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EFFECTIVENESS OF MICHIGAN'S MANDATORY CHILD RESTRAINT LAW

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16. Abstract

Michigan implemented a law in April, 1982, mandating the use of child restraint devices for children under age four traveling in automobiles. This study assessed the effects of that law on restraint use and injury rates among young children. Box-Jenkins intervention analysis models were developed using data on all police-reported crash-involved residents of Michigan between January, 1978, and December, 1983.

Results indicated a 299% increase in restraint use among crash-involved injured children under four years old after the child restraint law took effect. That is, the proportion of young children traveling restrained increased from 12% before to 51% after the law was implemented. More importantly, a 25% decrease in the number of children under age four injured in crashes was associated with the law. A reduction of this magnitude was repeatedly found, whether analyzing the raw frequency of children injured, the rate of injured children per crashed vehicle, the rate of injured children per vehicle mile traveled, or the proportion of all injured occupants accounted for by young children. The substantial increase in restraint use and decrease in number of children injured appear to be direct results of the law, since similar changes did not occur among any of the comparison age groups.

The 25% reduction in the number of injuries to young children means that an estimated 522 children per year are not injured because of Michigan's mandatory child restraint law. Based on these findings, expansion of the child restraint law to motorists of all ages is recommended.

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Chapter 1

INTRODUCTION

Although the number of traffic fatalities in Michigan declined 6.1% from 1982 to 1983, motor vehicle crashes continue to be a leading cause of death and disability for residents under age 45. In 1983, 1331 Michigan residents died and 135,811 were reported as injured in motor vehicle crashes. The health hazards associated with motor vehicle travel can easily be seen when fatal and serious injuries are aggregated. In 1983, 20,868 residents were killed or seriously injured, an increase of 5.2% from 1982. The total number of persons injured was up 4.4% from 1982 to 1983. Besides the enormous human loss and suffering, motor vehicle crashes impose significant economic loss on the State of Michigan.. One estimate of this loss in 1983 amounted to $1.2 billion (Michigan State Police, 1984).

There is widespread agreement that the proper use of occupant restraint systems substantially reduces the risk of death and injury associated with motor vehicle travel. Vehicle occupants in a crash reduce their risk of death or serious injury by almost half with the proper use of lap and shoulder belts. Similar estimates of the safety benefits for children properly restrained in safety seats are even higher.

The prevalence of motor vehicle related injuries and availability of effective protection in the form of seat belts has prompted some 30 jurisdictions around the world to adopt mandatory occupant restraint laws (Mackay, 1984b). A previous study of restraint use in Michigan recommended that the state make seat belt use compulsory for occupants of all ages (Wagenaar, 1984a). This recommendation was based on the beneficial effects found after implementation of Michigan's child restraint law and an examination of the benefits of mandatory seat belt laws in other countries.

New York, New Jersey, and Illinois recently became the first states in the nation to pass mandatory seat belt laws for adults. The landmark legislation in New York went into effect in December, 1984, but law enforcement officials did not begin issuing citations until January, 1985. The legislation requires that all front seat passengers over age ten be restrained by safety belts. Children under ten years old are required by the New York child passenger protection law to be protected by child restraint devices or conventional safety belts when riding in a vehicle. The state of New York holds the driver responsible for ensuring that he/she and all passengers under the age of 16 comply with the law. Passengers over 16 years old are responsible for themselves and can be cited for noncompliance. Persons in violation of the law are subject to fines of up to $50 (Chapters 365 and 366 of New York

Laws of 1984). New Jersey (National Safety Council, 1984) and Illinois (House Bill 2800) have enacted similar legislation. Some twenty-three other states, including Michigan, are currently considering seat belt legislation.

The enactment of state mandatory child restraint laws has also continued. Child restraint laws went into effect in 11 states in 1984, and five states have laws scheduled to go into effect in 1985. With Texas and Louisiana recently approving child restraint bills, Wyoming is the only state which has not taken legislative action to protect young children traveling in motor vehicles. Additionally, Kansas and Wisconsin have recently broadened the coverage of their child restraint laws.

The previous study, of which this is a follow-up, concluded that Michigan's child restraint law had an immediate impact of: (1) increasing restraint use among 1-3-year-olds from 12% to 36%; (2) reducing the number of crash-involved infants under age 1 reported injured by 50%; and (3) reducing the number of crash-involved children age 1-3 reported injured by at least 17%. Larger percentage declines were found in the less serious injury categories and among occupants of vehicles experiencing low or moderate damage (Wagenaar, 1984a).

The intent of this study was to determine whether the beneficial effects of the child restraint law: (1) remained constant through 1983, (2) have dissipated over time, or (3) have increased as more people have become accustomed to the law. Besides assessing the overall impact of the law, the current study examined effects of certain factors associated with restraint use and examined subpopulations that may be differentially affected by the law. The initial study suggested that the law may have varying effects according to such factors as seating position, time of day, day of week, severity of vehicle damage, and injury severity. The availability of an additional year of follow-up data for this study permitted more detailed analyses of such factors than was possible in the initial study. Understanding the relationship between these factors and the effect of the law may help to identify segments of the population that are not experiencing the full benefit of the law, so that intervention efforts may be designed appropriately.

Chapter 2

RECENT LITERATURE

Our 1984 report entitled *Restraint Usage Among Crash–involved Motor Vehicle Occupants* included a comprehensive review of the literature on the effects of mandatory restraint laws (Wagenaar, 1984a). This section provides an update by reviewing recent studies that were not available at the the time the previous report was prepared. Recent studies on the effects of adult seat belt use laws are discussed first, followed by a review of recent studies of child restraint laws.

2.1 Effects of Adult Restraint Laws

2.1.1 Australia

Earlier studies by Joubert (1979) and Vulcan (1978) reported dramatic increases in seat belt use in Victoria, Australia, after belt use became compulsory. A recent study by Manders (1983) indicated that the high rates of restraint use found after introduction of the seat belt law have been maintained. In an observational survey conducted in the Melbourne metropolitan area, 95% of drivers and 89% of all car occupants were wearing seat belts. The rate of restraint use varied little by the type of trip or time of day.

