figure 3.22 shows that the number of miles traveled declined from late 1978 through early 1981, held steady from mid-1981 through mid-1982, and increased from late

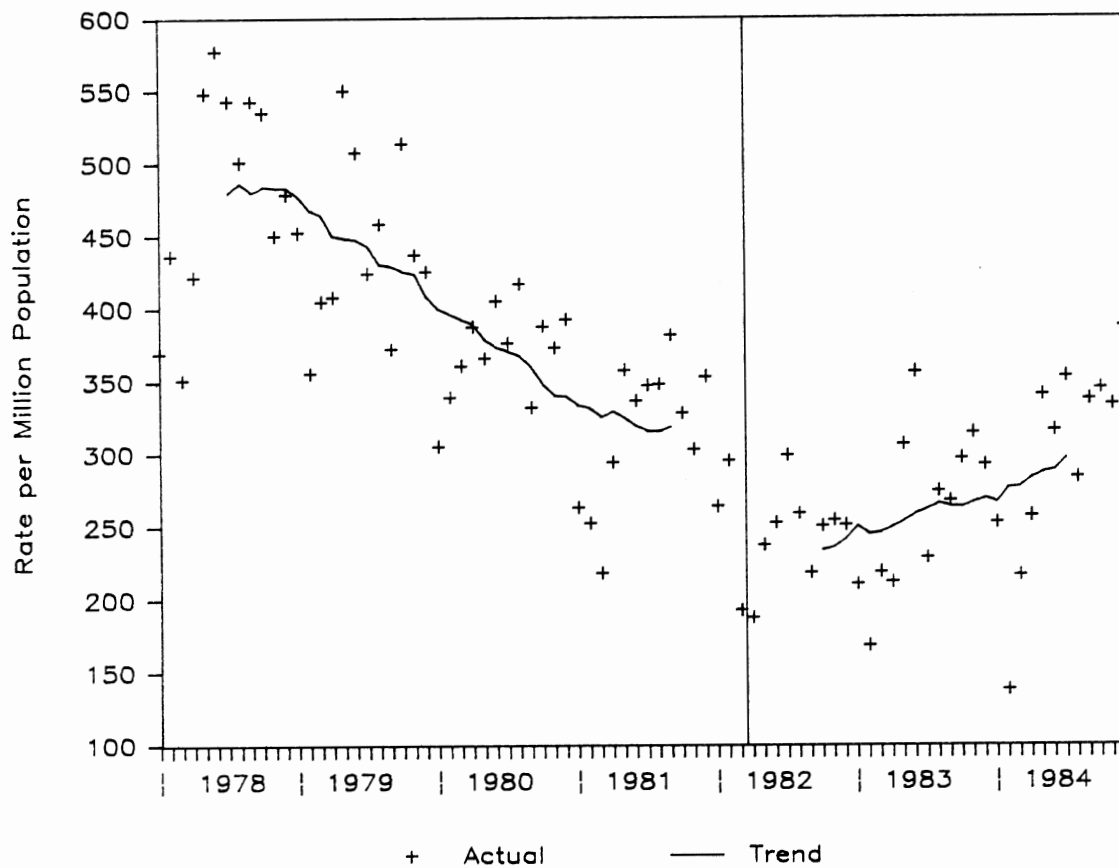


Figure 3.15 Rate of Injured Occupants Age 0-3 per Million Population

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-25.9	1.91
Effect of law, April 1982-December 1983*	-26.6	1.96
Effect of law, January 1984-December 1984	-35.4	2.10
Effect of law, April 1982-December 1984	-26.6	2.03

Baseline time-series model: ARIMA (0,1,1)(0,0,1)₃(0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