There has also been a decline in motor-vehicle-related fatalities since 1970, when the Victorian belt law was implemented. Trinca (1984) reports that there were 8.1 such deaths per 10,000 vehicles in 1970, compared to 3.4 deaths per 10,000 vehicles in 1982. This decline occurred despite a 50% increase in the number of licensed drivers and significant increases in fuel consumed and kilometers driven. Pedestrian and motorcycle fatalities have not decreased significantly during this period, providing support to the argument that the mandatory belt law contributed to the fatality declines. Nevertheless, it remains difficult to determine how much of the decline in death rate is attributable to compulsory seat belt use. Many casualty countermeasures were instituted in Victoria during the 1970s, including a maximum rural speed limit of 100 kilometers per hour, dramatic improvements in traffic control, and random breath testing stations to deter alcohol-impaired driving.

New South Wales instituted a compulsory seat belt law for occupants of passenger cars in October, 1971. Surveys of occupant restraint use report that restraint use increased from 30 to 75% within six months after the law was implemented (Schnerring, 1983). Rates of belt use gradually increased until 1976 and then declined slightly for five years. The 1981 survey reported belt use rates of 85% for drivers and 75% for front seat passengers in the metropolitan Sydney area. Approximately 76% of rural drivers used belts, according to the 1981 survey.

2.1.2 Canada

Quebec passed a mandatory seat belt law in August of 1976 for all passenger occupants weighing more than 23 kg (the approximate weight of a five-year-old child). Results of an observational survey by Stulginskas and Pless (1983) suggest that even the children not covered by Quebec's legislation may be benefitting from the law. The rate at which infants (children under age one) were being restrained before the law was 6%, compared to 49% in 1978. Restraint use for children age 1-4 increased from 10% in 1976 to 22% in 1978. In 1981 these rates leveled off to 44% for infants and 21% for children age 1-4. Restraint use by children ages 5-11 increased steadily from 4% in 1976, to 18% in 1978, and to 41% in 1981. Drivers showed a similar trend in the use of seat belts, increasing from 15% before the law to 23% in 1981. However, the observations upon which these use estimates are based were made at only one site near a large urban children's hospital. As a result, they may not be representative of the majority of Quebec's motorists.

Previous studies have reported that a dramatic increase in seat belt use occurred immediately following implementation of Ontario's seat belt law in 1976 (as high as 70%). Belt use subsequently declined to about 50%, where it remained through 1980 (Snow, 1979; Mathews, 1982). According to Dalmotas and others (1984), the latest observational survey reports belt use at 49% for occupants over fifteen years old.

Although children five years old and younger are not covered by the law, the rate of restraint use for this group is comparable to that of occupants covered by the law (i.e., 47% in 1981). The increase in the proportion of children being restrained may be a direct result of increasing seat belt use by drivers. Several studies have noted high correlations between use of restraints by the driver and that of the child passengers (Philpot and others, 1979; Agent, 1983; Hletko, 1983; O'Day and Wolfe, 1984). In comparing restraint use of passengers riding with belted versus unbelted drivers, Dalmotas and others (1984) reported that children younger than age six were twice as likely to be restrained with a belted driver, those age 6-15 were nearly 20 times more likely to be restrained; and passengers over age 15 were 4 times more likely to wear seat belts if the driver was belted.

2.1.3 England

A mandatory seat belt law was implemented in England in February, 1983. A series of observational surveys at several sites in the Birmingham area document a substantial rise in occupant restraint use following the law's implementation. Restraint use increased from approximately 42% a year prior to the law to approximately 95% eleven weeks after the law went into effect (Ashton and others, 1983). There was virtually no difference between rural and urban areas in this study.

Observation studies reported by Mackay (1984a, 1984b) show that seat belt use rates have remained at approximately 90% from January, 1983, through January, 1984. An analysis of the first eleven months of post-law casualty data indicate an overall decline of 25% for occupants of cars and light vans when compared with data from February-December of 1982. The 25% reduction in casualties is the exact level of impact expected with an assumed 41% technical effectiveness of seat belts (based on detailed analyses by Griffiths and others, 1976) and 90% compliance. Since traffic mileage increased by approximately 1%, it appears that the observed casualty reductions were largely attributable to the mandatory seat-belt legislation.

Mackay (1984b) also compared 1982 and 1983 data from 15 hospitals. He reported a 20% decline in front-seat occupants **treated** at hospitals, and a 35% decline in front-seat occupants **admitted** to hospitals. The types of injuries to front seat occupants also changed from the pre-law to post-law period. Head injuries, injuries to soft facial tissue, and abdominal and internal chest injuries have declined dramatically, while neck sprains have increased by 21%. The reduction in admissions of 15% over the reduction in occupants treated, and typological analyses of injuries suggested that the law has been successful in preventing more serious and disabling injuries.

Pye and Waters (1984) reviewed records of motor vehicle casualties at a large university hospital emergency room three months prior to and three months after England's seat belt law went into effect. The 437 patients studied were categorized by the severity of their injury, based on the abbreviated injury scale. The overall number of injuries fell by 52% ($p<.001$), with significant declines at all levels of severity. Facial injuries fell by 72% ($p<.001$), head injuries by 63% ($p<.001$), and neck injuries by 50% ($p<.01$). Although there was a significant reduction in severe chest injuries, there was no significant change in total chest injuries. The number of motor-vehicle-related deaths in this sample declined from 15 to three after the belt law was implemented ($p<.001$). Due to the limited sampling procedures, including only one hospital and a six-month observation period with no controls on seasonality, the findings should not be generalized to the total population affected by the law.[1]

2.1.4 Sweden

Sweden introduced a law in January, 1975, requiring front-seat passengers over age 14 to use seat belts. Previous observational studies found driver seat belt use to vary between 30 and 50% from 1966 to 1974. These rates increased to over 90% in 1975 and leveled off around 90% through 1982 (Norin and others, 1984). Norin and others also found that restraint use among front-seat passengers mirrored the trend exhibited by drivers, though passenger rates have remained 5-10% lower than those of drivers over the 1975 to 1982 period. There were 12% fewer fatalities and 20% fewer severe injuries due to motor vehicle

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[1] The crash experience (and therefore injuries from such crashes) from November through January when the pre-law measurements were taken is likely to vary from that in February through April, the post-law measurement period.

crashes in 1975, compared to expected levels based on exposure as measured by motor fuel consumption.

2.1.5 United States

In March, 1983, the State of New York began requiring all drivers with learning permits to use seat belts. Shapiro and others (1984) compared rates of restraint use by learner's permit holders to that of licensed drivers at two local Department of Motor Vehicle (DMV) offices and at a gas station. Learner's permit holders were identified as such at the gas station when they redeemed a coupon for free gas mailed to learner's permit holders under 21 years old in the local DMV jurisdiction. Thirty-nine percent of the learner's permit drivers and 7% of other drivers sampled at the gas station were belted. At the Albany DMV office, observed rates were 32% for permit holders and 12% for other drivers. Belt use for both groups was 6% at the Bay Shore DMV office. Although these comparisons seem to indicate that the regulation had a positive impact on restraint use, overall restraint use increased to only 25%. This rate may also be an overestimate, since two-thirds of the observations were made in settings where those with learner's permits are likely to be more compliant (i.e., DMV offices). Methodological inadequacies such as no pre-regulation measures, biased sampling techniques, and small sample sizes preclude any definitive interpretation of these results. Further studies of the New York experience are underway, but no results have yet been reported (Brick and Edmonds, 1984).

2.2 Effects of Child Restraint Laws

2.2.1 Australia

Queensland extended its adult mandatory restraint law to children 8 years old and younger (the only age group previously exempted) in December, 1979. The law requires children under 1 year old to be in child restraint devices; older children may be restrained with a seat belt. As with the previous adult restraint law, only passengers riding in the front seat must be restrained. King (1981) observed the use of restraints by occupants of cars having young children six months before and six months following implementation of the child restraint law. Observations were made on weekday and Saturday mornings. Since preschool children were overrepresented in the weekday sample, this sample was used as a surrogate for "younger children," while the Saturday sample was used as a surrogate for "older children." Although the "younger children" were more likely to be restrained than "older children" in each period studied, only the increase in restraint use among "older children" from 30 to 39% was significant.

The reliability of the surrogate measure used for age of the child is questionable. It is possible that the difference found between weekday and weekend observations is due to such things as trip type or the sex of the driver. At a minimum, such factors confound the results, making interpretation of their significance difficult.

2.2.2 Canada

Saskatchewan's child restraint law went into effect in July, 1980, but covers only children born after June 30, 1980. Shields (1981) reported that less than 15% of the children under age five in 1979 were restrained by either a child restraint device or a seat belt. Similar figures for 1980 and 1981 were 27% and 33% (Dalmotas and others, 1984). It should be noted that fewer than 20% of the children surveyed in 1981 were actually subject to the provisions of the law because of their age.

2.2.3 United States

Phillips (1983) conducted an extensive bi-monthly survey of child restraint use for one year in and around 19 major U.S. cities. These studies included observations before and after child restraint laws were put into effect in four states. Aggregate measures of restraint use in the four states showed child restraint use increased from 29% before to 39% after the laws were implemented. When infants (under age one) were combined with children age one through four. there were significant increases in restraint use in New York, Minnesota, and Michigan, but not in Massachusetts. When infants were analyzed separately, only the older children showed significant increases, but this may be due to the small number of infants in the sample.

Chapter 3

METHODS

This section briefly reviews the 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, the data collection and processing procedures, and the key statistical methods used. The presentation is brief, with extensions and additions from the earlier project noted. Additional discussion of methods used can be found in Wagenaar (1984a).

3.1 Research Design

Three basic dimensions of the study design are noteworthy. First, a monthly **time-series** design was used to control for numerous factors influencing the number of crash injuries reflected in multi-year trends, cycles, or other regularities. This study used the same 51-month baseline as the initial study. Twenty-one months of post-law data were available, however, compared to nine months post-law data examined last year.

Second, **multiple age groups** were included 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 previous study, with the exception of young children. In the initial study, infants under age one were examined separately from toddlers age 1-3. Because those results indicated limited utility in separate analyses of infants under one (due to the relatively small number of cases), all children covered by the law were analyzed as a single age group in the follow-up study (i.e., age 0-3).

Third, the availability of an extended 21-month period of post-law data permitted more extensive analyses of the **differential effects** of the child restraint law than was possible in the initial study. In addition to repeating 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 separately for male and female drivers, for different hours of the week, and for various areas of the state stratified by population density and poverty level. These analyses were designed to provide additional information on appropriate target groups for further efforts to increase restraint use and decrease injuries.

3.2 Data Collection

Information on occupants involved in motor vehicle crashes required 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. Data obtained were divided into individual records representing crashes, vehicles, and occupants (or pedestrians). Detailed information was available for all crashes, vehicles, and **injured** occupants. However, the only information available for uninjured occupants was whether or not 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 contained records on three-quarters of a million crash-involved occupants per year. Files for the years 1978 through 1983 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 many bivariate tables containing the number of occupants stratified by (1) month, and (2) 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 frequency counts in such tables were extracted to form many individual 12-month time-series. The separate monthly time-series for each year were combined to produce the 72-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. 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. Likewise, 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

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[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.

vehicle damage (V118:5-8)

(12) possible injury severity (V210:4) and severe vehicle damage (V118:5-8)[3]

F. Total number of injured 0-3-year-old occupants per month by:

(1) Monday-Friday 5:00 a.m. to 7:59 p.m. (V9:029-043,053-067,077-091, 101-115,125-139)
(2) Saturday and Sunday 5:00 a.m. to 7:59 p.m. (V9:005-019,149-163)
(3) Monday-Thursday 8:00 p.m. to 4:59 a.m. (V9:044-052,068-076, 092-100, 116-124)
(4) Friday-Sunday 8:00 p.m. to 4:59 a.m. (V9:000-004,020-028,140-148, 164-167)

G. Total number of injured 0-3-year-old occupants per month by:

(1) male driver (V150:1)
(2) female driver (V150:2)

H. Total number of injured 0-3-year-old occupants per month by:

(1) driver age 16-24 (V147:16-24)
(2) driver age 25-34 (V147:25-34)
(3) driver age 35-54 (V147:35-55)
(4) driver age 56 and over (V147:56-98)

I. Total number of injured 0-3-year-old occupants per month by:

(1) two occupants in vehicle (V127:2)
(2) three occupants in vehicle (V127:3)
(3) four occupants in vehicle (V127:4)
(4) five occupants in vehicle (V127:5)
(5) six occupants in vehicle (V127:6)
(6) seven occupants in vehicle (V127:7)
(7) eight or more occupants in vehicle (V127:8)

J. 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)

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

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

The county-specific 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, the county-specific time-series were grouped for analyses of

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[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.

the impact of the law across areas of varying population density and socio-economic status.