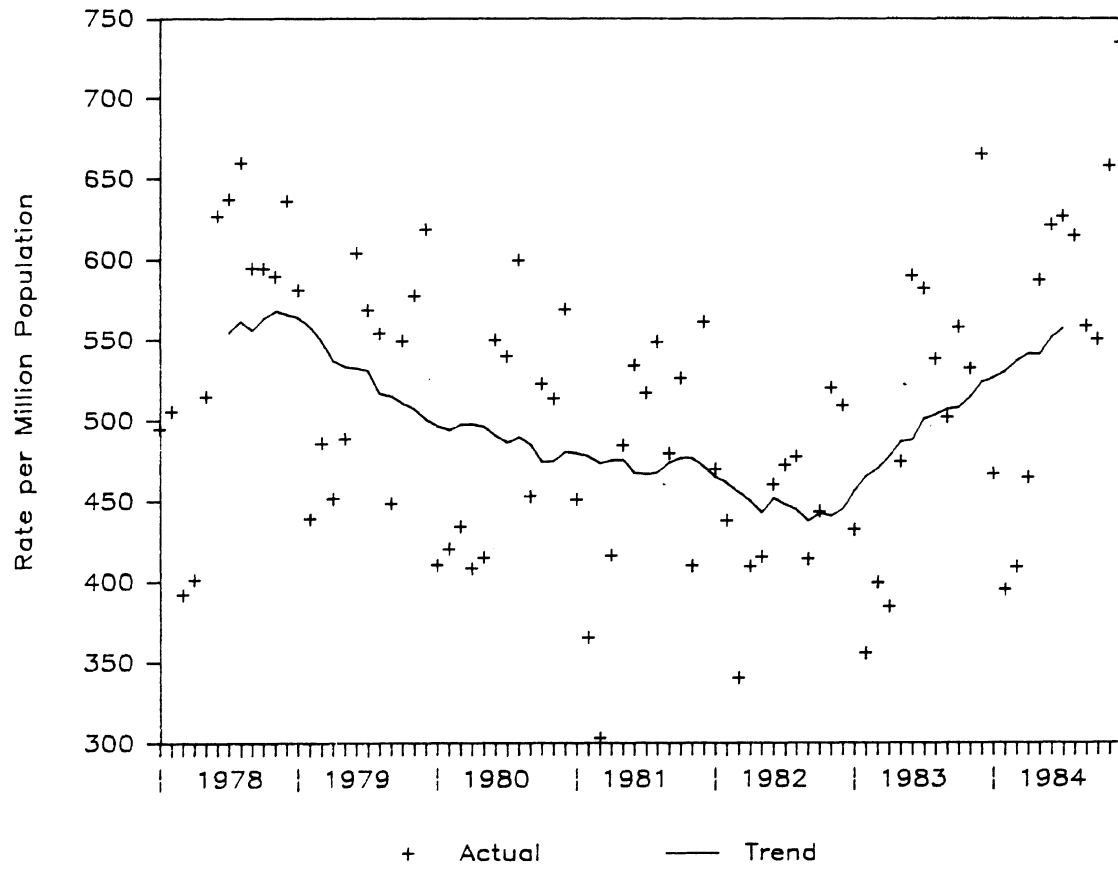


Figure 3.16 Rate of Injured Occupants Age 4-15 per Million Population

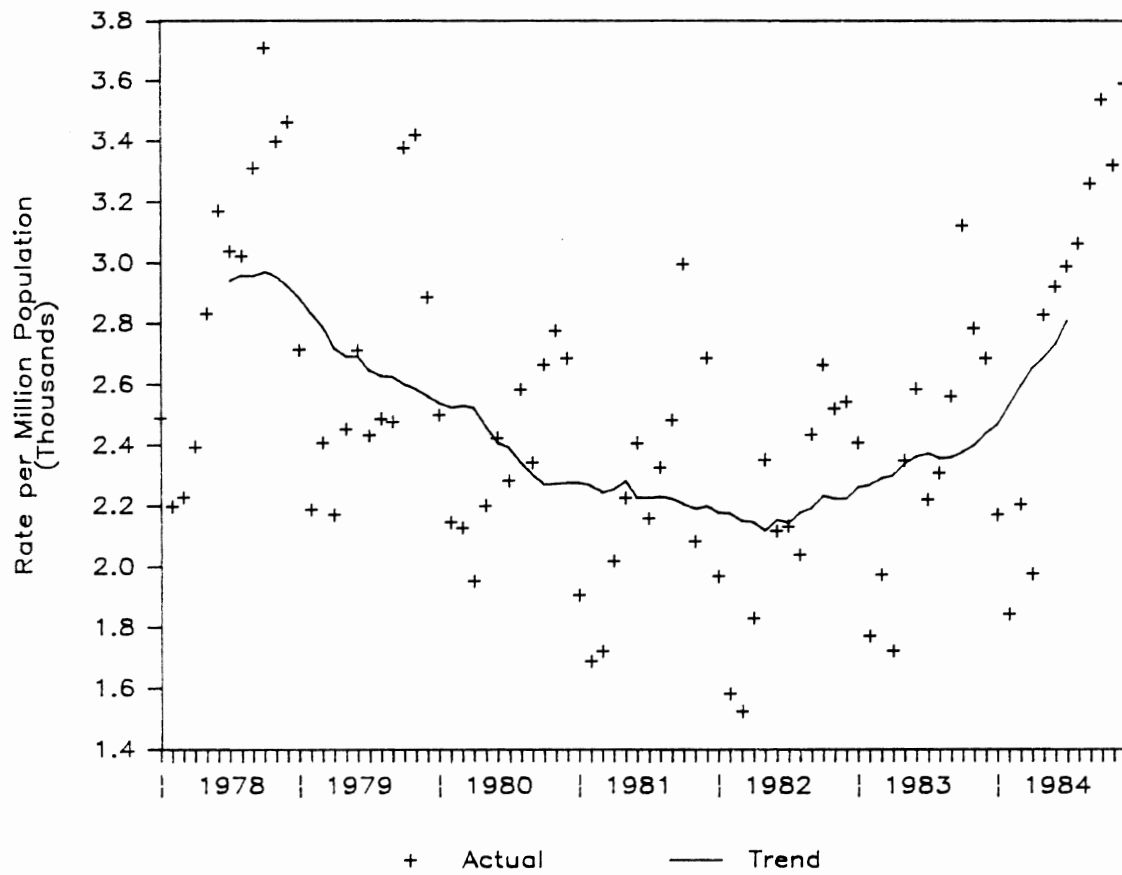


Figure 3.17 Rate of Injured Occupants Age 16-17 per Million Population

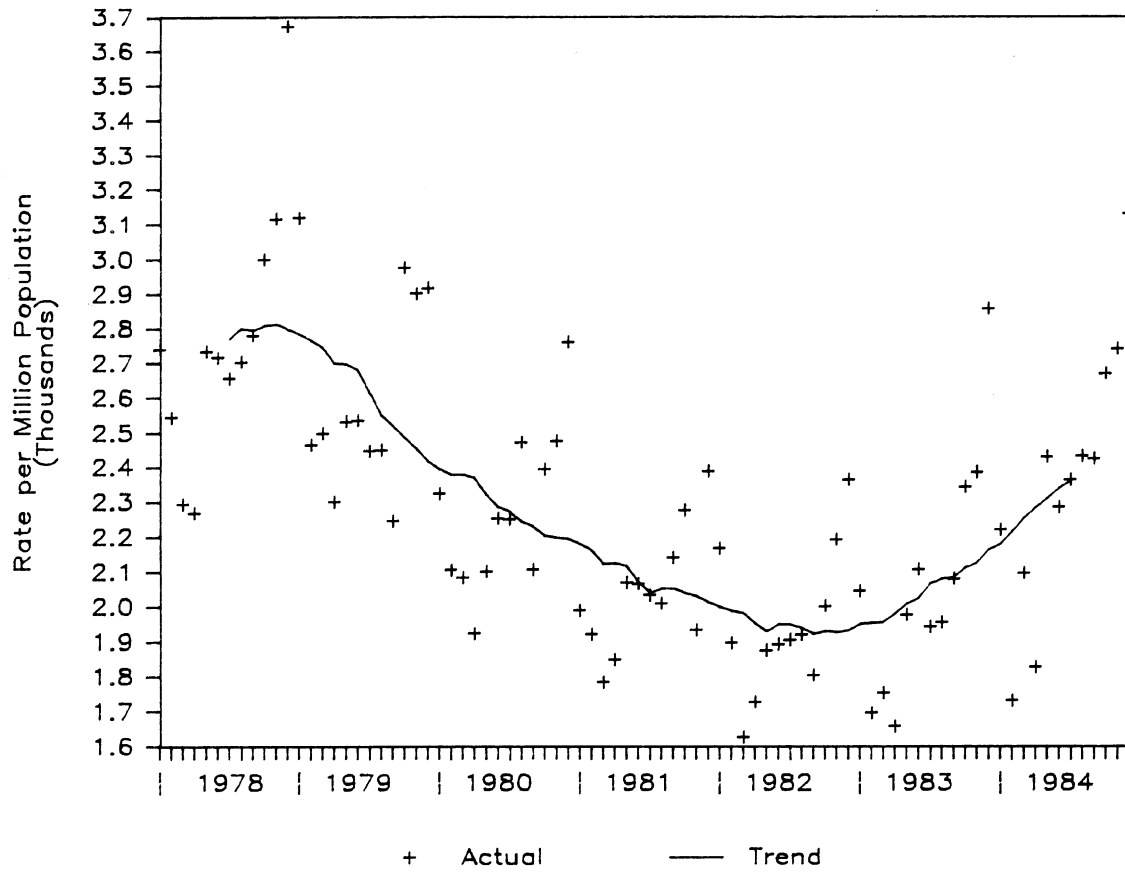


Figure 3.18 Rate of Injured Occupants Age 18-24 per Million Population

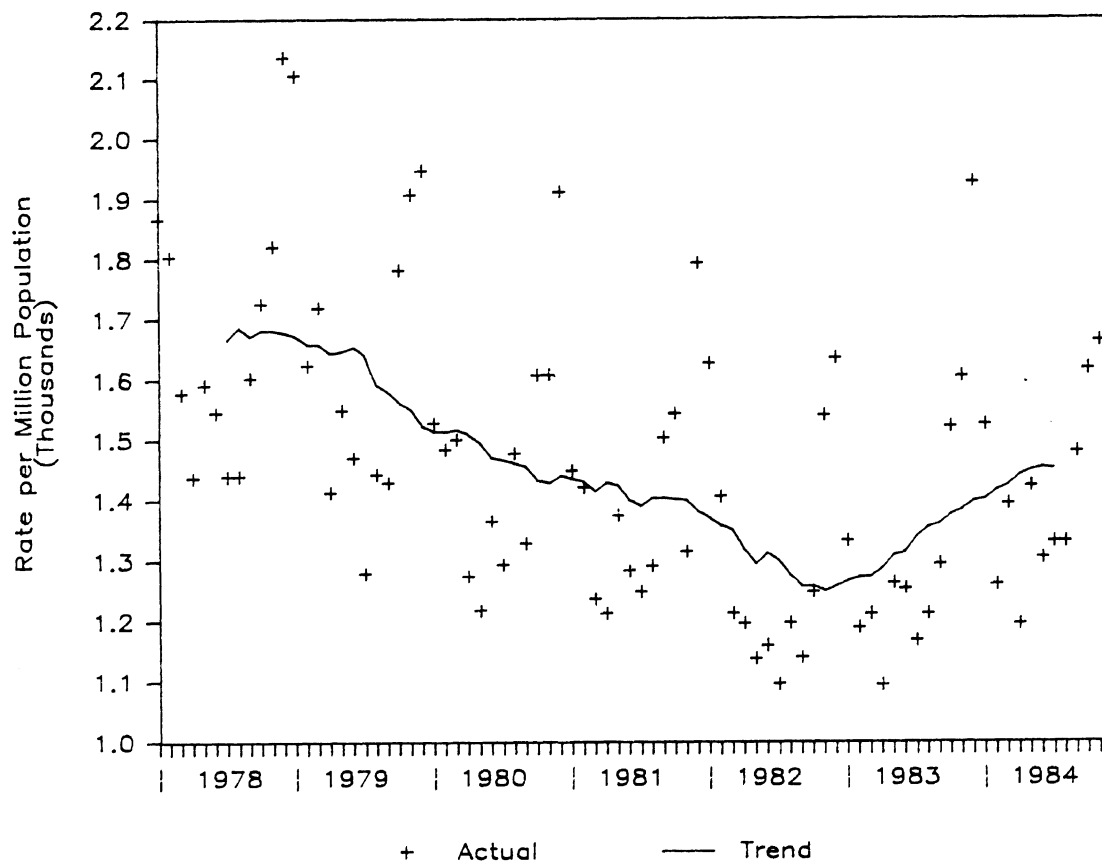


Figure 3.19 Rate of Injured Occupants Age 25-34 per Million Population

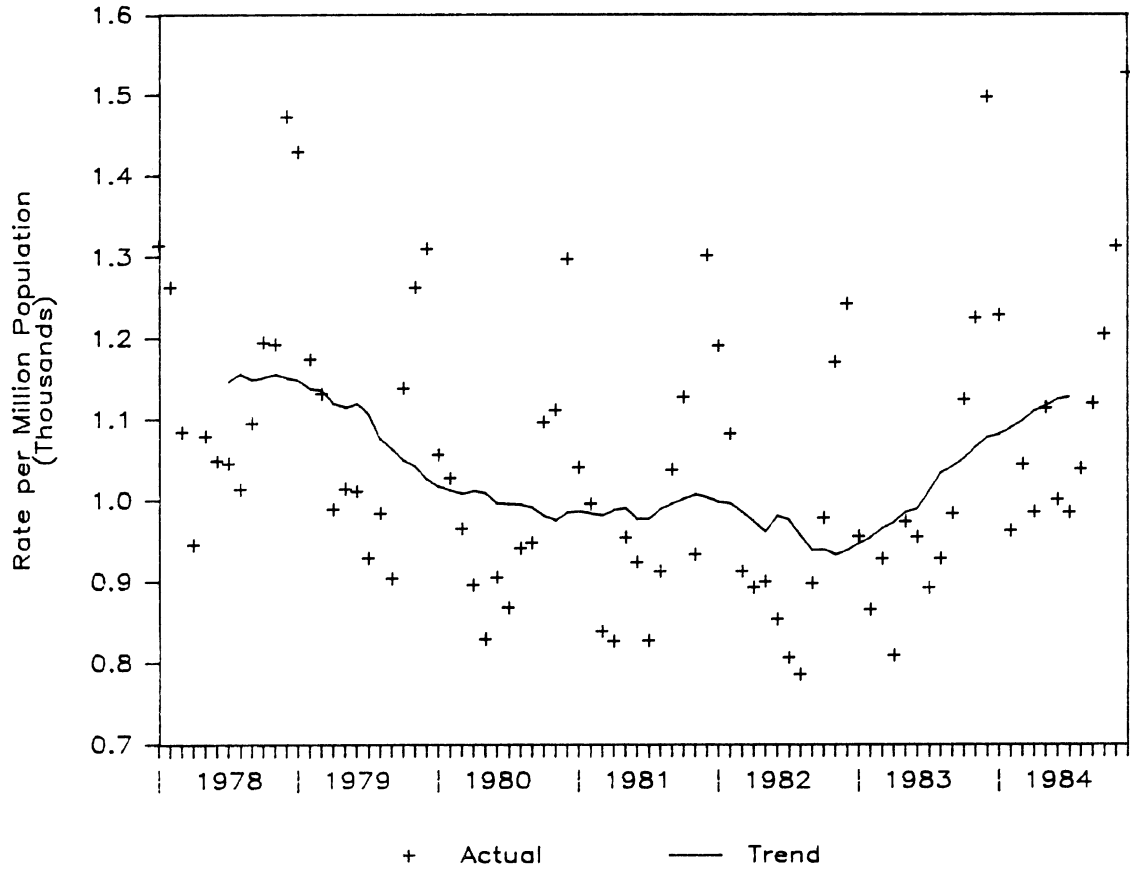


Figure 3.20 Rate of Injured Occupants Age 35-54 per Million Population

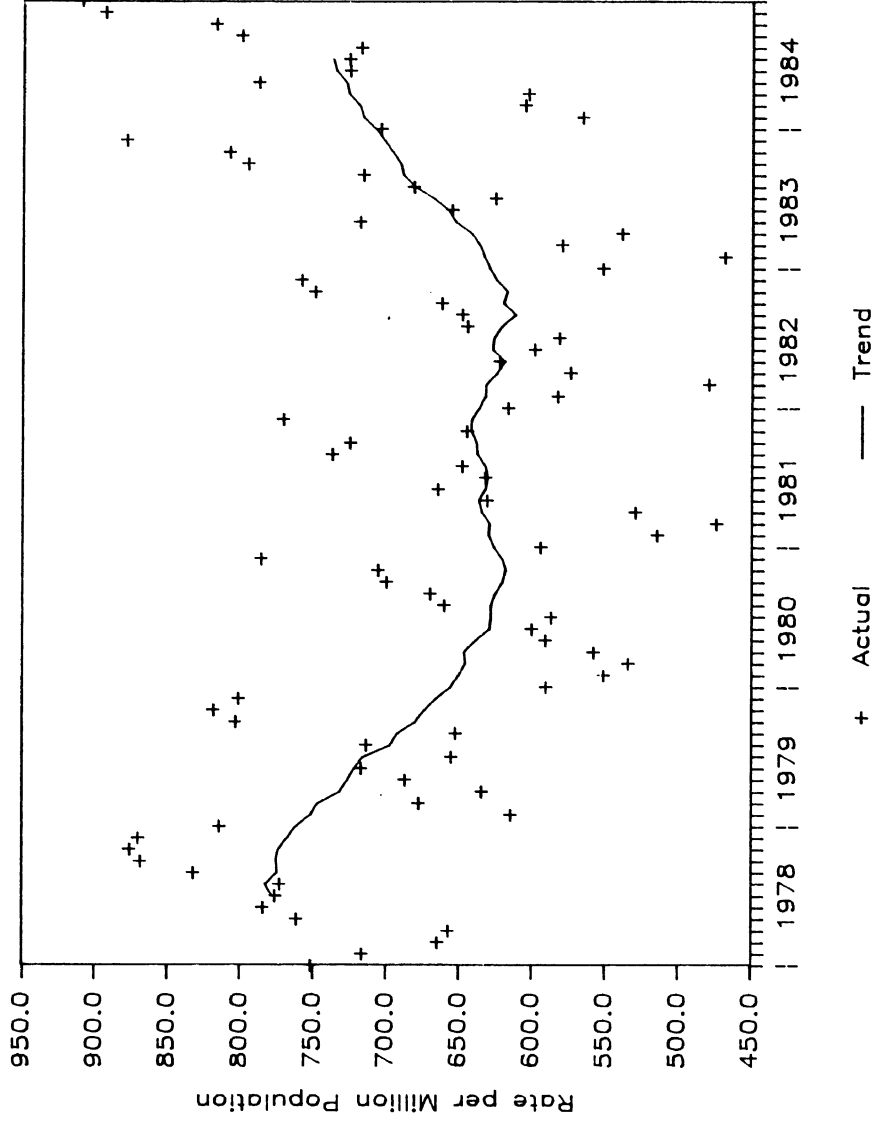


Figure 3.21 Rate of Injured Occupants Age 55 and Over per Million Population

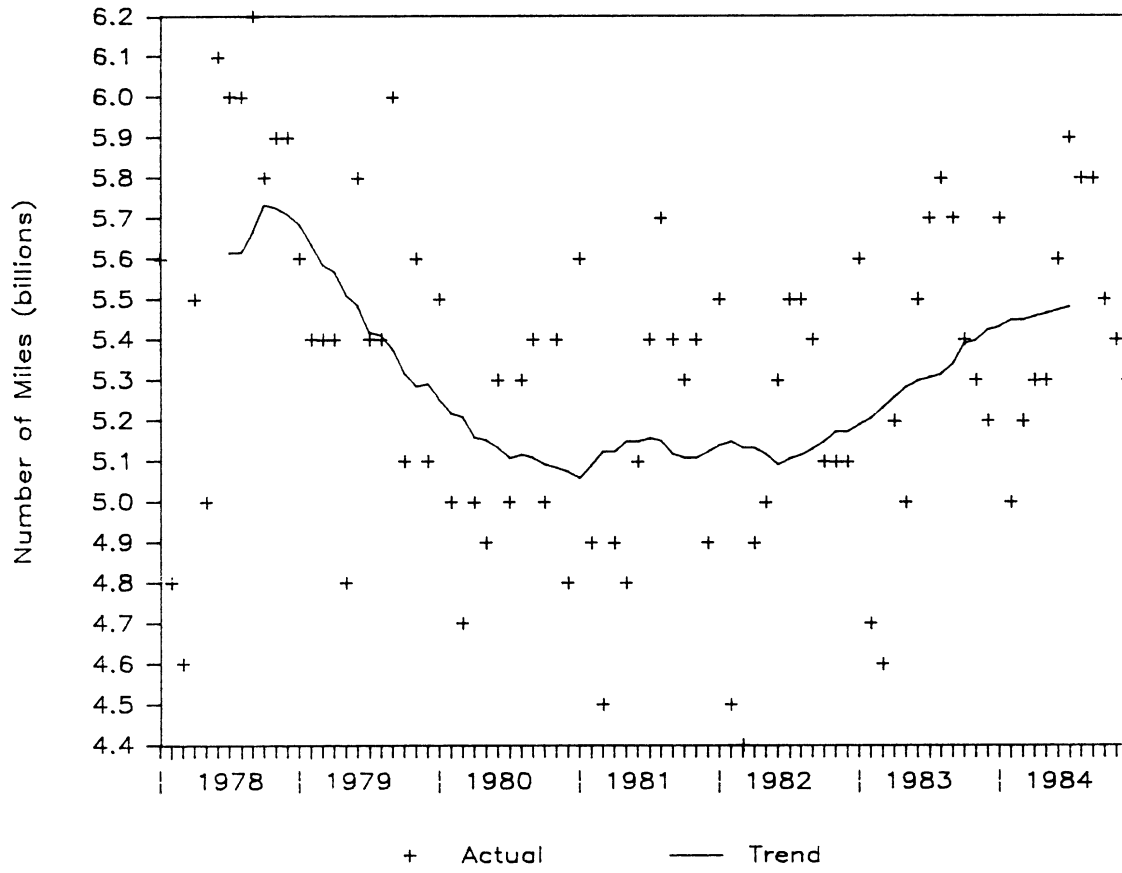


Figure 3.22 Estimated Number of Vehicle Miles Traveled

1982 through 1984. This pattern is similar to the pattern in number of injuries across all age groups during that period. Declining travel mileage in the earlier years is partially explained by the major economic recession Michigan experienced during that period, and the recent increase in travel came at a time of economic expansion (Wagenaar, 1984b).

Fluctuating economic conditions in recent years appear associated with both changes in total travel mileage and in the distribution of these travel miles across various kinds of driving (for example, commuting to work versus recreational driving). To take into account such multiple factors influencing exposure to risk of crash-induced injury, rates of injuries per 10,000 crashed vehicles were examined for each age group.⁶ Analyses of injuries per 10,000 crashed vehicles is particularly appropriate, since the child restraint law is expected to increase the protection of children once they are involved in a crash, but not affect the number of crashes.⁷ Figure 3.23 depicts the trend in the total number of motor-vehicle crashes in Michigan from 1978 through 1984.

Time-series modeling of the rate of children injured per 10,000 crashed vehicles revealed an estimated 26.7% reduction immediately following implementation of the child restraint law (i.e., April 1982 through December 1983); the PI&E program was associated with a 16.6% reduction (Figure 3.24). The addition of 1984 data had a very small effect of increasing the estimated effect of the child restraint law to 27.5%. The 27.5% estimated reduction in rate of child injuries per 10,000 crashed vehicles is virtually identical to the 27.4% estimated reduction in the raw frequency of children injured (Figure 3.8). It is clear that controlling for the effects of broader conditions influencing the number of crashes does not change the estimated effect of the child restraint law.

There were no large declines after the law took effect in the rate of occupants injured per 10,000 crashed vehicles for any of the other age groups (Figures 3.25 to 3.30). An estimated 6% decline in the rate for occupants age 18-24 was statistically significant, though the decline was clearly small when compared to the age group subject to the law. The two oldest age groups experienced statistically significant increases in their injury rate after April 1982, when the child restraint law was implemented. The rate of injured occupants age 35-54 years old was up 11.5%, and the 55-and-over age group increased 15.4%. These increases in injury rates among occupants not affected by the law provide further support for the hypothesis that decreases in injury rates among children are due to the restraint law and not other factors influencing the rate of injury to occupants of all ages.

The effect of the PI&E program on the rate of occupants injured per crashed vehicle, however, was not limited to children under 4 years old. The PI&E-program-only period (January-March 1982) was associated with a 16.6% decline in the rate of injured 0-3 year olds. Only the 21.5% decline in the injury rate among 16-17 year old occupants during this period was larger. The decline in the rate of occupants injured associated with the PI&E program for the

6. These rates are the number of injured occupants in a specific age group per 10,000 total crashed vehicles in the state. The denominator of the rate is not age-specific because the age of uninjured crash-involved occupants is not recorded.

7. One might argue that increased restraint of children may also reduce the number of crashes because restrained children may be less of a distraction to drivers. However, this effect is assumed to be small.

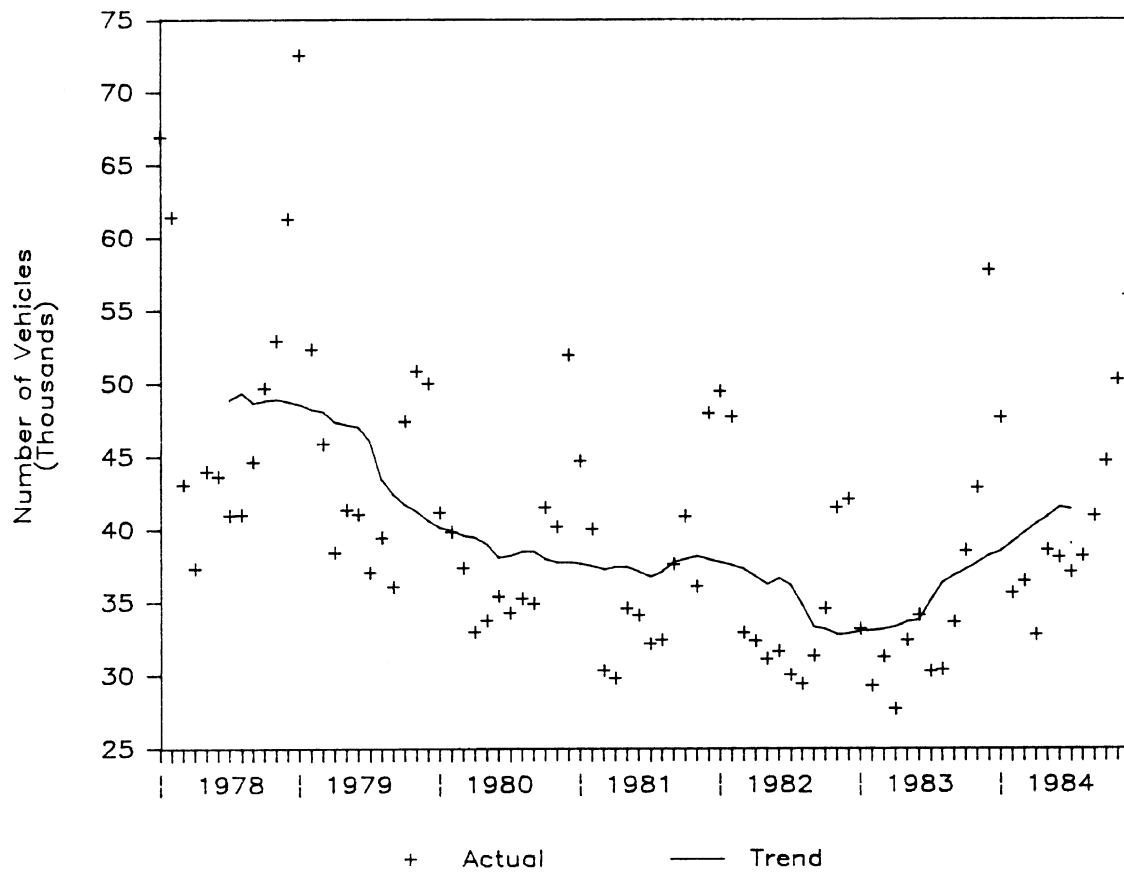


Figure 3.23 Total Number of Vehicles Involved in Traffic Crashes

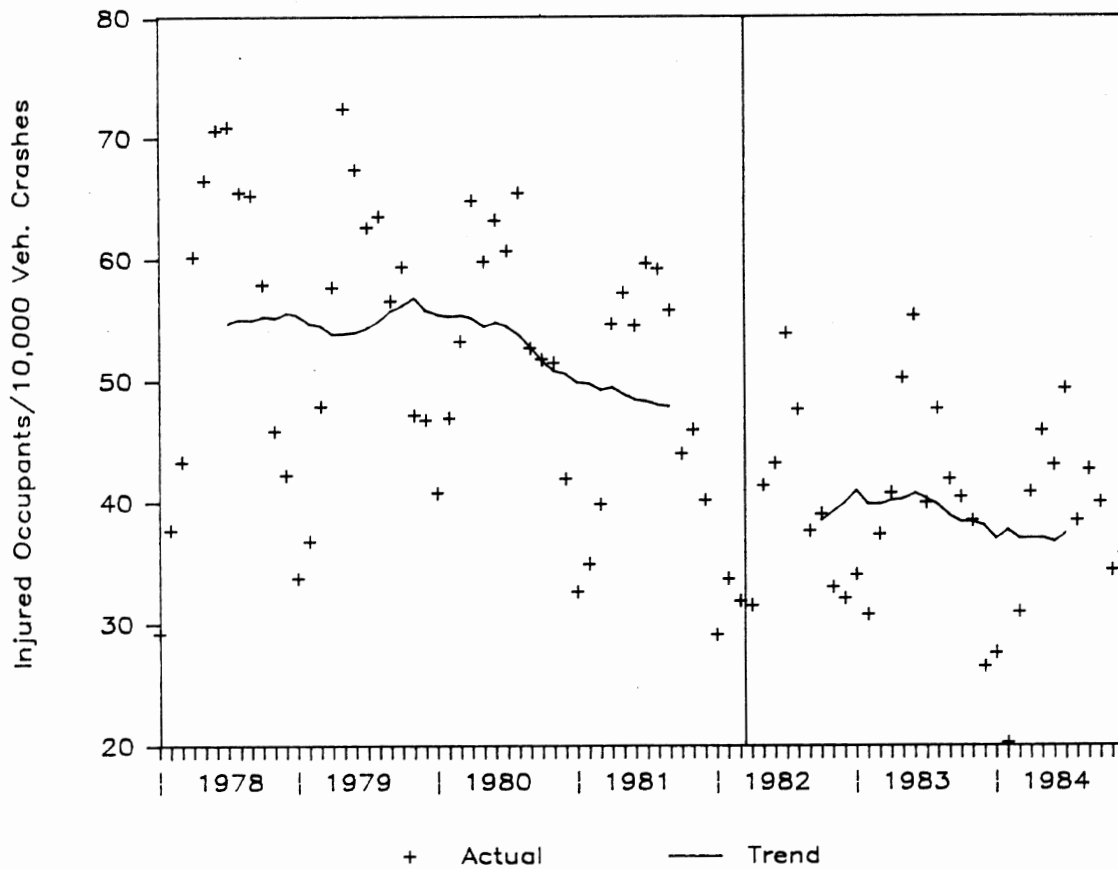


Figure 3.24 Injured Occupants Age 0-3 per 10,000 Crashed Vehicles

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-16.6	2.25
Effect of law, April 1982-December 1983*	-26.7	6.66
Effect of law, January 1984-December 1984	-29.0	6.23
Effect of law, April 1982-December 1984	-27.5	7.71

Baseline time-series model: ARIMA (0,0,5)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

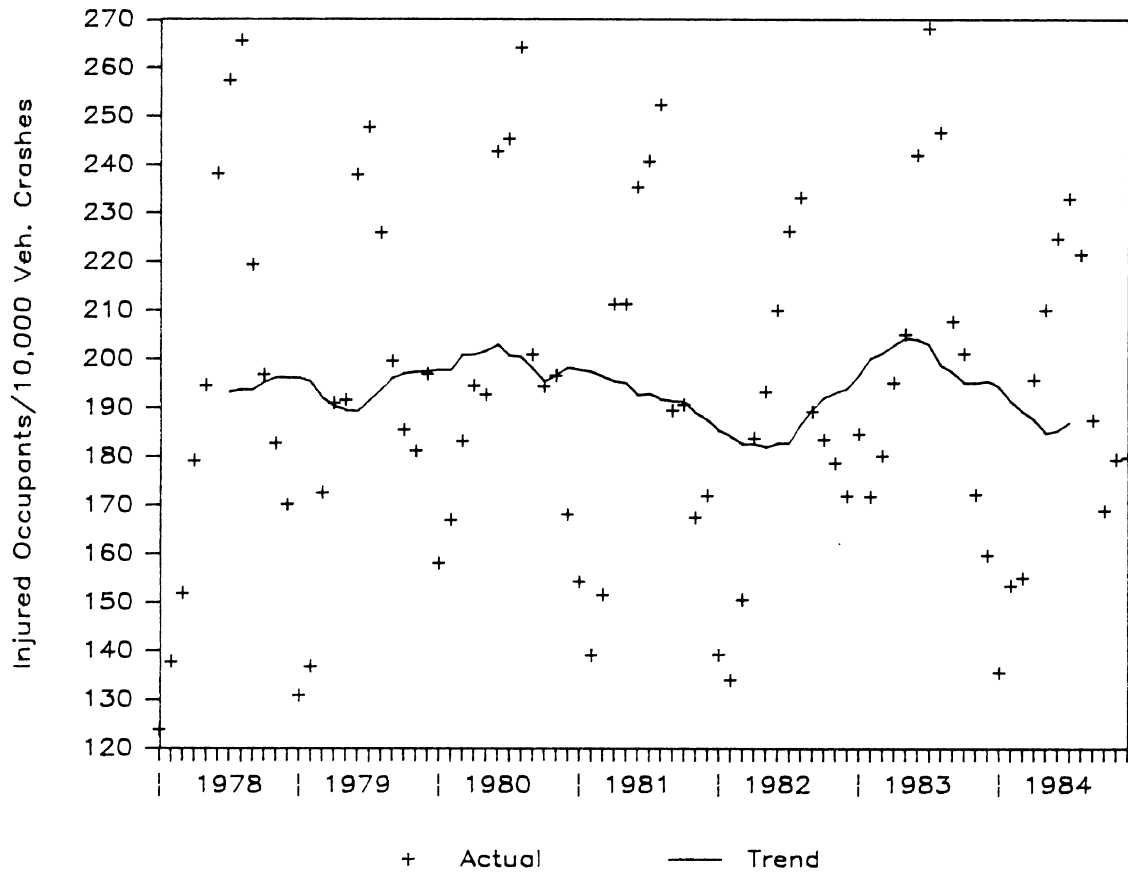


Figure 3.25 Injured Occupants Age 4-15 per 10,000 Crashed Vehicles

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-7.8	1.67
Effect of law, April 1982-December 1983*	0.7 [†]	0.28
Effect of law, January 1984-December 1984	-3.4 [†]	1.27
Effect of law, April 1982-December 1984	-1.0 [†]	0.47

Baseline time-series model: ARIMA (0,0,1)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

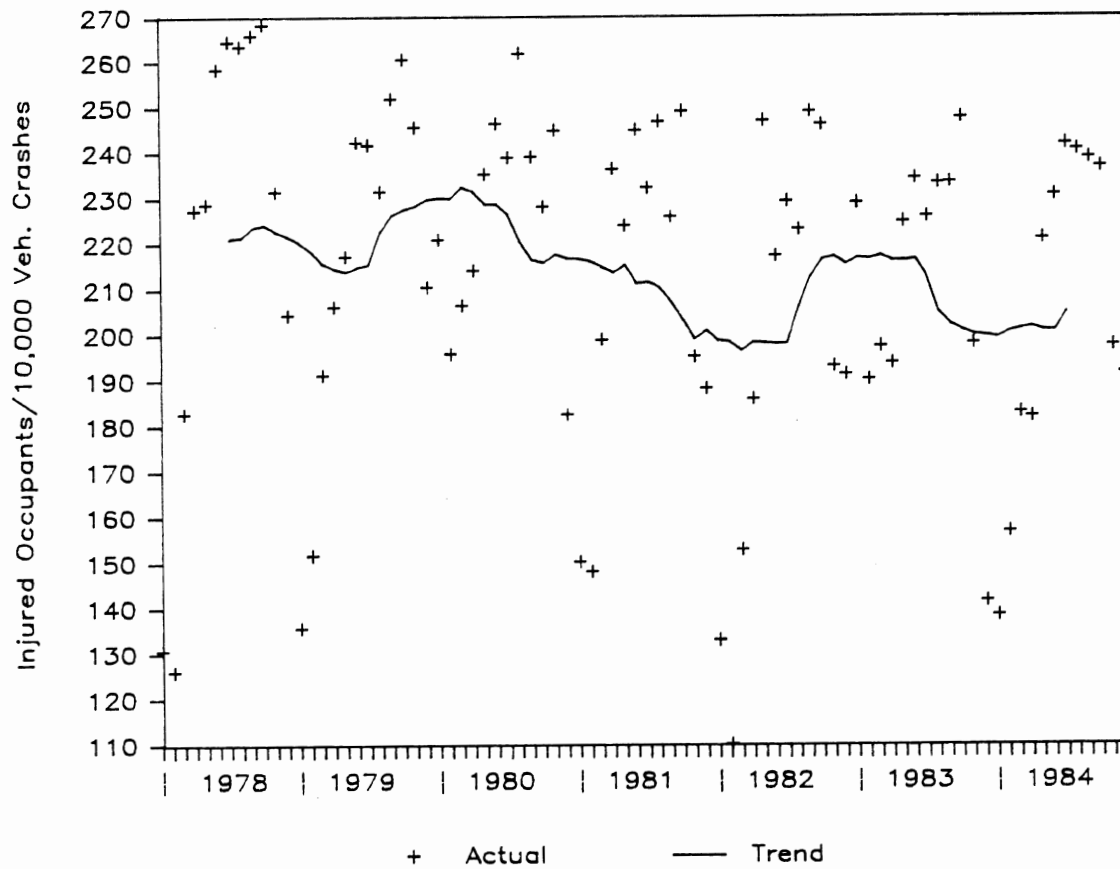


Figure 3.26 Injured Occupants Age 16-17 per 10,000 Crashed Vehicles

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-21.5	3.39
Effect of law, April 1982-December 1983*	-4.0 [†]	1.17
Effect of law, January 1984-December 1984	-5.5 [†]	1.48
Effect of law, April 1982-December 1984	-4.6 [†]	1.60

Baseline time-series model: ARIMA (0,0,1)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

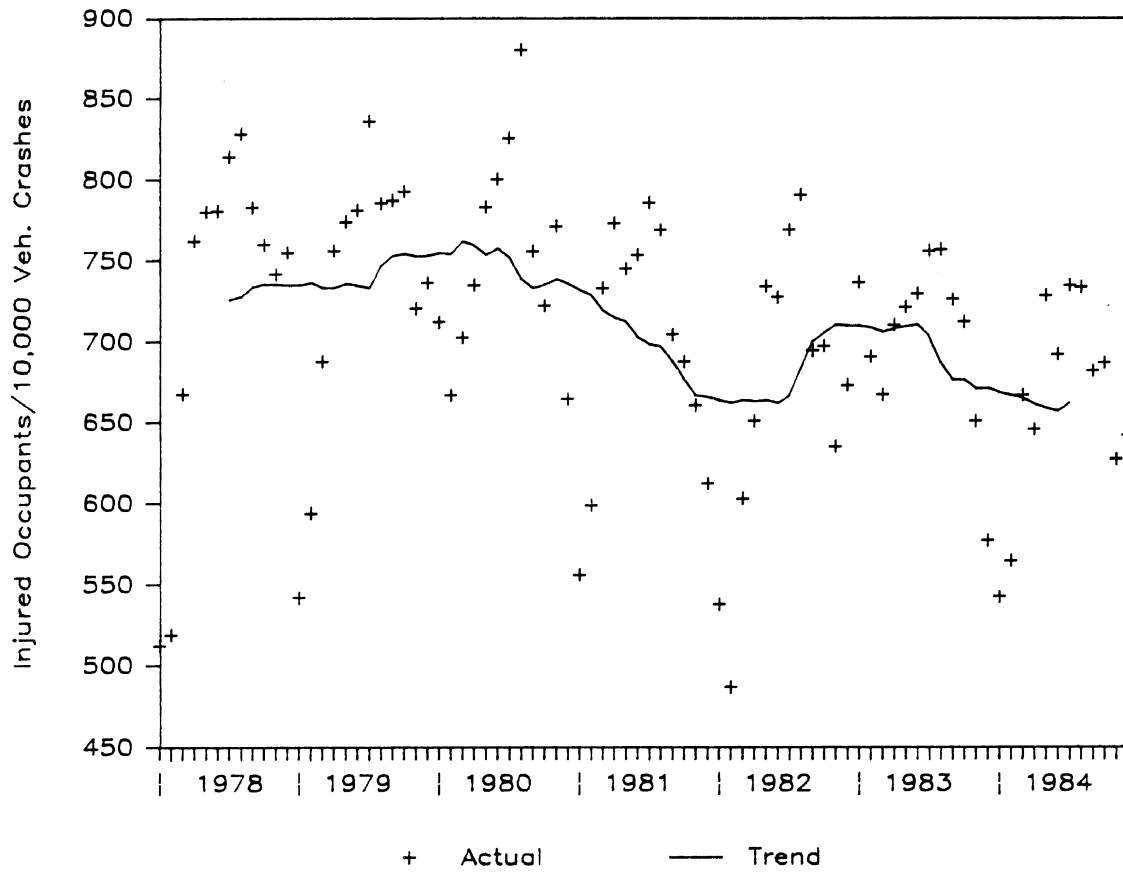


Figure 3.27 Injured Occupants Age 18-24 per 10,000 Crashed Vehicles

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-10.6	2.38
Effect of law, April 1982-December 1983*	-4.4	2.04
Effect of law, January 1984-December 1984	-7.9	3.54
Effect of law, April 1982-December 1984	-6.0	3.13

Baseline time-series model: ARIMA (0,0,1)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

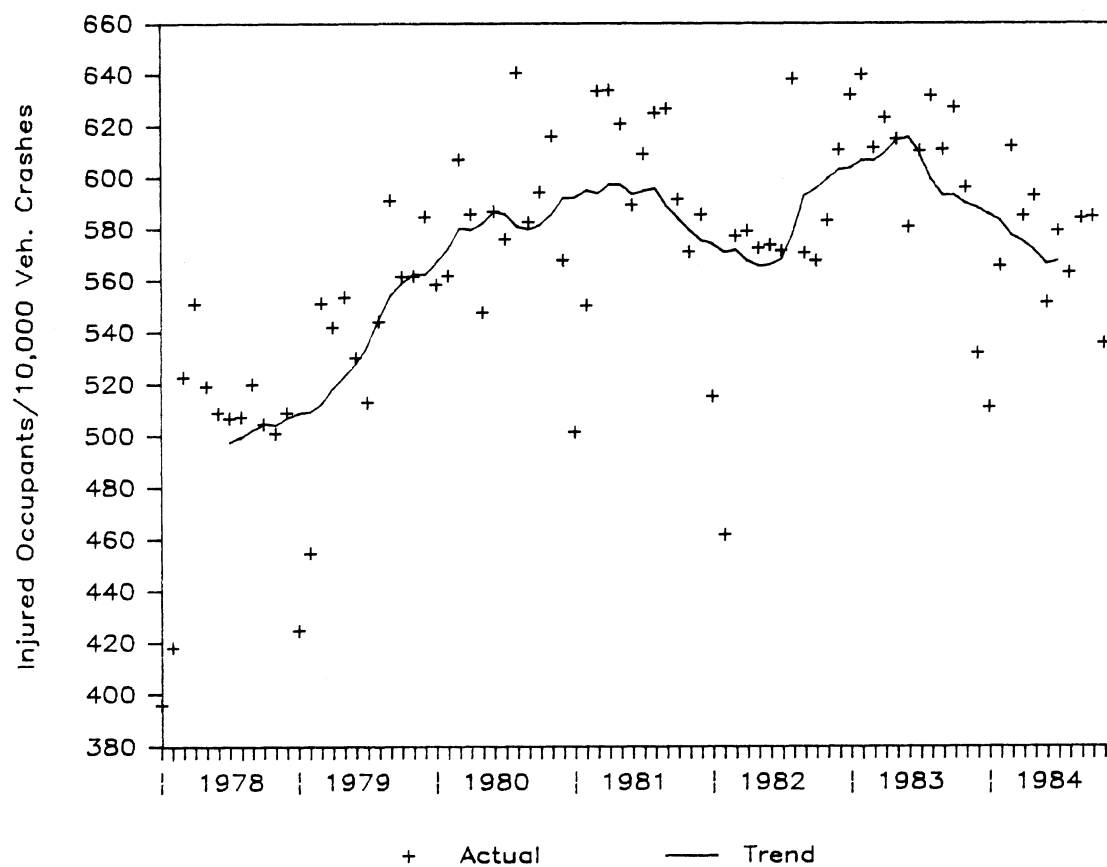


Figure 3.28 Injured Occupants Age 25-34 per 10,000 Crashed Vehicles

	Percent Change	t-Ratio
Effect of PI & E, January-March 1982	-10.8	2.35
Effect of law, April 1982-December 1983*	-6.1 [†]	1.05
Effect of law, January 1984-December 1984	-7.0 [†]	0.86
Effect of law, April 1982-December 1984	-5.9 [†]	1.02

Baseline time-series model: ARIMA (0,1,1)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

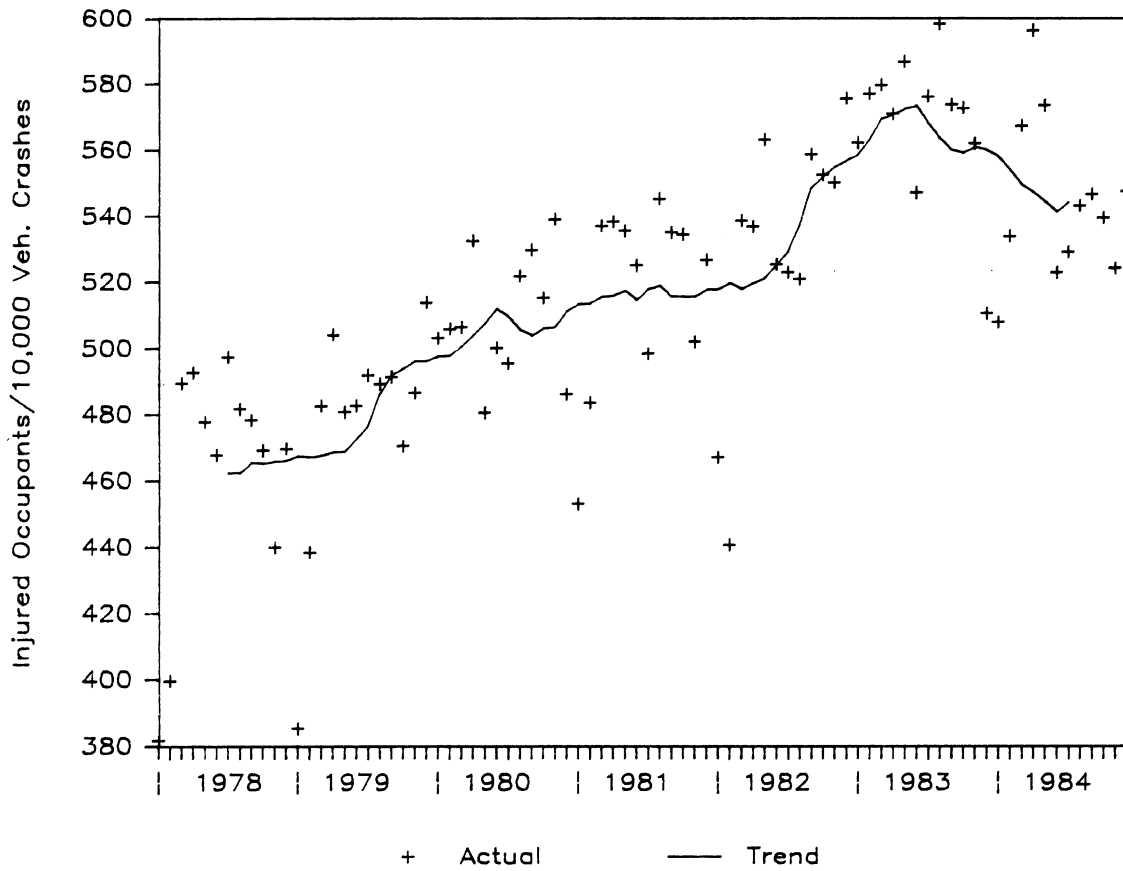


Figure 3.29 Injured Occupants Age 35-54 per 10,000 Crashed Vehicles

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	2.3 [†]	0.56
Effect of law, April 1982-December 1983*	11.5	4.97
Effect of law, January 1984-December 1984	11.5	5.07
Effect of law, April 1982-December 1984	11.5	6.09

Baseline time-series model: ARIMA (0,0,2)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

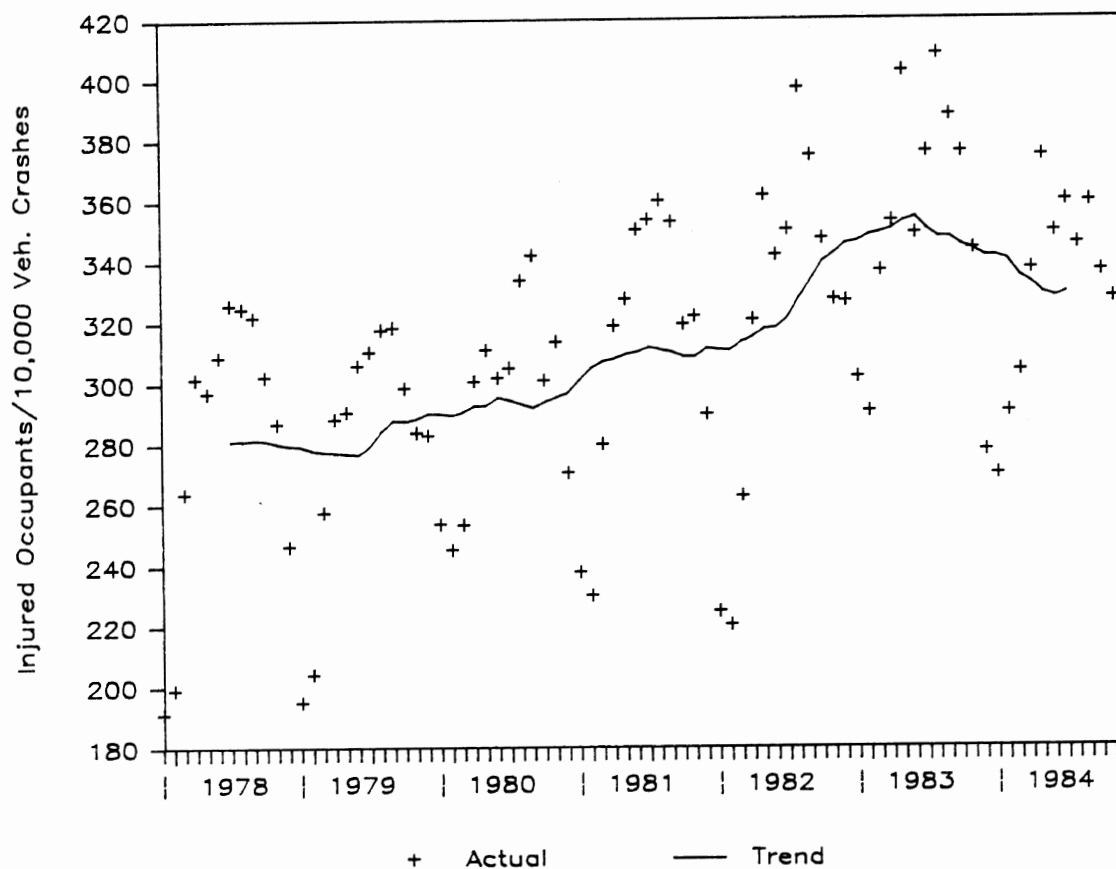


Figure 3.30 Injured Occupants Age 55 and Over
per 10,000 Crashed Vehicles

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-1.3 [†]	0.31
Effect of law, April 1982-December 1983*	16.4	6.76
Effect of law, January 1984-December 1984	14.0	5.03
Effect of law, April 1982-December 1984	15.4	7.14

Baseline time-series model: ARIMA (0,0,1)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

4-15, 18-24, and 25-34 age groups was between 7% and 11%, while occupants over age 35 experienced no significant change.