3.3 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. Long series of observations were required to assess the degree to which restraint use and injury frequencies in 1982 and 1983 (after child restraints became mandatory) were different from the level expected, given regular patterns over the previous four-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 Chapter 4 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. To estimate such shifts beginning the first month after the law took effect, long-term trends and seasonal cycles must first be controlled. The Box-Jenkins and Box-Tiao (Box and Tiao, 1975; Box and Jenkins, 1976) intervention analysis methods were used to accomplish this. 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). This approach of intervention analysis was particularly appropriate for the present 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. The most important point is that 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 multi-year 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.

Chapter 4

RESULTS

Michigan's mandatory child restraint law took effect on April 1, 1982. The law requires children under the age of four to be properly restrained in an approved child restraint device. Children age one to three may be restrained by a conventional adult seat belt, 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). The 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 separately by the inclusion of two parameters in the time-series intervention models. Results of the present study using 21 months of post-law observations are compared with an initial study limited to nine months of post-law data (Wagenaar, 1984a).

This section shows a plot of each outcome measure examined and discusses the net change in each measure associated with the two interventions. When examining the plots, note that the solid line represents a smoothed trend line, which is useful for discerning overall trends. When comparing the plots, the reader should be careful to note differences in the vertical axis scale. Understanding the scale used is important for discerning the magnitude of any discontinuity seen in the time series. The final model is shown below each plot for which Box-Jenkins time-series models were developed.[4] Most readers will concentrate on the last line in each figure, which indicates the net estimated shift in the series associated with implementation of the child restraint law. The net shift is expressed in terms of percent change of the post-law period from the levels expected, given baseline patterns.

4.1 Effects of the Child Restraint Law on Restraint Use

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[4]For those familiar with Box-Jenkins time-series analysis, note that the P_t in the equations refers to a three-month pulse function with value one for the January-March, 1982, period in which major PI&E efforts were underway, and zero otherwise. The S_t refers to a step function with a value zero prior to April, 1982, and value one after April, 1982, when the child restraint law took effect. Standard errors are shown in parentheses below each estimated parameter. The adjusted R^2 statistic (when multiplied by 100) indicates the percent of total variance explained by the model.

The rate of restraint use among injured children under four years old is depicted in Figure 4.1. Restraint use within this age group has shown a gradual but consistent increase from 1979 through 1981. Restraint use before the PI&E program and mandatory child restraint law were implemented averaged about 12%. Measures of restraint use during the 21 months following implementation of the law show a dramatic increase, with rates averaging about 51%. The initial study found no significant increase in restraint use for children between one and three years old associated with the PI&E program only (January-March, 1982). However, when the data for all children under age four were aggregated and data for 1983 were added, results indicated a 35% increase in restraint use during the PI&E-only period. More importantly, analyses revealed a 299% increase in restraint use among 0-3-year-olds after the enactment of the child restraint law (i.e. from 12% to 51%).

Restraint use among motor vehicle occupants of other ages was also analyzed. Objectives in analyzing occupants of other ages were twofold. First, to identify possible spillover effects of the child restraint law. Second, 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, but were in fact due to implementation of the child restraint law.

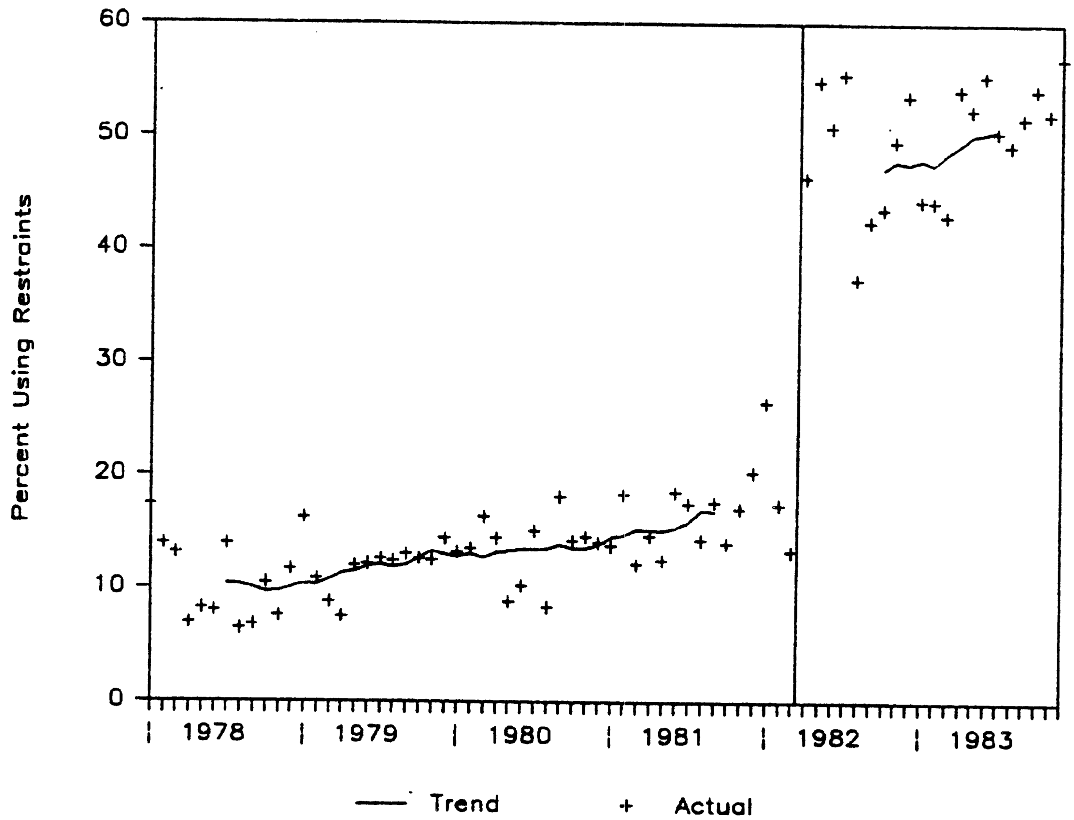
From 1978 through 1981, restraint use among occupants age four to 15 averaged about 5 to 6%, with little variation from month to month (see Figure 4.2). A sharp increase in restraint use can be seen in early 1982 with introduction of the child restraint law. The upward trend continued over the following 21 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 131% increase in restraint use among children age four to 15. The 131% increase represents a change in restraint use from 6% before the law to 14% after. The estimated 131% increase in use is slightly higher than the estimate of 102% found in the earlier study limited to the first nine months of post-law experience. Finally, note that even though the rate of increase in this age group appears large, it reflects a much smaller percentage-point increase than the under-four age group (i.e., an increase from 6% to 14% for 4-15-year-olds versus an increase from 12% to 51% for 0-3-year-olds).