The rate of 0-3 year olds injured per billion miles traveled in Michigan was also examined as an alternative way to control for exposure to risk of injury (Figure 3.31). The time-series modeling results revealed an estimated 26% reduction during the April 1982 to December 1983 period, and a 28.9% reduction during 1984. The entire post-law period averaged 26.4% lower than the baseline period.

As a third way to control for broader trends in crash involvement when estimating the effect of the child restraint law, the number of children age 0-3 injured as a percent of the total number of injured occupants across all age groups was analyzed (Figure 3.32). Time-series analyses indicated a 13.9% decrease during the PI&E-only period, a 29.1% decrease over the entire post-law period, and virtually no change in the estimated effect when 1984 was examined separately from 1982-83.

In summary, these alternative estimates of the effect of the child restraint law in reducing child injuries associated with automobile travel are remarkably similar. Over the entire 33-month post-law period, analyses revealed the following injury reductions:

- 27.4% reduction in the frequency of injured children;
- 26.6% reduction in the rate of injured children per million population;
- 27.5% reduction in the rate of occupants injured per crashed vehicle;
- 26.4% reduction in the rate of children injured per vehicle mile traveled;
- 29.1% reduction in the number of children injured as a percent of injured occupants of all ages.

3.3 Differential Effects of Child Restraint Law

To further delineate the benefits of the child restraint law, the effect of the law was assessed for different levels of injury severity. The impressive reductions in number of children injured discussed above would be less dramatic if the law was only effective in preventing minor injuries and had no effect on fatal and incapacitating injuries. Therefore, injured children were separated into two groups for analysis. The first group consisted of children who were classified as having either a "possible" or "nonincapacitating" injury (labeled here as moderate injuries). The second group included children who were fatally injured or received incapacitating injuries (labeled here as serious injuries).

Figure 3.33 shows a significant 31.6% decline in the number of moderately injured 0-3 year olds in the 33 months after the child restraint law took effect. The effects of the law through 1984 on moderate injuries are the same as the shorter term effects identified previously. Although the decrease in the number of severely injured occupants depicted in Figure 3.34 is less

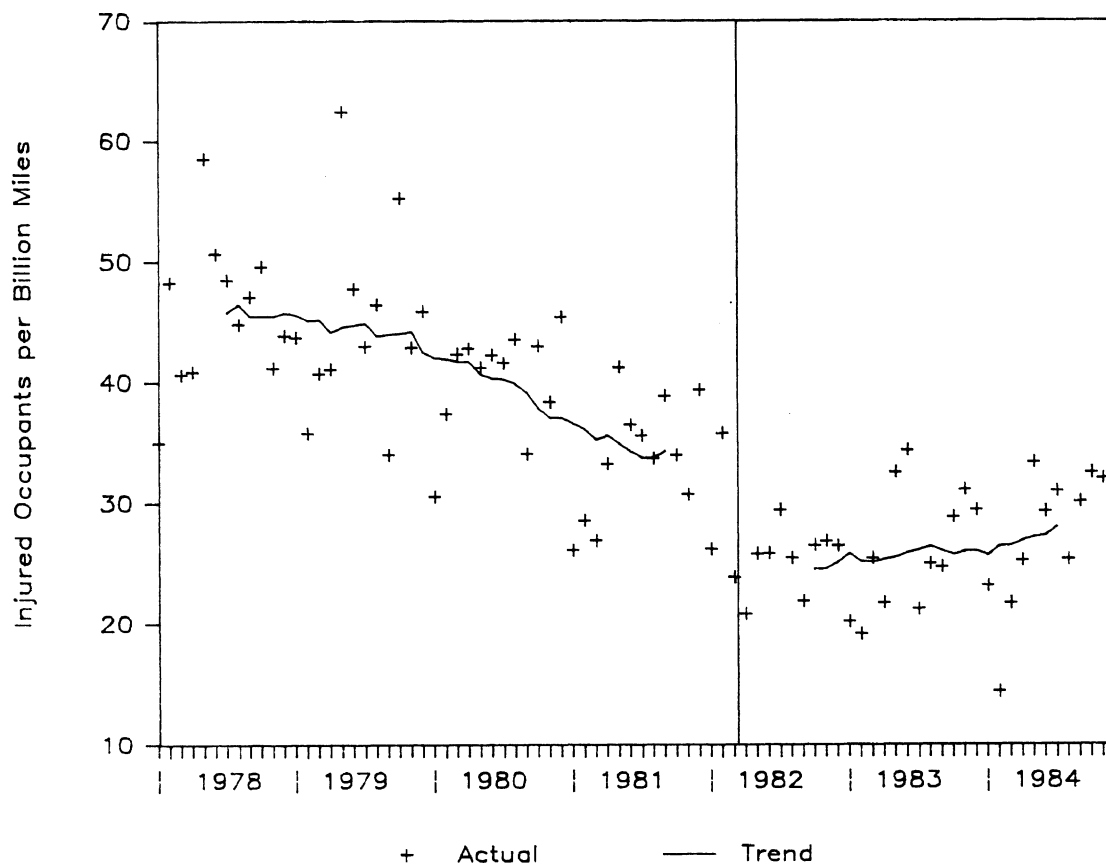


Figure 3.31 Injured Occupants Age 0-3 per Billion
Vehicle Miles Traveled

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-3.1 [†]	0.31
Effect of law, April 1982-December 1983*	-26.0	3.20
Effect of law, January 1984-December 1984	-28.9	2.90
Effect of law, April 1982-December 1984	-26.4	3.47

Baseline time-series model: ARIMA (0,1,1)(0,0,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

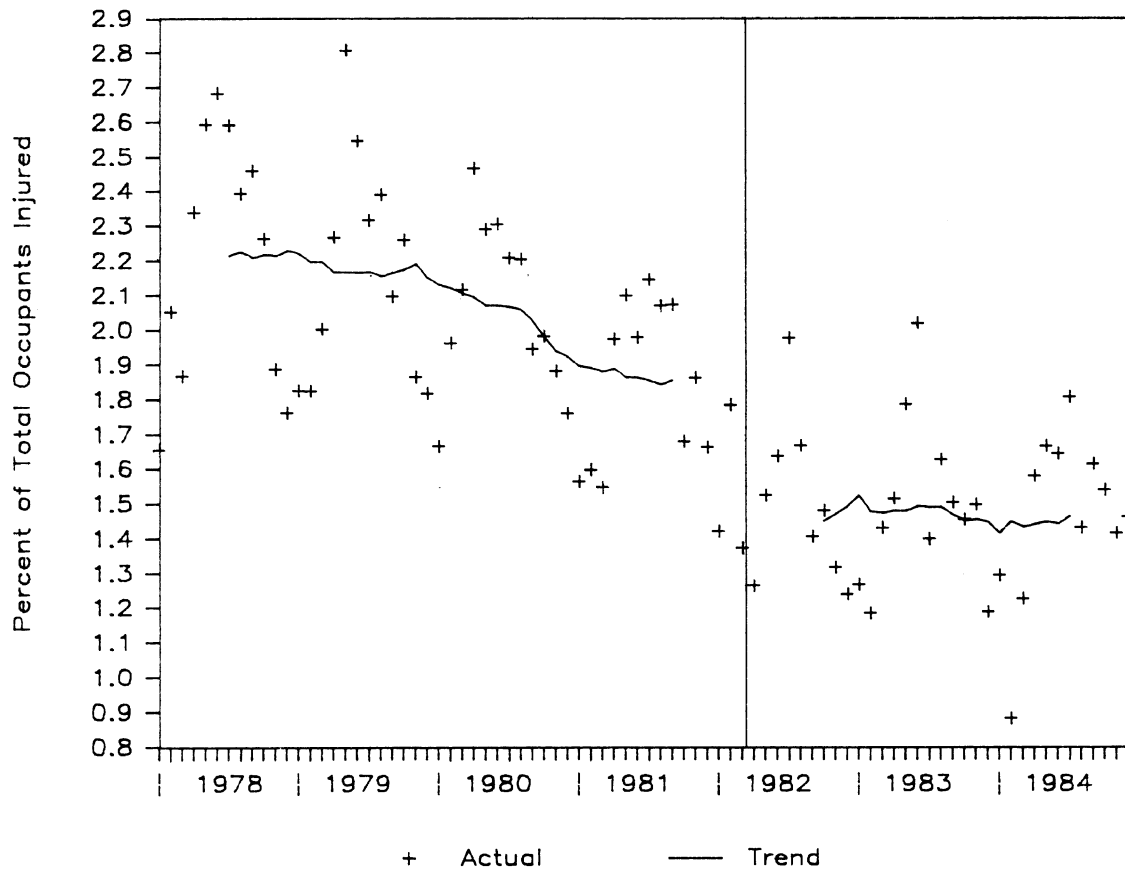


Figure 3.32 Injured Occupants Age 0-3 as Percent of All Injured Occupants

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-13.9	2.12
Effect of law, April 1982-December 1983*	-29.0	9.41
Effect of law, January 1984-December 1984	-29.4	9.07
Effect of law, April 1982-December 1984	-29.1	10.57

Baseline time-series model: ARIMA (0,0,5)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

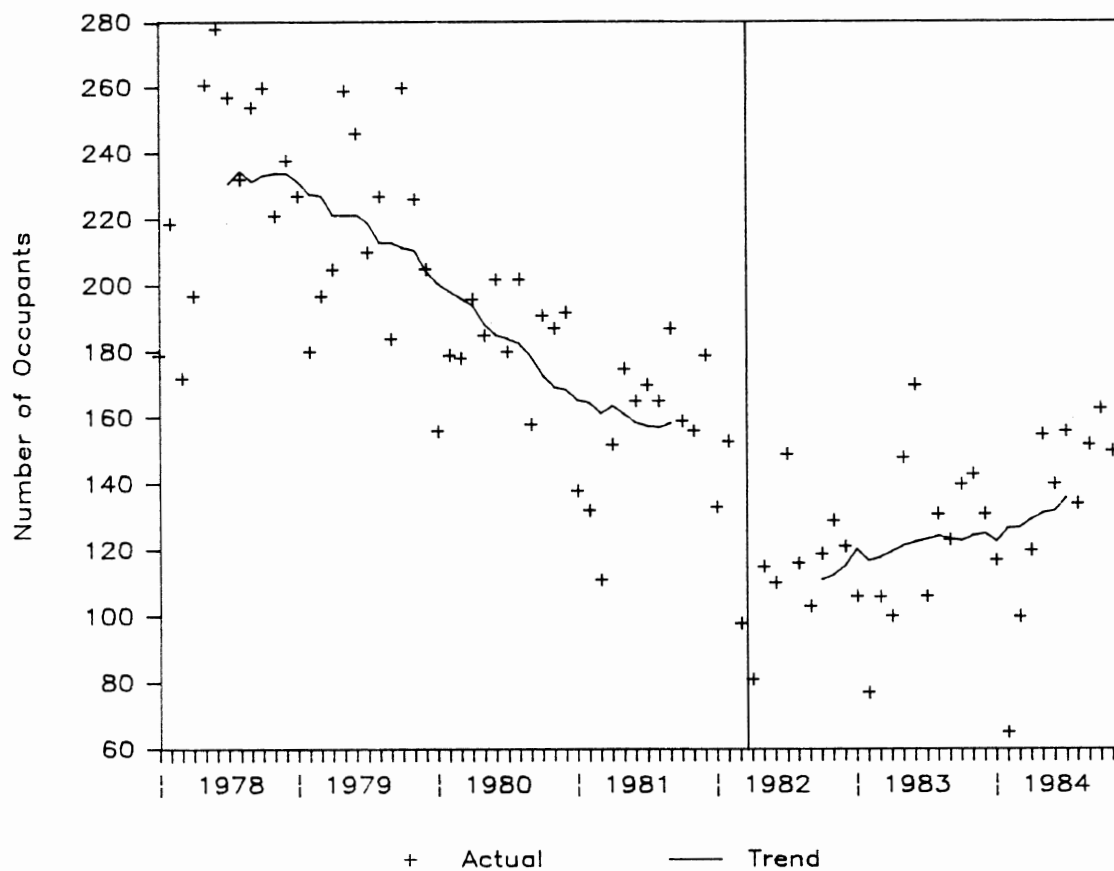


Figure 3.33 Moderately Injured Occupants Age 0-3

	Percent Change	t-Ratio
Effect of PI & E, January-March 1982	-22.0 [†]	1.59
Effect of law, April 1982-December 1983*	-31.5	2.61
Effect of law, January 1984-December 1984	-32.1	2.14
Effect of law, April 1982-December 1984	-31.6	2.66

Baseline time-series model: ARIMA (0,1,3)(0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, p<.05, one-tailed test.

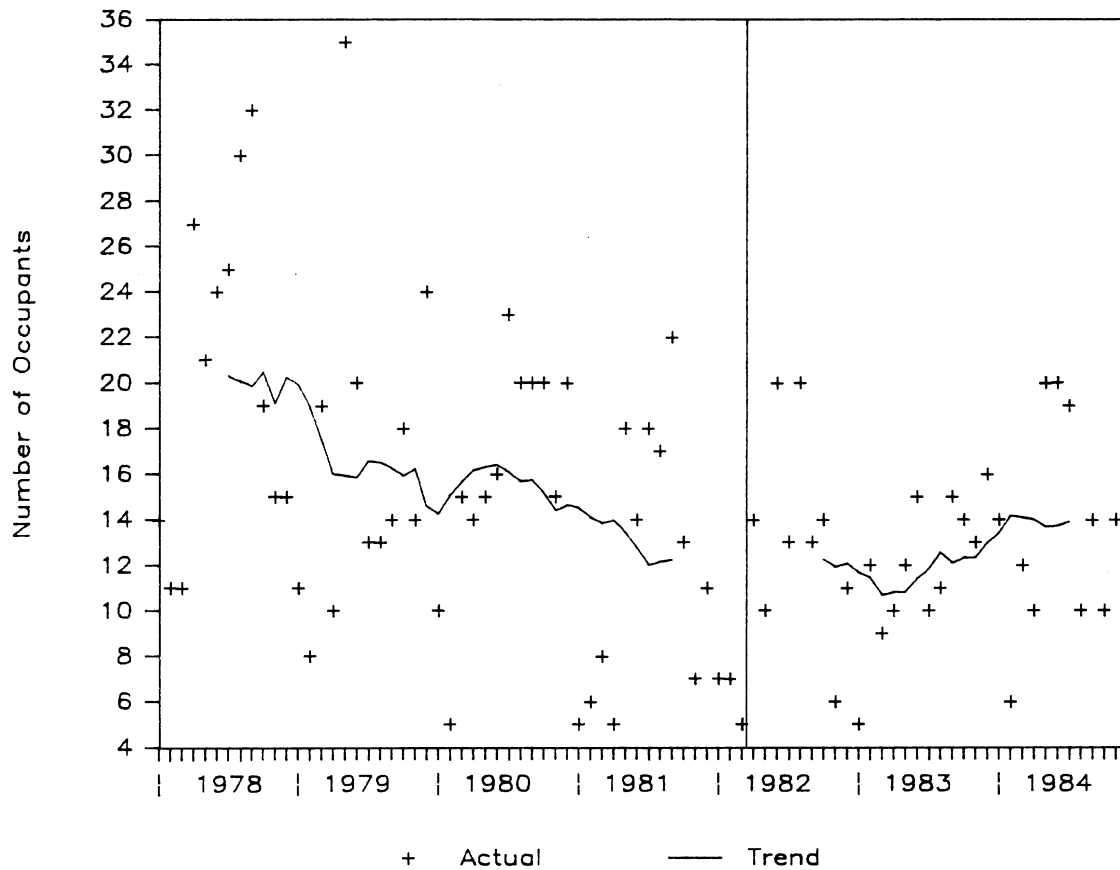


Figure 3.34 Severely Injured Occupants Age 0-3

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-36.8	2.25
Effect of law, April 1982-December 1983*	-22.5	2.92
Effect of law, January 1984-December 1984	-9.7 [†]	1.06
Effect of law, April 1982-December 1984	-17.2	2.46

Baseline time-series model: ARIMA (0,0,0)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

obvious than the decrease in the number of moderately injured occupants, time-series analyses revealed a significant 17.2% decline in the number of severe injuries during the entire 33-month post-law period. The long-term effects of the law on number of severely injured children were smaller than the short-term effects (22.5% decline during the first 21 post-law months versus 17.2% decline over the 33-month post-law period). Comparing the results for moderate and severe injuries, it appears that the child restraint law had its largest impact on number of children experiencing moderate injuries, but also may have had some effect on the number of children seriously injured.

The contrast between the effect of the law on moderate versus severe injuries was larger when rates of injuries per million population were examined. The rate of moderate injuries per million population was 24.3% lower during the 33-month post-law period (Figure 3.35).⁸ The rate of severe injuries per million population, however, did not change at the time the child restraint law was implemented (Figure 3.36).

Figures 3.37 through 3.39 illustrate how the number of injured children has changed from 1978 through 1984 for low-, medium-, and high-damage crashes. The child restraint law was associated with a 47.7% reduction in the number of occupants injured in low-damage crashes, compared to declines of 31.8% and 32.4% for medium- and high-damage crashes, respectively. For all three damage categories the effects of the law in 1984 were slightly smaller than the effects in 1982 and 1983. The child restraint law appears to have had a larger impact in reducing the number of children injured in cars experiencing low levels of damage than among children in cars experiencing extensive damage. This finding is consistent with the finding that the primary effect of the law was in reducing the number of children experiencing moderate injuries.

The larger effect of the child restraint law in reducing the number of occupants with less severe injuries and the number of occupants injured in low-damage crashes has three possible explanations. First, child restraints could be less effective in preventing serious injuries occurring in high-damage crashes than moderate injuries occurring in low-damage crashes. Available evidence indicates that there is a small difference in the effectiveness of child restraint devices at different levels of impact, provided there is no intrusion into the passenger compartment of the vehicle.⁹ For example, Hall and others (1984) estimate that proper use of child restraint devices reduces the probability of severe head injury or death by 81% in low-damage crashes and 74% in high-damage crashes; proper use of CRDs reduces the probability of any injury by an estimated 66% in low-damage crashes and 59% in high-damage crashes. Such differences in CRD effectiveness may partially explain the differential effect of the child restraint law in reducing the number of children injured across levels of vehicle damage.

A second possible explanation for finding a larger effect of the child restraint law on moderate injuries and low-damage crashes is that it reflects an artifact of the injury reporting

8. This decrease was significant at $p < 0.10$, but not $p < 0.05$.

9. Although intrusion is more likely to occur in crashes with higher levels of vehicle damage, recent estimates indicate that less than 10% of all crashes involved intrusions of more than 5 centimeters (The University of Michigan Transportation Research Institute, 1984). This estimate is based on 1983 data from the National Accident Sampling System, and is limited due to the large proportion of cases for which intrusion status was unknown.

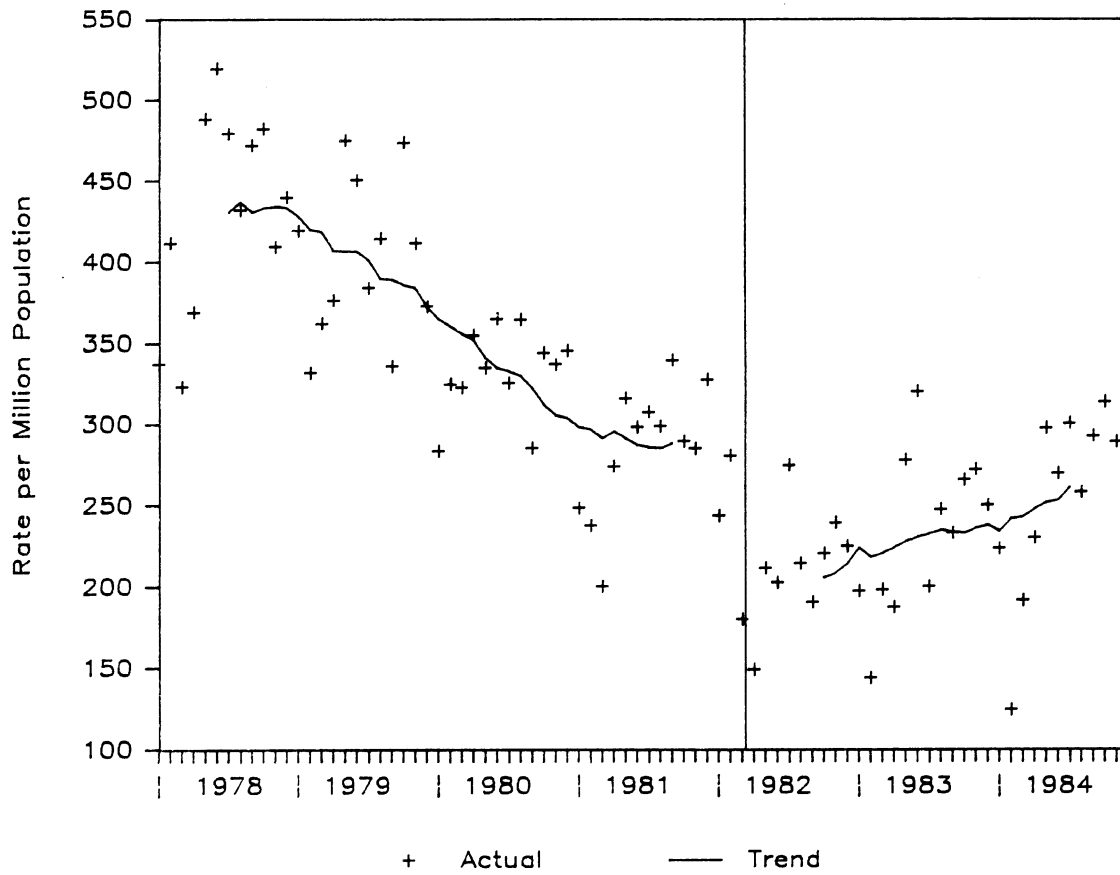


Figure 3.35 Rate of Moderately Injured Occupants Age 0-3 per Million Population

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-30.2	2.40
Effect of law, April 1982-December 1983*	-21.1 [†]	1.51
Effect of law, January 1984-December 1984	-30.9	1.94
Effect of law, April 1982-December 1984	-24.3 [†]	1.48

Baseline time-series model: ARIMA (0,1,3)(0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

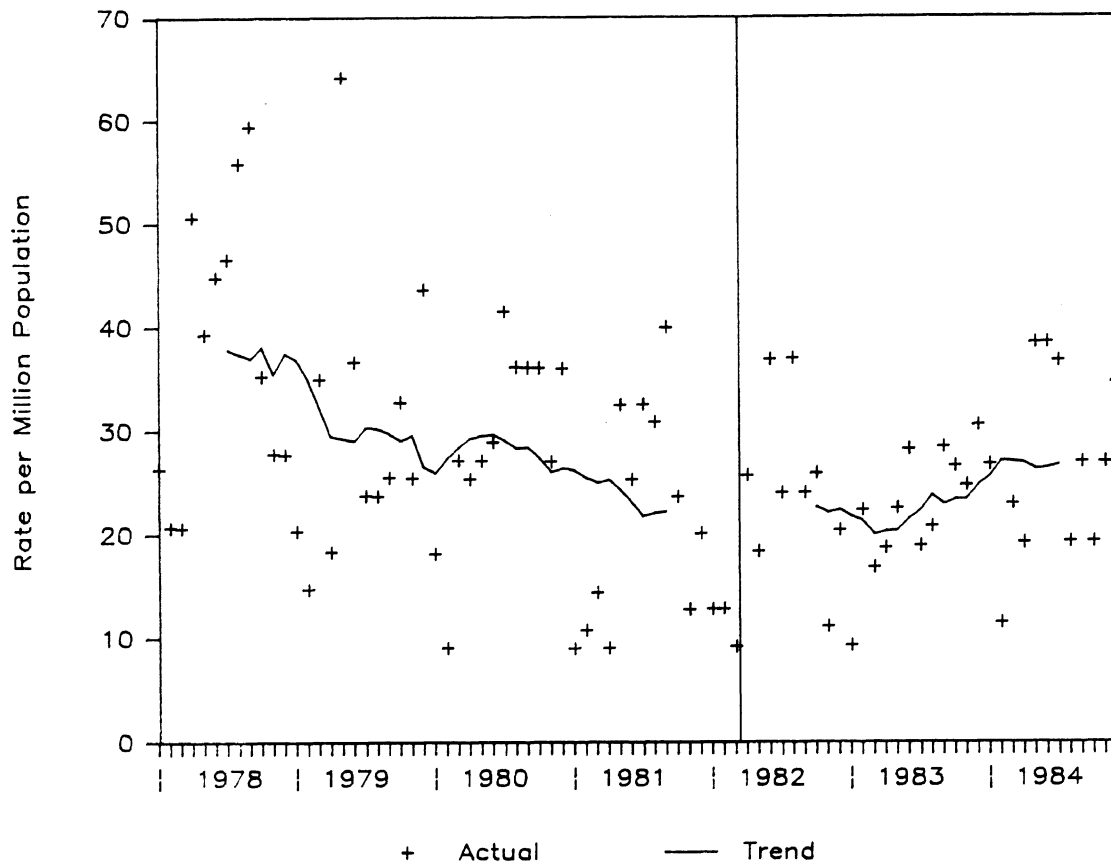


Figure 3.36 Rate of Severely Injured Occupants Age 0-3 per Million Population

	Percent Change	t-Ratio
Effect of PI & E, January-March 1982	-19.6	2.00
Effect of law, April 1982-December 1983*	-26.5 [†]	1.42
Effect of law, January 1984-December 1984	-4.0 [†]	0.34
Effect of law, April 1982-December 1984	-1.4 [†]	0.12

Baseline time-series model: ARIMA (0,1,3)(0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

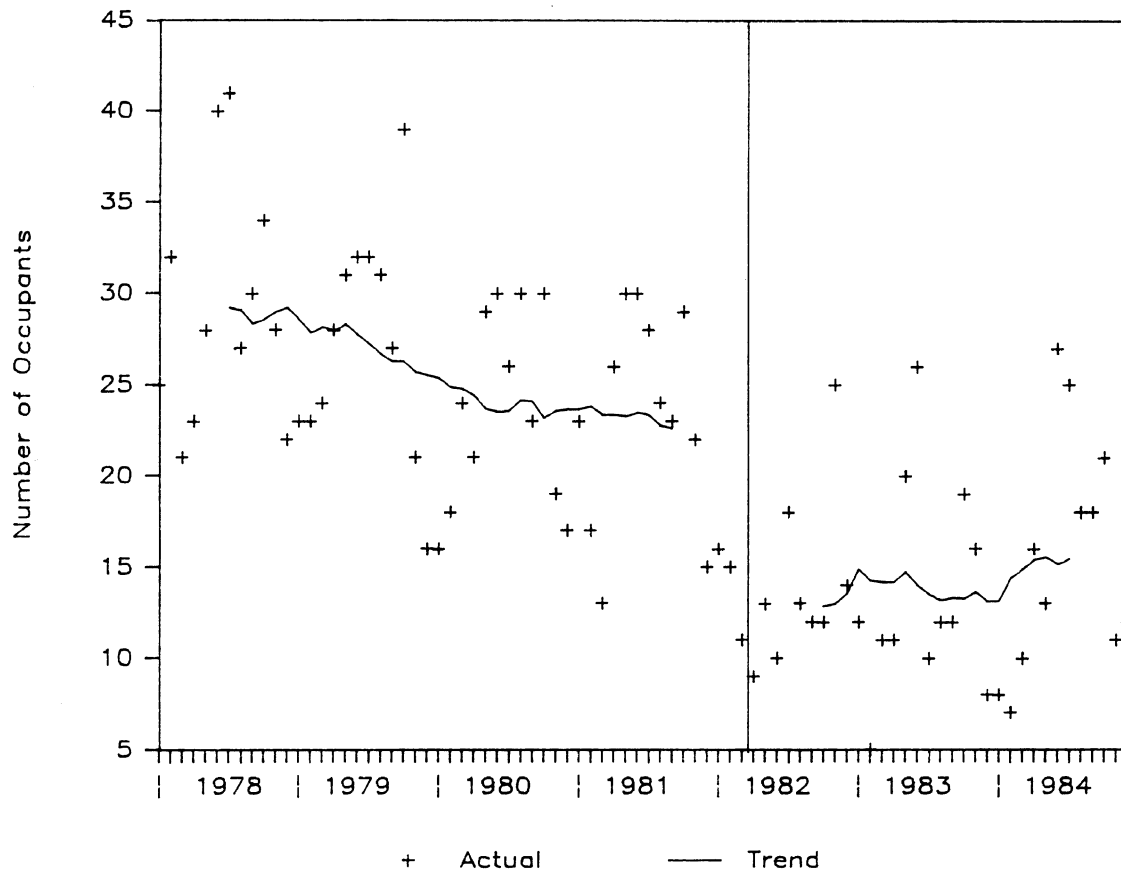


Figure 3.37 Injured Occupants Age 0-3 in Low-damage Vehicles

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-26.2	2.00
Effect of law, April 1982-December 1983*	-50.6	10.67
Effect of law, January 1984-December 1984	-42.7	7.25
Effect of law, April 1982-December 1984	-47.7	10.90

Baseline time-series model: ARIMA (0,0,0)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

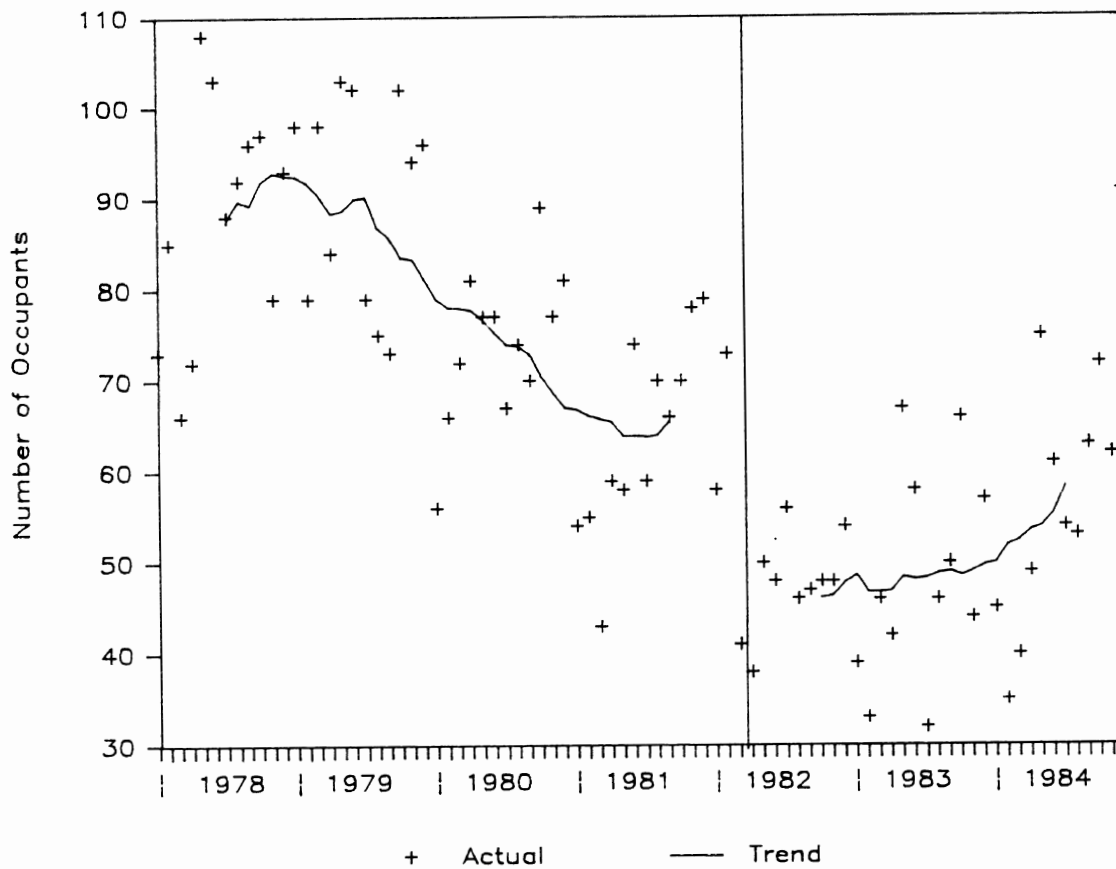


Figure 3.38 Injured Occupants Age 0-3 in Medium-damage Vehicles

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	5.5 [†]	0.43
Effect of law, April 1982-December 1983*	-28.2	2.55
Effect of law, January 1984-December 1984	-14.0 [†]	0.83
Effect of law, April 1982-December 1984	-31.8	2.63

Baseline time-series model: ARIMA (0,1,1)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

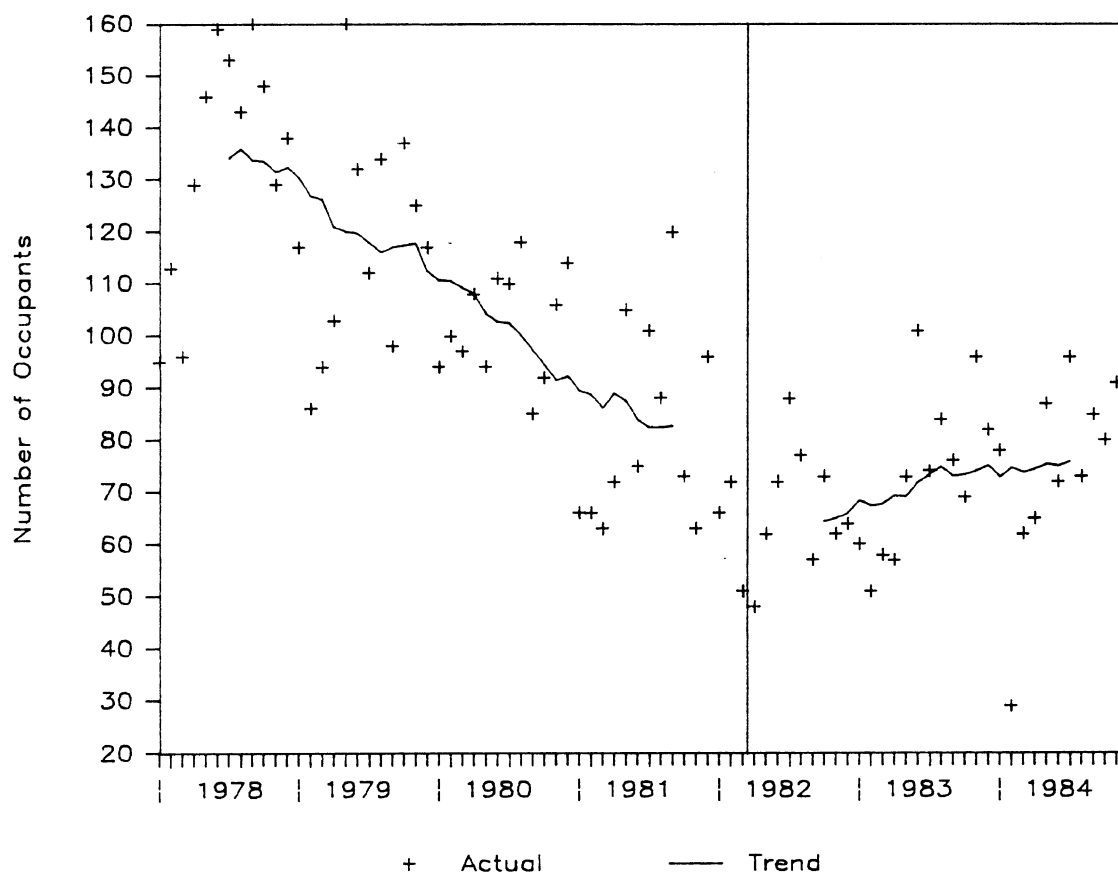


Figure 3.39 Injured Occupants Age 0-3 in High-damage Vehicles

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-24.0	2.39
Effect of law, April 1982-December 1983*	-33.3	5.61
Effect of law, January 1984-December 1984	-30.8	4.35
Effect of law, April 1982-December 1984	-32.4	5.92

Baseline time-series model: ARIMA (0,0,5)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

† Percent change not significantly different from zero, $p < .05$, one-tailed test.

system upon which these data are based. A police officer's coding of some minor injuries may be based on the self-report of drivers involved in the crash. If it is required by law that drivers restrain children, when crash involved they may be slightly less likely to report a minor injury if they were violating the law by driving with an unrestrained child. Such underreporting of minor injuries may bias the estimate of the effect of the child restraint law by producing a larger estimated decline in less severe injuries than is true. It is unlikely that such underreporting accounts for more than a very small part of the estimated decline in the number of children injured following implementation of the child restraint law, because most parents are likely to be more concerned for the safety of their child than concerned about the consequences of admitting the violation of a law that results in a fine of only \$10.¹⁰

A third possible explanation is that the post-law increase in restraint use among children with a higher than average probability of involvement in a serious crash may have been less than the average increase in restraint use. In fact, there are some indications of a varying effect of the law on restraint use according to vehicle damage severity. Restraint use rates among 0-3 year olds before and after the law took effect were compared for children in low-, medium-, and high-damage crashes. Children in low-damage vehicles increased their restraint use 204%, children in medium-damage vehicles increased 179%, while children in high-damage vehicles increased their restraint use by (only) 151%.¹¹ The smaller increase in restraint use among those in high-damage vehicles may partially explain the smaller effect of the law in reducing the number of children severely injured and number injured in high-damage vehicles.

The effect of the child restraint law on the number of children injured was also analyzed separately for different seating positions. Under current law, children under age 1 to 4 in the front seat must be restrained in an approved child restraint device, but such children riding in the rear seat may use an adult lap belt. Furthermore, publicity and education programs surrounding the law advocated placing children in the rear seat for maximum safety.