Restraint use among 16-17-year-old occupants remained constant at about 7% between 1978 and 1982 (Figure 4.3). Although earlier analyses did not reveal a significant change in restraint use after the child restraint law was introduced, a significant increase of 33% was detected with the extension of the time series through 1983. However, a 33% increase in the baseline 7% use rate means the use rate in 1983 was up to only about 9%. In short, the statistically significant increase represents a very small absolute change in restraint use.

The pattern of restraint use of occupants age 18 to 24 (Figure 4.4) varies little from that of the 16-and-17-year-olds. Use rates averaged about 8% from 1978 through 1981, with little variation. A statistically significant 36% increase in restraint use followed implementation of the child restraint law. Again, because of the low baseline rate, this increase represents a small absolute change in the number of occupants restrained.

Figure 4.1

Restraint Use Among Injured Occupants Age 0-3



$$(1 - .420B)\ LnY_t = 2.529 + .297P_t + 1.38S_t + a_t$$

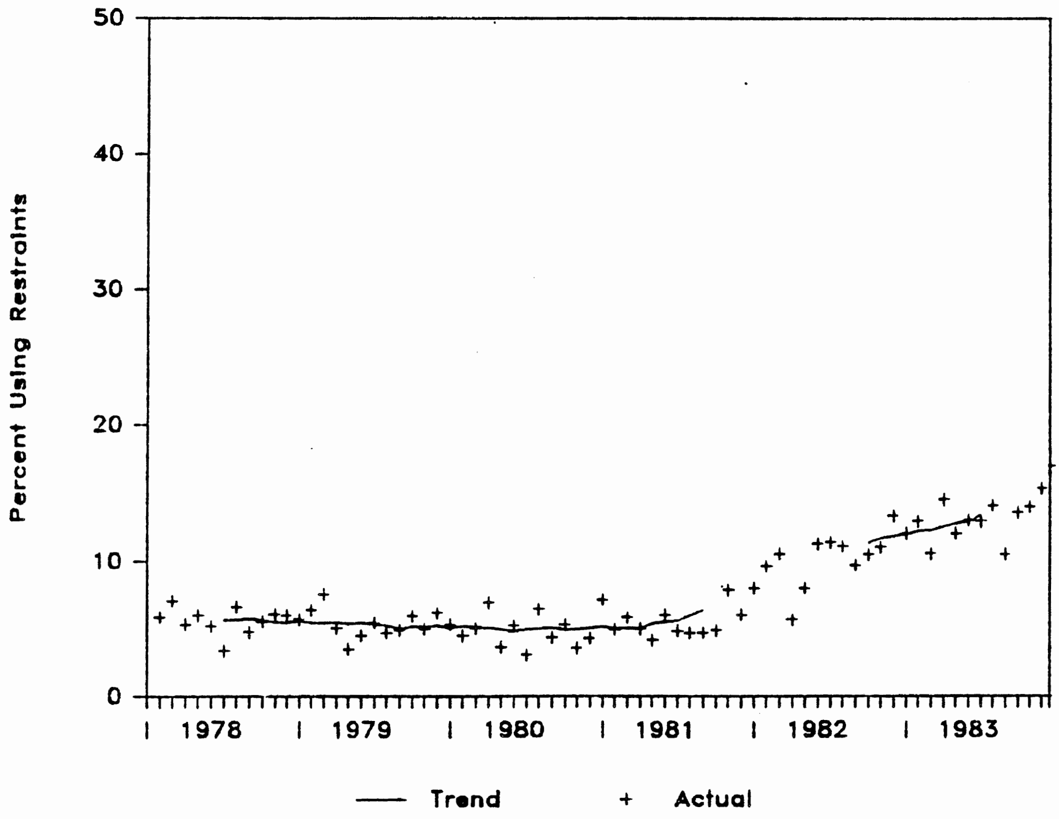
(.113) (.057) (.187) (.102)