Time series of the number of children injured for five different seating positions were analyzed: (1) front-center, (2) front-right, (3) rear-left, (4) rear-center, and (5) rear-right. An examination of Figures 3.40 through 3.44 reveals pronounced differences in the effect of the child restraint law according to seating position of the child. Substantial decreases in the number of children injured while sitting in front-center and front-right seats are evident in these figures; the number of front-center occupants injured decreased 44.5%, and the number of front-right occupants injured decreased 39%. The number of children injured in the rear-center position, generally considered the safest seating position, declined by 52% after the law took effect. However, there were increases in the number of children injured in rear-left and rear-right seating positions, though these increases were statistically significant only after the 1984 data were added. Given that there is no measure of the number of uninjured occupants in these various seating positions, it is not possible to prove whether these differential effects are due to different rates of restraint use by seating positions, differences in the protection provided by the

10. Furthermore, the small fine is infrequently imposed.

11. These estimates are based on simple comparisons of restraint use during April-December 1982, after the law was implemented, with use during the April-December 1981 period, before the law took effect. Detailed time-series models of restraint use stratified by vehicle damage level were not developed.

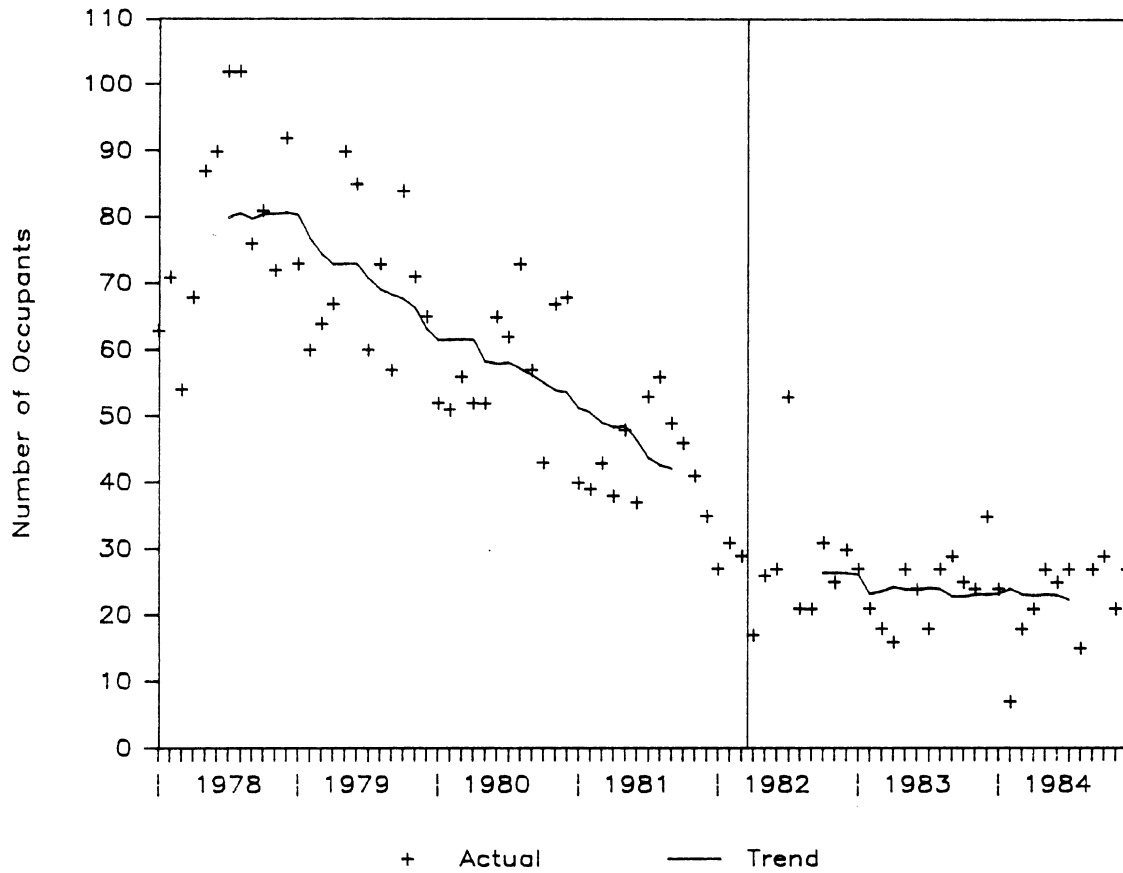


Figure 3.40 Injured Occupants Age 0-3 in Front-center Position

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-34.1	2.20
Effect of law, April 1982-December 1983*	-54.7	3.03
Effect of law, January 1984-December 1984	-59.7	3.69
Effect of law, April 1982-December 1984	-44.5	3.36

Baseline time-series model: ARIMA (0,1,1)(0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

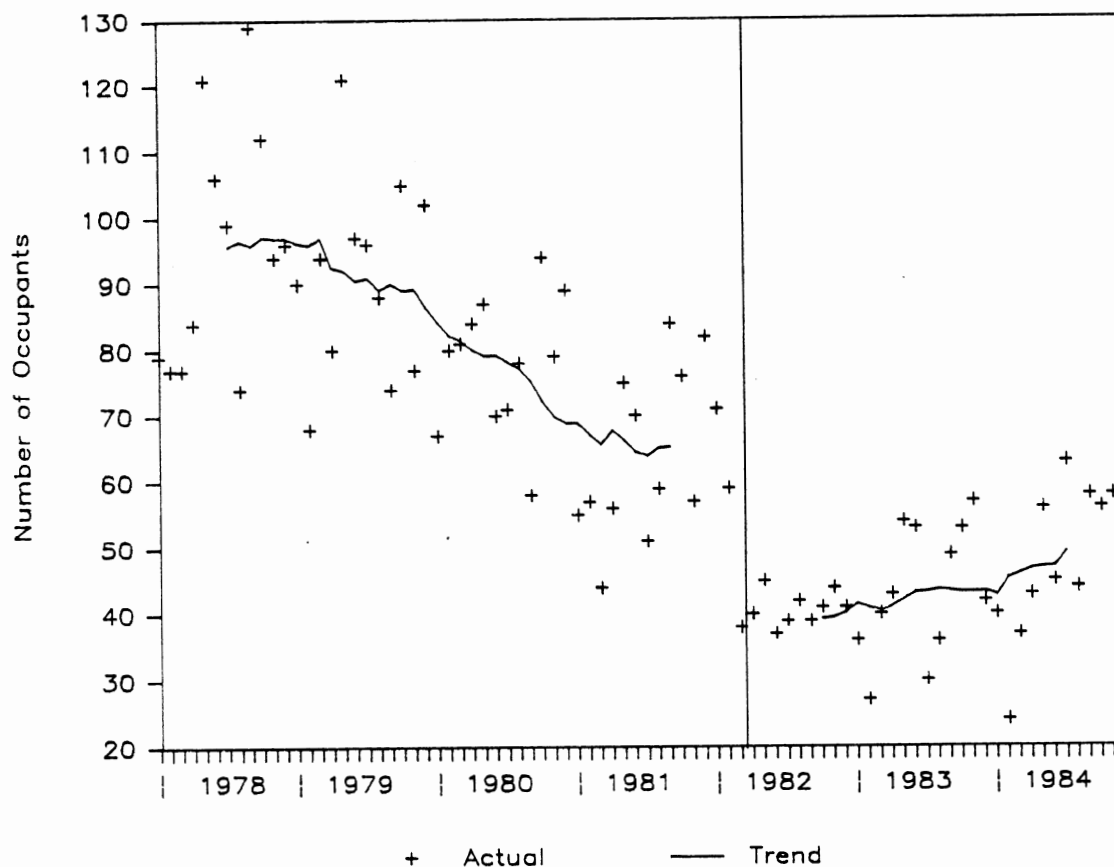


Figure 3.41 Injured Occupants Age 0-3 in Front-right Position

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-19.7 [†]	1.35
Effect of law, April 1982-December 1983*	-38.3	2.78
Effect of law, January 1984-December 1984	-46.9	2.77
Effect of law, April 1982-December 1984	-39.0	3.21

Baseline time-series model: ARIMA (0,1,1)(0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

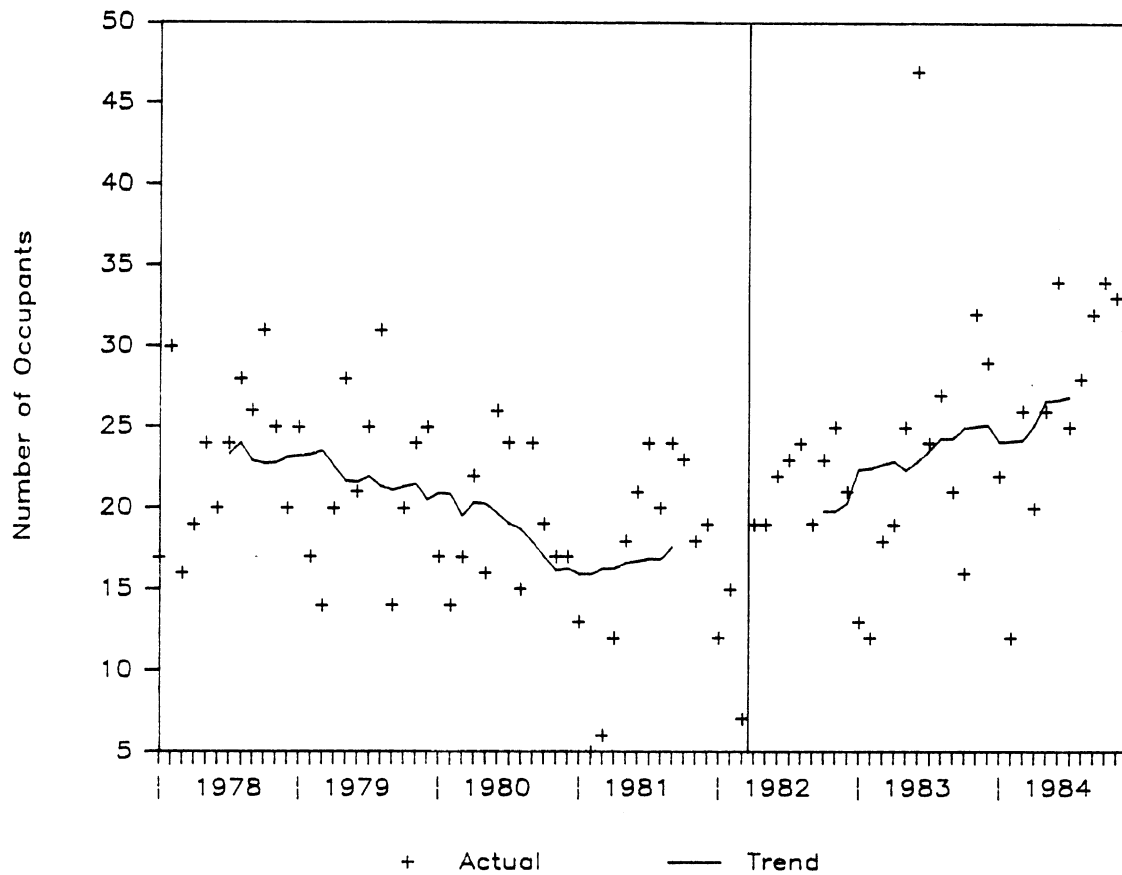


Figure 3.42 Injured Occupants Age 0-3 in Rear-left Position

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	27.8	1.69
Effect of law, April 1982-December 1983*	9.7 [†]	1.05
Effect of law, January 1984-December 1984	35.6	3.14
Effect of law, April 1982-December 1984	20.0	2.27

Baseline time-series model: ARIMA (0,0,1)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

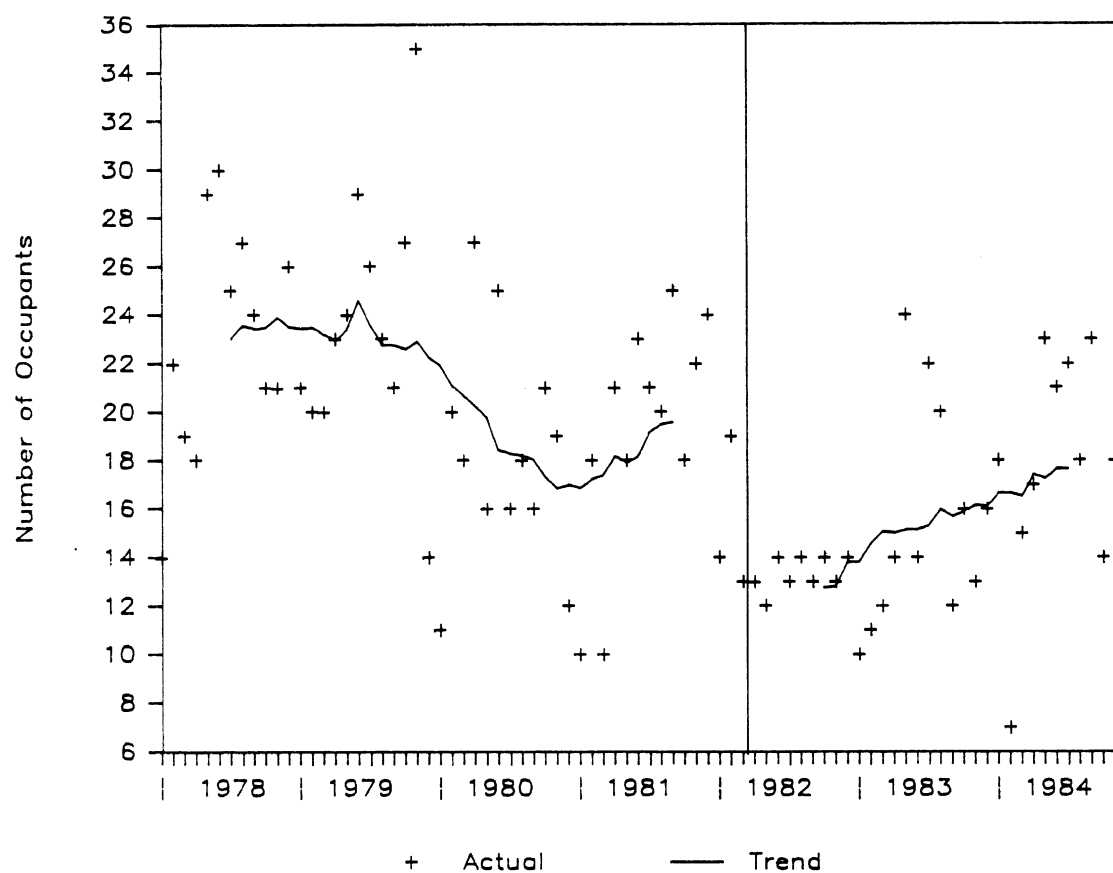


Figure 3.43 Injured Occupants Age 0-3 in Rear-center Position

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-15.1 [†]	1.21
Effect of law, April 1982-December 1983*	-52.2	5.28
Effect of law, January 1984-December 1984	-51.6	4.34
Effect of law, April 1982-December 1984	-52.0	5.57

Baseline time-series model: ARIMA (0,1,1)(0,0,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

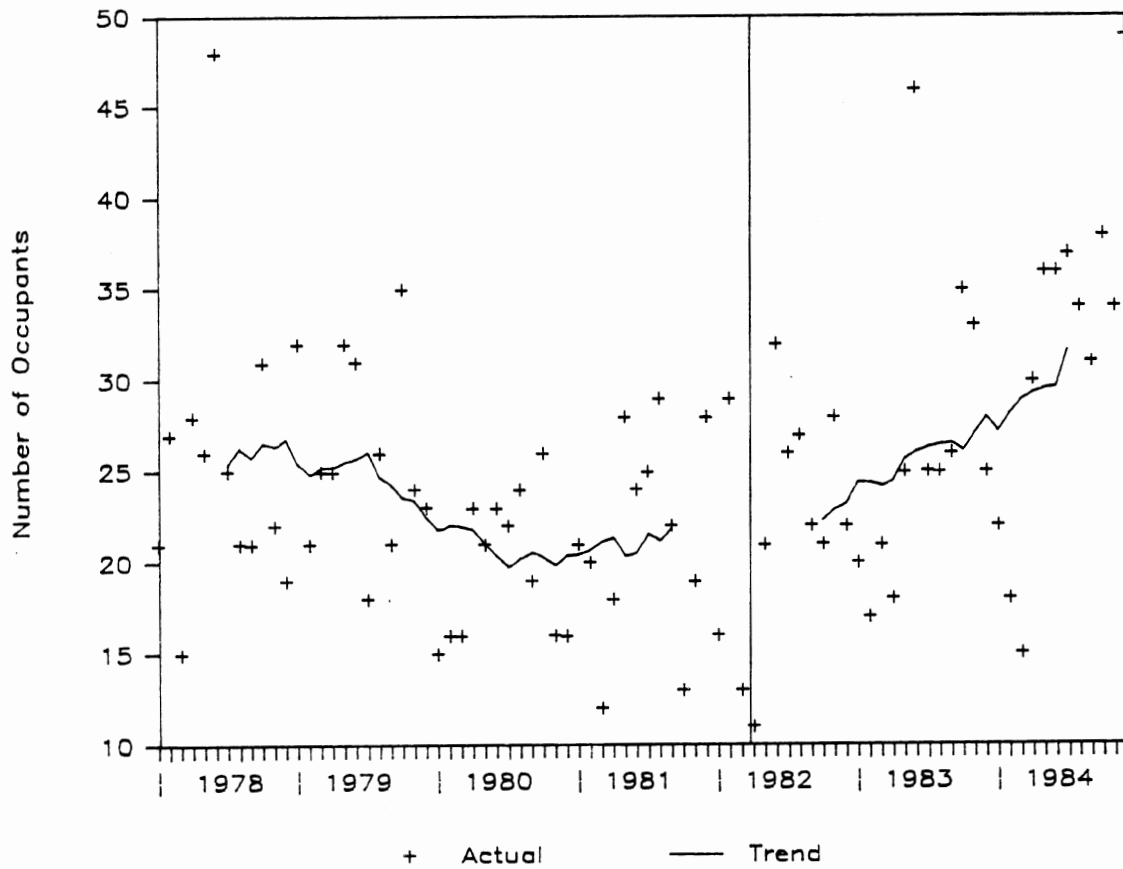


Figure 3.44 Injured Occupants Age 0-3 in Rear-right Position

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	3.0 [†]	0.19
Effect of law, April 1982-December 1983*	4.3 [†]	0.65
Effect of law, January 1984-December 1984	35.1	4.07
Effect of law, April 1982-December 1984	15.4	2.34

Baseline time-series model: ARIMA (0,0,0)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

restraint device in different seating positions, or to a shift in the seating patterns of children following passage of the child restraint law and related PI&E efforts. There is other evidence, however, that child restraint laws may be associated with a decrease in children riding in the front seat. For example, the National Highway Traffic Safety Administration's 19-city observation survey of restraint use found 64% of infants (under age 1) riding in a front-seat position and 36% in a rear-seat position in the 1977-79 study, before child restraint laws were passed. However, in 1982-83, after many states passed child restraint laws, the distribution between front and rear was 50-50. For toddlers age 1-3, 44% were in the front and 56% in the rear in 1977-79, but 35% were in the front and 63% in the rear in 1982-83 (Phillips, 1980; Perkins, Cynecki, and Goryl, 1984). O'Day and Wolfe (1984), found only 22% of children under 4 in front-seat positions, while 78% were in rear-seat positions in a Michigan statewide survey in September 1983, after Michigan's child restraint law was in effect. Similar data collected before Michigan's law took effect are not available. Nevertheless, available data indicate that one reason for a larger effect of the law on the number of front-seat child occupants injured was a decrease in the proportion of children riding in front-seat positions.

Observational studies have shown wide discrepancies between urban and rural communities in terms of the rate of adult and child restraint use and the amount of change in those rates subsequent to the passage of mandatory child restraint laws (Ward and Clearie, 1982; Agent, 1983; Ashton, 1983; Schnerring, 1983). To determine if Michigan's child restraint law had a differential impact on urban versus rural communities, counties were collapsed into five groups based on population density. The 83 counties were ranked by their population density, and cutpoints for four groups were based on an analysis of changes in the slope of a plot of the ranked population densities. Wayne County (which includes the City of Detroit) was analyzed separately because it has a very high population density and is significantly different from the rest of the state on a number of socioecological factors.¹²

The present study found that the most densely populated areas experienced the smallest declines in injuries associated with the law (Figures 3.45 through 3.49). The child restraint law was associated with the following reductions in the number of children injured: 32.7% in low-density counties, 35.3% in medium-density counties, 35% in high-density counties, 25.9% in very-high-density counties, and 23.6% in Wayne County. However, even in very-high-density counties (including Wayne County) a significant reduction in the number of children injured was found. Addition of 1984 data did not appreciably change the pattern of legal impact by population density.

Family income is known to be related to restraint use and may help explain why Michigan's child restraint law had less effect in very-high-density urban areas. The differential effects of the law across areas with various levels of poverty were examined. The 83 Michigan counties were grouped in terms of the percentage of persons in the county falling below the poverty line. Each county was ranked by the percent of residents below the poverty line, and the counties (with the exception of Wayne) were collapsed into groups. Four groups resulted from

12. Population densities for the groups are as follows (in people per square mile of land area: low-density counties ranged from 3.7 to 69.9, medium-density counties ranged from 78.2 to 235.5, high-density counties ranged from 267.7 to 387.2, very-high-density counties ranged from 491 to 1440, and Wayne County has a density of 3711 persons per square mile. All population data are based on the 1980 census, as recorded in the *1983 City and County Data Book*, published by the U.S. Department of Commerce.

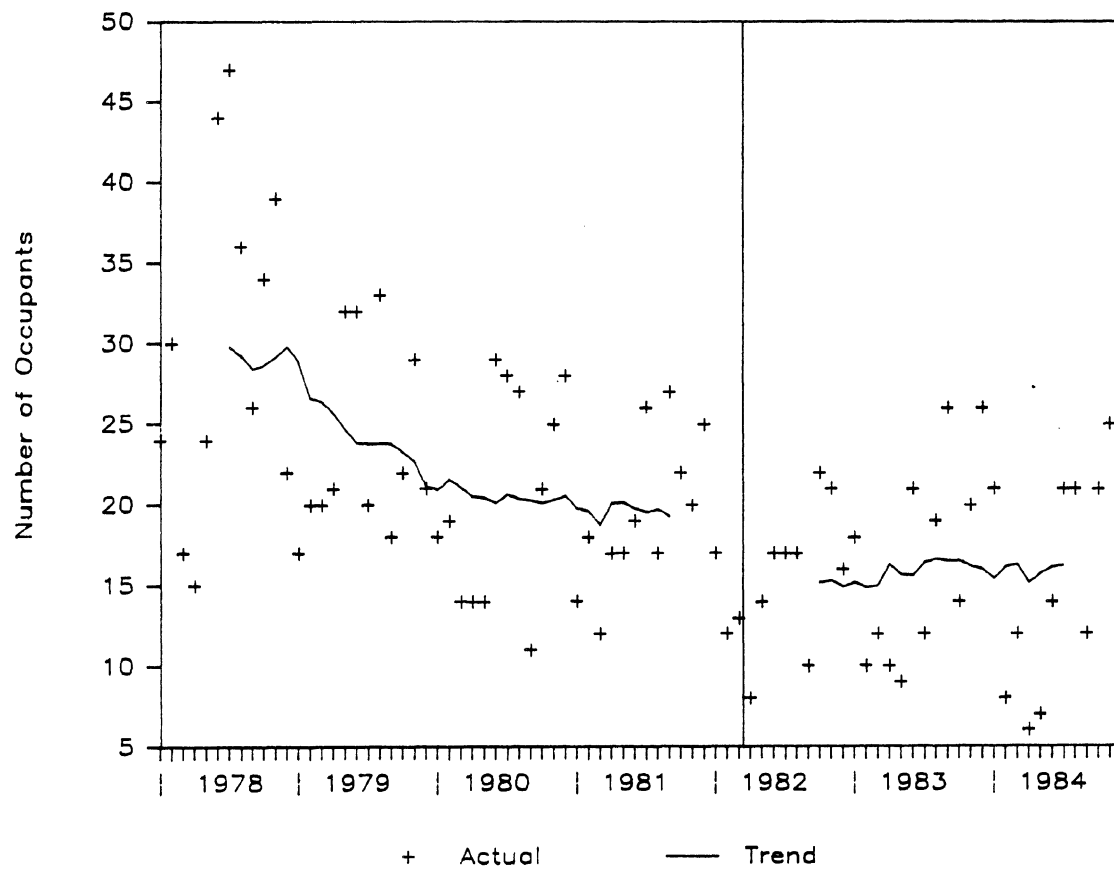


Figure 3.45 Injured Occupants Age 0-3 in Low-density Counties

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-24.2 [†]	1.63
Effect of law, April 1982-December 1983*	-32.1	5.21
Effect of law, January 1984-December 1984	-33.7	4.60
Effect of law, April 1982-December 1984	-32.7	6.06

Baseline time-series model: ARIMA (0,0,0)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

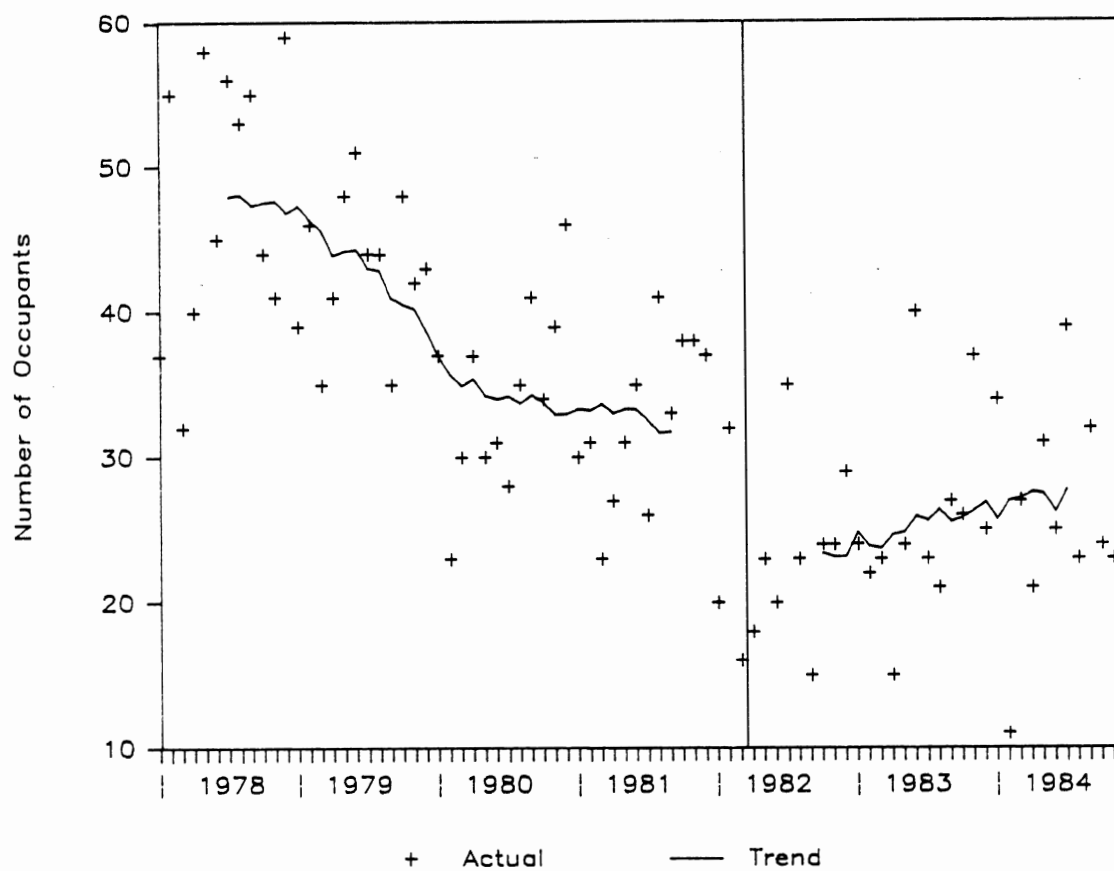


Figure 3.46 Injured Occupants Age 0-3 in Medium-density Counties

	Percent Change	t-Ratio
Effect of PI & E, January-March 1982	-35.3	2.99
Effect of law, April 1982-December 1983*	-37.6	6.20
Effect of law, January 1984-December 1984	-31.1	4.14
Effect of law, April 1982-December 1984	-35.3	6.22

Baseline time-series model: ARIMA (0,0,1)₅(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

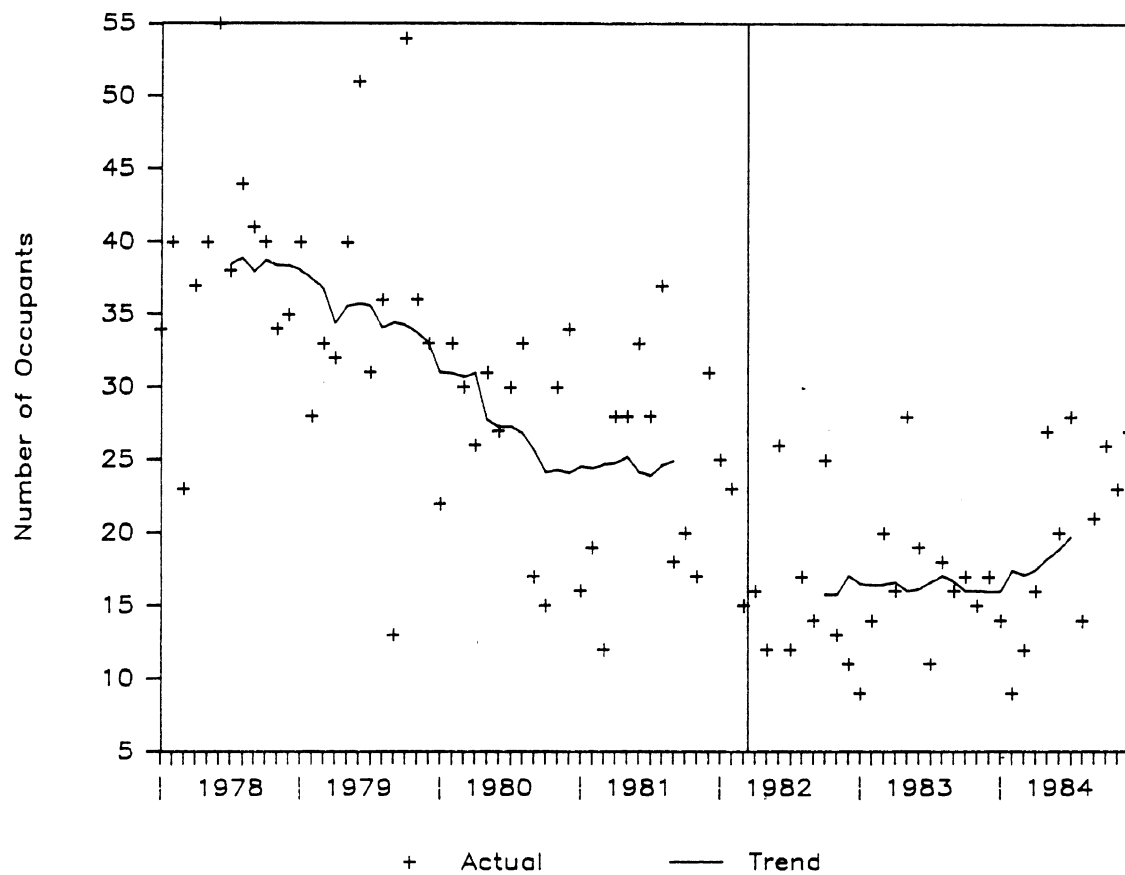


Figure 3.47 Injured Occupants Age 0-3 in High-density Counties

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-13.6 [†]	0.67
Effect of law, April 1982-December 1983*	-35.2	2.58
Effect of law, January 1984-December 1984	-29.1 [†]	1.56
Effect of law, April 1982-December 1984	-35.0	2.48

Baseline time-series model: ARIMA (0,1,1)(0,0,1)₃(0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

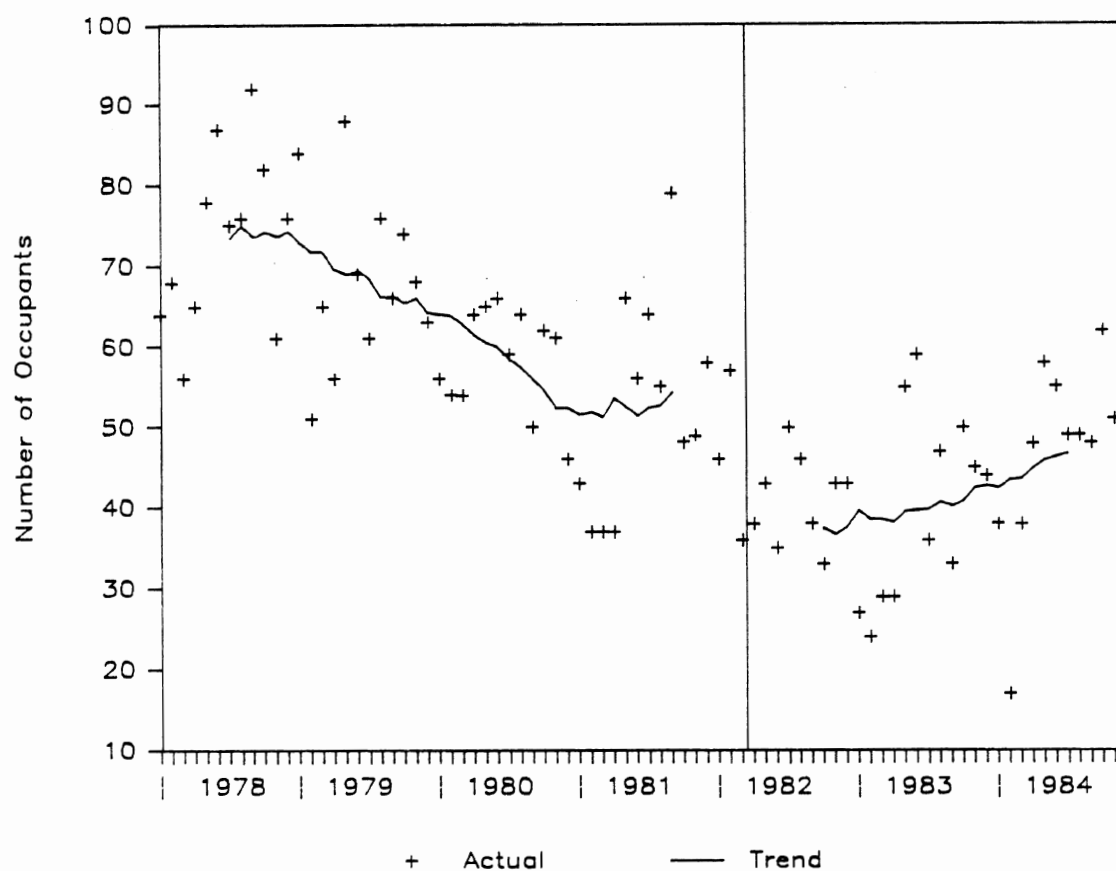


Figure 3.48 Injured Occupants Age 0-3 in Very High-density Counties

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	20.3 [†]	1.50
Effect of law, April 1982-December 1983*	-17.4	1.99
Effect of law, January 1984-December 1984	3.4 [†]	0.23
Effect of law, April 1982-December 1984	-25.9	2.32

Baseline time-series model: ARIMA (0,1,1)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

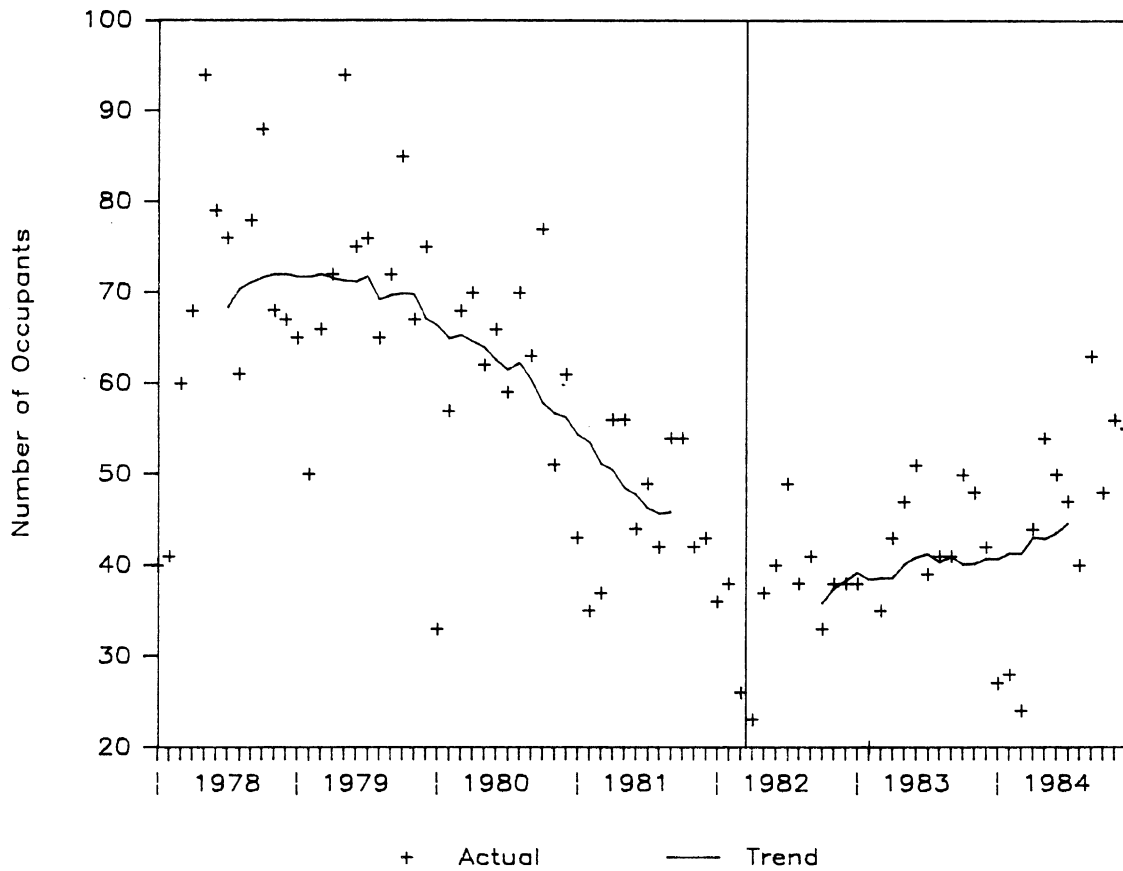


Figure 3.49 Injured Occupants Age 0-3 in Wayne County

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-18.0 [†]	0.97
Effect of law, April 1982-December 1983*	-22.7 [†]	1.26
Effect of law, January 1984-December 1984	-27.2 [†]	1.28
Effect of law, April 1982-December 1984	-23.6 [†]	1.36

Baseline time-series model: ARIMA (0,1,3)(0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

this process: (1) low-poverty counties, with less than 9.5% of their population below the poverty line, (2) medium-poverty counties, with 9.6% to 12.7% below the poverty line, (3) high-poverty counties, with over 12.9% below the poverty line, and (4) Wayne County, with 14% of its residents below the poverty line.¹³

There was no consistent relationship between the extent of poverty in an area and the magnitude of the impact of the child restraint law. Analyses revealed the following declines in the number of child occupants injured in the 33 months after the child restraint law took effect: 23.6% in Wayne County, 28.9% in low-poverty counties, 28.6% in medium-poverty counties, and 35.9% in high-poverty counties (Figures 3.50 through 3.52).