Adjusted $R^2 = .88$

Legal Impact Percent Change = +299

Figure 4.2

Restraint Use Among Injured Occupants Age 4-15



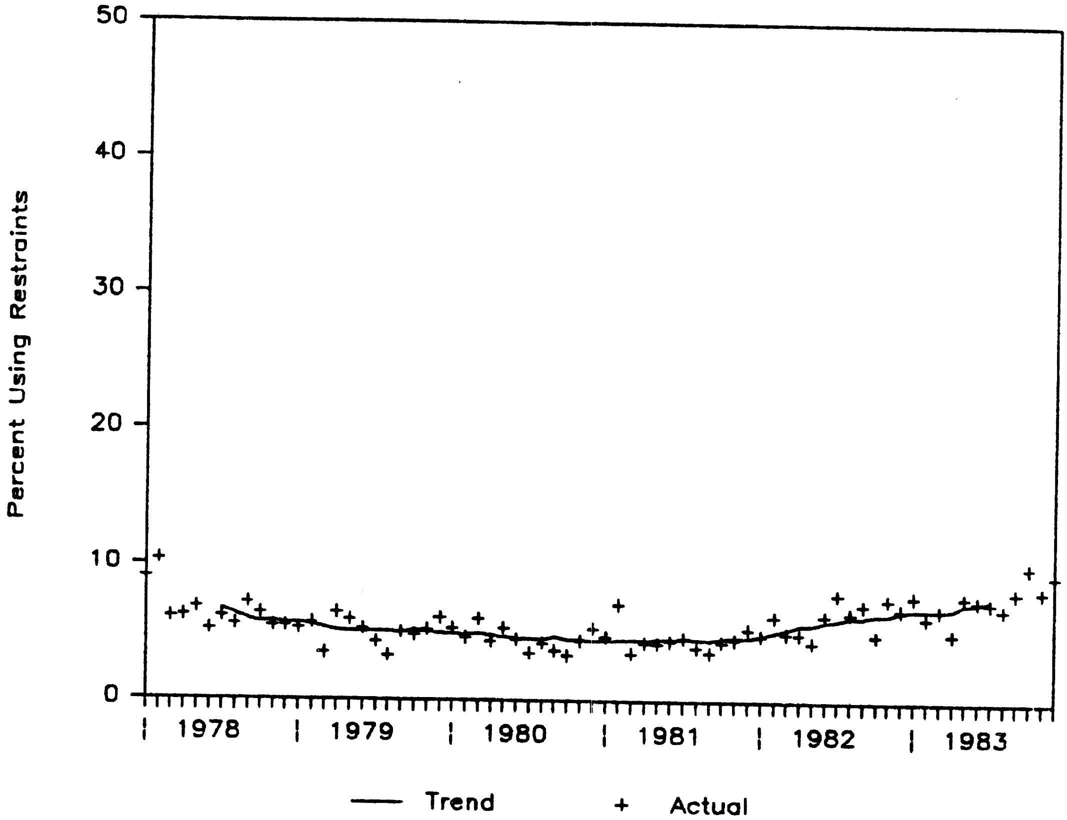
$$\text{LnY}_t = 1.66 + .459P_t + .839S_t + a_t$$
$$(.030) \quad (.125) \quad (.055)$$

Adjusted $R^2 = .77$

Legal Impact Percent Change = +131

Figure 4.3

Restraint Use Among Injured Occupants Age 16-17



$$(1 - .45B)LnY_t = 1.63 + .071P_t + .289S_t + a_t$$

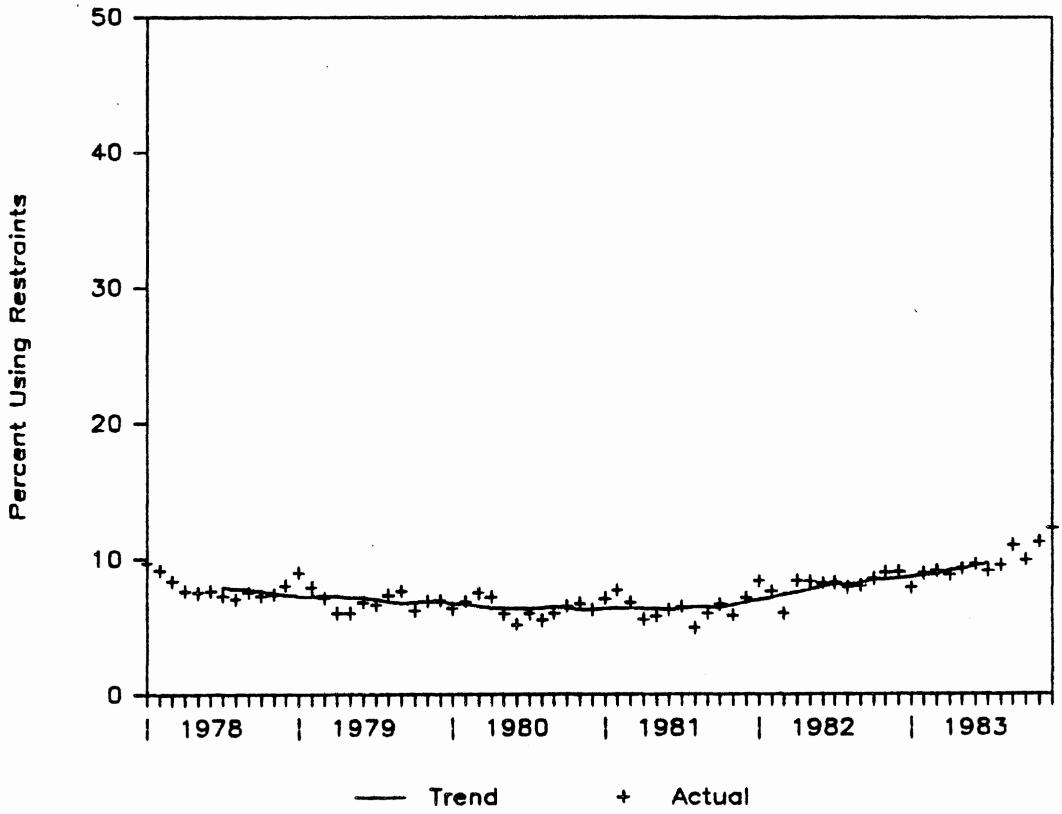
(.100) (.053) (.159) (.094)

Adjusted $R^2 = .42$

Legal Impact Percent Change = +33

Figure 4.4

Restraint Use Among Injured Occupants Age 18-24



$$LnY_t = 1.93 + (1 + .878B + .234B^2)a_t + .033P_t + .304S_t$$

(.030) (.120) (.124) (.078) (.053)

Adjusted R^2 = .71

Legal Impact Percent Change = +36

An examination of restraint use by 25-to-34-year-old occupants over the study period (Figure 4.5) shows a slight downward trend between 1978 and 1981, with a gradual increase in 1982 and 1983. 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 4.6) was very similar to that for the 25-34 age group. Analyses revealed an estimated 14% increase in the use rate (12% to %14), but this increase was significant only at the $p<.10$, not the $p<.05$.

The earlier study indicated an increase in the rate of belt use among occupants age 55 and over of 16% (16.5% to 19%) in the first quarter of 1982 and 20% (16.5% to 20%) in the last three quarters of 1982. However, the current study, including an additional 12 months of data, found that the increase during the PI&E-only period is no longer significant, and that a 14% increase in restraint use occurred after the child restraint law took effect (Figure 4.7). The increase in belt use was significant at $p<.10$ but not $p<.05$. Again, keep in mind that a 14% increase in a baseline belt use rate of only 14% means that belt use increased a mere two percentage points.

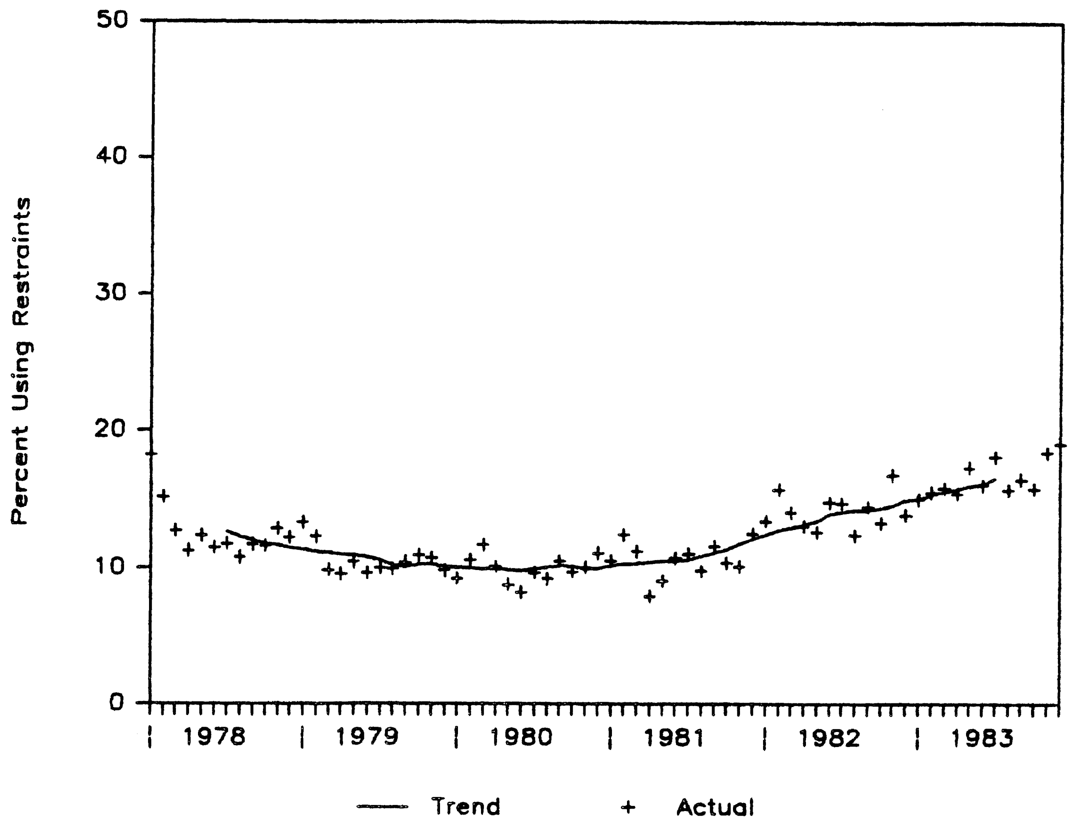
Results presented thus far indicate that the child restraint law and the PI&E program did have a positive effect on police-reported child restraint use. There were dramatic increases in reported restraint use among young children, and only very small increases in reported belt use among adult motor vehicle occupants. 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 four was not restrained is an admittance of a violation of law.

Correct versus incorrect use of child restraints in another complicating factor. The degree to which restraint devices are being used correctly is not assessed and recorded by police officers. Incorrect use significantly reduces the protection provided by child seats. Surveys have indicated that up to 70% of all child restraint devices are used incorrectly (Shelness and Jewitt, 1983).

Finally, Michigan's 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.