13. Poverty data are from the *1983 City and County Data Book* published by the U.S. Department of Commerce, Bureau of the Census.

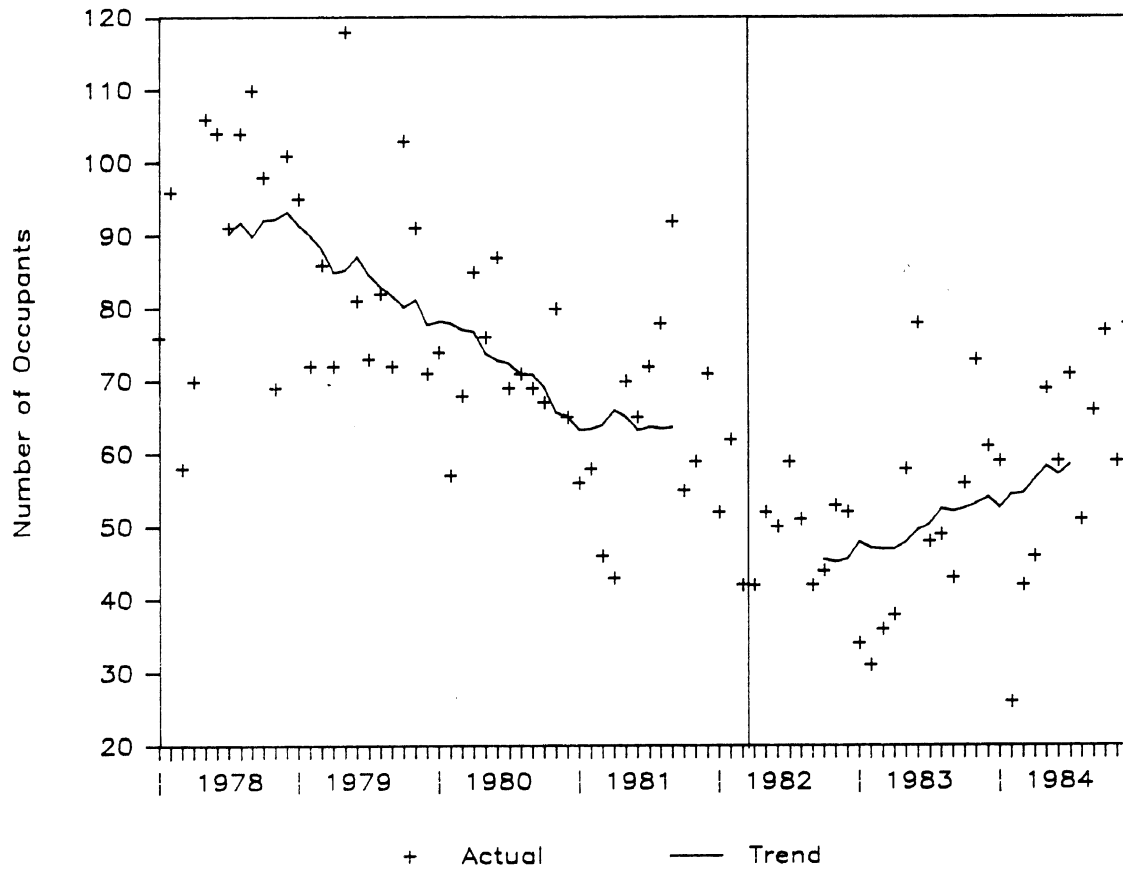


Figure 3.50 Injured Occupants Age 0-3 in Low-poverty Counties

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-27.2	2.02
Effect of law, April 1982-December 1983*	-29.8	2.71
Effect of law, January 1984-December 1984	-23.0 [†]	1.57
Effect of law, April 1982-December 1984	-28.9	2.43

Baseline time-series model: ARIMA (0,1,2)(0,0,1)₉(0,0,0)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

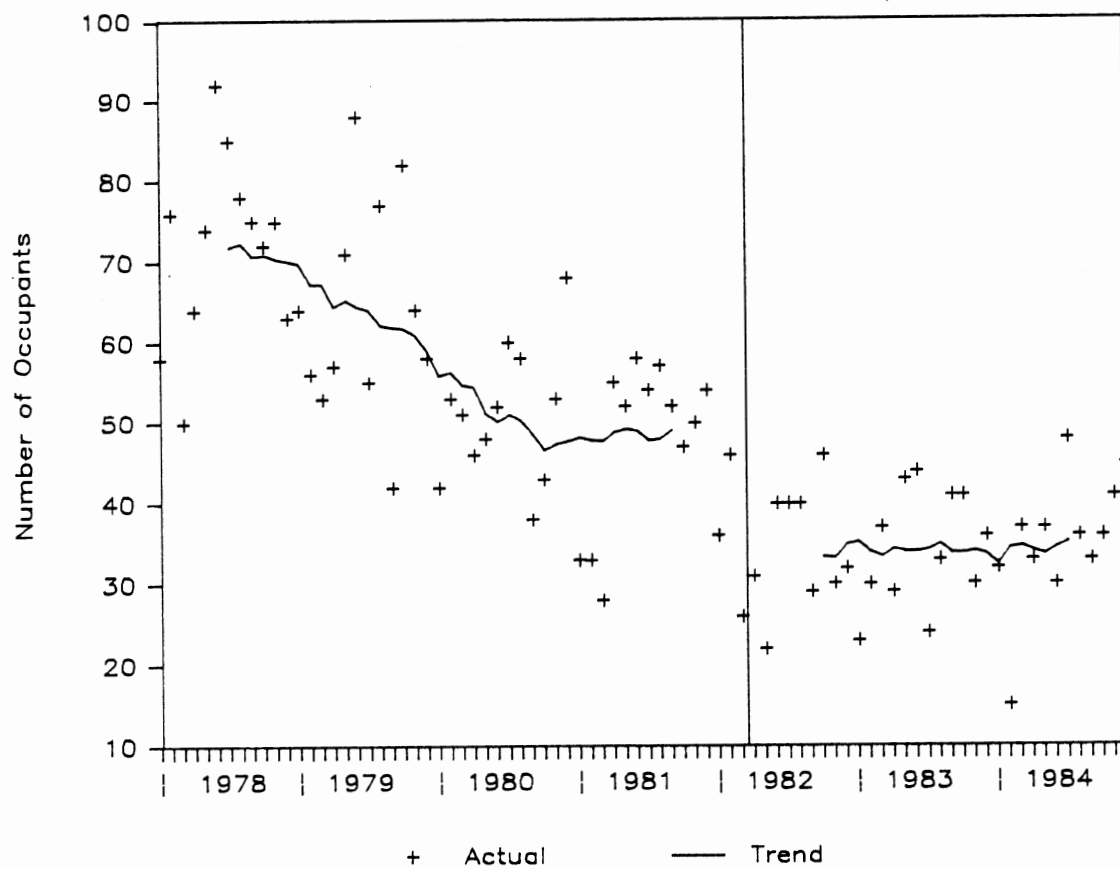


Figure 3.51 Injured Occupants Age 0-3 in Medium-poverty Counties

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	-0.9 [†]	0.06
Effect of law, April 1982-December 1983*	-19.7	1.92
Effect of law, January 1984-December 1984	-1.5 [†]	0.09
Effect of law, April 1982-December 1984	-28.6	2.41

Baseline time-series model: ARIMA (0,1,1)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

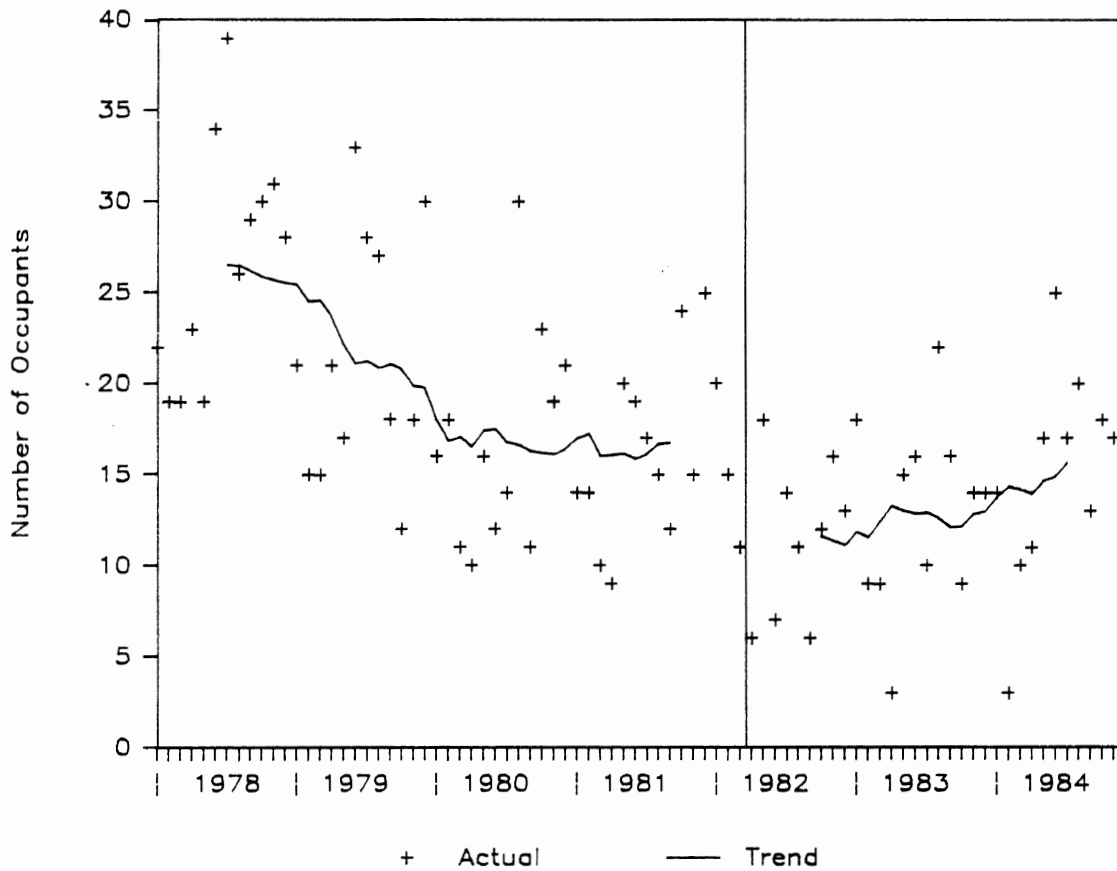


Figure 3.52 Injured Occupants Age 0-3 in High-poverty Counties

	Percent Change	<i>t</i> -Ratio
Effect of PI & E, January-March 1982	0.5 [†]	0.02
Effect of law, April 1982-December 1983*	-41.9	5.77
Effect of law, January 1984-December 1984	-24.7	2.57
Effect of law, April 1982-December 1984	-35.9	5.07

Baseline time-series model: ARIMA (0,0,0)(0,1,1)₁₂

* Effective date of mandatory child restraint law was April 1, 1982.

[†] Percent change not significantly different from zero, $p < .05$, one-tailed test.

4 DISCUSSION

Restraint use among young children in the 33 months after Michigan's mandatory child restraint law took effect was 307% higher than would have been expected without the law. Restraint use increased from 10% to 12% during the 1978-81 baseline period to 48% to 53% during the 1982-84 post-law period. There appears to have been some spillover effect of the law on 4-15 year olds, with their use rate increasing from 6% before to 16% after. Much smaller increases in restraint use were found among motorists of other ages.

More importantly, results indicated that a 27% decline in the number of injured children under age 4 is associated with passage of the child restraint law. This 27% decrease means that an estimated 564 children per year are apparently saved from injury by the mandatory child restraint law. A decline of this magnitude in the number of children injured was consistently found, whether analyzing the raw number of children injured, the rate of occupants injured per million population, the rate of occupants injured per crashed vehicle, the rate of occupants injured per mile traveled, or the percent of all injured occupants accounted for by young children. There were no significant ($p < 0.05$) declines in the rate of occupants injured for other age groups, with the exception of a 6% decrease among 18-24 year olds. A large decrease in the number of injured children under age 4, without similar decreases in the number of occupants injured for other age groups not subject to the law, provides considerable support for the hypothesis that the law caused the decrease in the number of children injured.

Most of the injuries prevented as a result of compulsory restraint use were moderate injuries (frequency down 32%, rate per million population down 24% over the 33-month post-law period). The number of severely injured children declined 17%, while the rate of severe injuries per million population showed no significant change over the 33-month post-law period. The largest declines in number of children injured were seen among occupants in crashes involving low levels of vehicle damage (48%), and among occupants in the rear-center seat position (52%).

In general, an additional year of follow-up data had little impact on the estimated effects of the child restraint law. The immediate effects of the law have been maintained through 1984. However, the addition of follow-up data through 1984 made clear the discrepancy between the effects of the law on moderate versus severe injuries. Previous reports on the shorter term effects of the law noted a smaller effect on severe injuries (Wagenaar, 1984a; Wagenaar and Webster, 1985). By mid-1984, the rate of severe injuries per million children returned to the levels seen in 1980, while the rate of moderate injuries remained clearly lower than 1980 (compare trend lines in Figures 3.35 and 3.36).

Significant reductions occurred in rates of children injured while seated in the front-center, front-right, and rear-center positions; the number of injured children sitting in either the right or left side of the rear seat increased (rear-left, up 20%; rear-right, up 15%). This finding may reflect a change in seating positions of children after the child restraint law. Available

evidence indicates that a decrease in the proportion of young children riding in the front seat and an increase in the proportion riding in the rear seat follows passage of child restraint laws. Because rear-seat positions are generally safer than front-seat positions, a shift of some children from front to rear seats may contribute to the beneficial effects of the law in reducing the overall number of children injured.

There were some differences in the effects of the law across counties stratified by population density. The highest density counties in the state experienced a 24% to 26% decline in the number of children injured following the child restraint law, while lower density counties experienced a 33% decline. There was no consistent relationship between the proportion of a county's population below the poverty level and the magnitude of the effects of the child restraint law.

Results of this study clearly indicate that Michigan's child restraint law has been associated with significant increases in reported restraint use and significant declines in the reported number of injured young children. The accuracy of these estimates of the effects of Michigan's law was enhanced by: (1) examination of multiple comparison age groups, (2) use of state-of-the-art statistical methods, and (3) careful consideration of confounding variables, including analyses of rates based on various indicators of aggregate exposure to risk of injury. However, definitive conclusions regarding the exact magnitude of the effects of the child restraint law are limited by the quality of the data on which the analyses are based. As with any source of data, police records on restraint use and number of injured children in traffic crashes are not perfect. First, the measure of restraint use is based on police officers' judgments concerning use in serious crashes and on a combination of officer judgment and motorist self-reporting in less serious crashes. Motorists with young children might be less likely to correctly report an unrestrained child when restraint use is legally required. Thus, a change in reported restraint use after the law took effect may be a combination of a change in actual use and a change in reporting.

The main question, however, is whether police crash reports accurately reflect actual trends in the number of children injured in motor-vehicle crashes. Recent studies indicate that police reports underestimate the number of motor-vehicle-related injuries. Two studies by McGuire (1973, 1976) found that driver self-reports often reveal more crashes than are indicated in police reports. Bull and Roberts (1973) reported that 30% of the injury-producing crashes in England had not been reported to police. In a survey of records from hospital emergency departments in northeastern Ohio, Barancik and others (1983) found that 43% of the crash-related injuries were not recorded in police crash reports.

Underreporting the true incidence of occupant injury in police crash reports does not necessarily imply that police reports cannot be used to assess the effects of a mandatory restraint law. If the law has not affected reporting practices, then the proportion of injuries which do not get into police records should be relatively constant through the pre-law and post-law periods. A consistent undercount of the number of occupants injured does not prevent an accurate estimate of the **change** in injury frequency associated with the mandatory restraint law. A more serious question is whether **reporting** of injured occupants changed when the law took effect. Such a coincidental change in reporting would make it more difficult to determine the true impact of the

law on the incidence of occupant injury. It is possible that drivers involved in crashes are less likely to report injured children after a law mandating child restraint use is implemented. Because the penalty for failure to restrain a child in Michigan is a maximum of \$10, however, and because citations for failure to restrain a child are infrequent, there is little incentive for a crash-involved driver to lie about injured children.

Results of this study clearly indicate that Michigan's mandatory child restraint law was effective in substantially reducing the number of children injured in motor-vehicle crashes. The beneficial effects of the law were not short-lived, and continue essentially unchanged two and a half years after initial implementation. Nevertheless, the beneficial consequences of the child restraint law are not as large as desired. Almost half of young children involved in traffic crashes after the compulsory use law took effect were not restrained in a safety seat or seatbelt. The rate of severely injured crash-involved children did not substantially decline after the law was implemented. Both the demonstrated injury reductions following passage of the child restraint law and the limits to the beneficial effects of the law to date indicate that further programmatic and enforcement efforts are warranted for continued reductions in injury risk to young children.

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