Figure 4.5

Restraint Use Among Injured Occupants Age 25-34

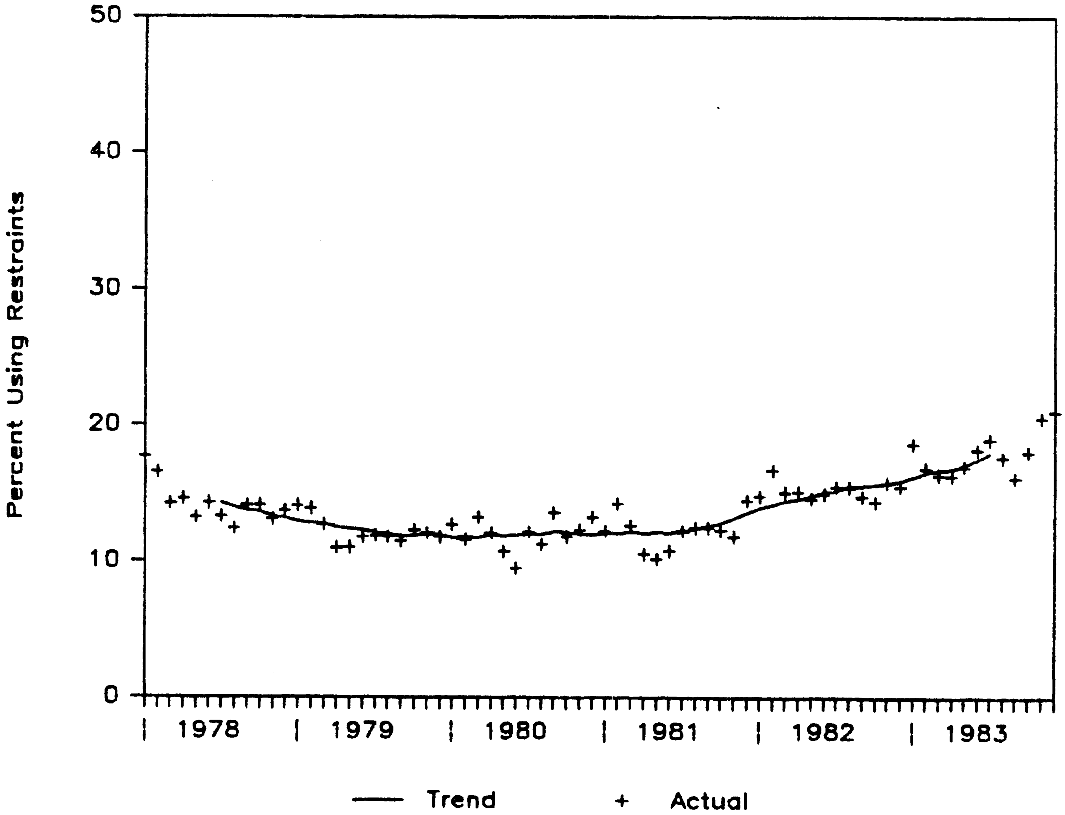


$$(1-B)\ LnY_t = .071P_t + .003S_t + a_t$$
$$(.119) \quad (.169)$$

Adjusted $R^2 = .69$

Figure 4.6

Restraint Use Among Injured Occupants Age 35-54



$$(1-B)\ LnY_t = (1 - .305B - .300B^3)a_t + .118P_t + .130S_t$$

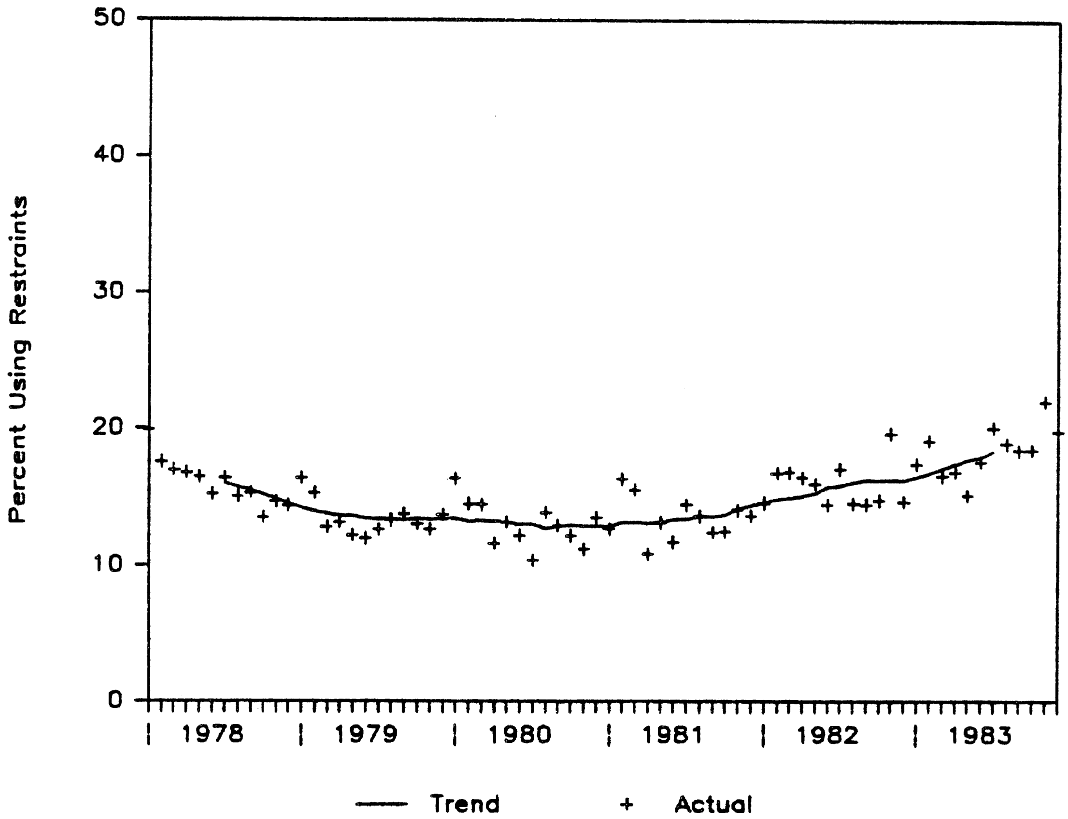
$$(.111) \quad (.110) \quad (.084) \quad (.095)$$

Adjusted $R^2 = .75$

Legal Impact Percent Change = +14 ($.05 < p < .10$)

Figure 4.7

Restraint Use Among Injured Occupants Age 55 and Over



$$(1-B)\ LnY_t = (1 - .647B)\ (1 + .509B^{12})a_t + .082P_t + .130S_t$$

$$(.091) \qquad (.109) \qquad (.070) \qquad (.086)$$

Adjusted $R^2 = .63$

Legal Impact Percent Change = +14 ($.05 < p < .10$)

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

The previous report included separate analyses for two groups affected by the child restraint law, infants under age one, and 1-3-year-olds. This separation was of limited utility because of the small number of infants injured each month. The small sample problem becomes even more pronounced when sub-groups of particular interest are examined separately (based on variables such as seating position and injury severity). Therefore, the current study examined all children under age four as a single age group.

The number of injured crash-involved occupants under age four is depicted in Figure 4.8.[5] The number of children injured in this age group declined from 1978 through the beginning of 1983, but drifted upward during the last nine months of 1983. A similar pattern can be found for occupants in the other age groups (Figures 4.9 through 4.14). The previous report, which did not include the 1983 data, gave two estimates of the effects of the interventions. One assumed that the 1978-1982 decline reflected a long-term downward trend determined by some unmeasured factor(s) (i.e. "deterministic trend"). The other assumed that the decline was simply random drift. The upward swing in the 1983 time series, and the similar pattern of injuries across time for all age groups, seem to confirm that the decline from 1978 to 1982 should not be considered a deterministic trend. Thus, the time-series models for the number of injured children under age 4 in this study generally did not include a parameter for deterministic trend.

Results of the current time-series analyses reveal a 25% decline (from 180 to 135 per month) in the number of children under age four injured in crashed during the PI&E-only period and a 28% decline (from 180 to 130 per month) after the child restraint law was implemented. Earlier results using only the first nine months of post-law observations estimated a 50% decrease in the number of infants injured after the law took effect, assuming there was no deterministic downward trend in such injuries, and a 29% reduction if the downward trend is included in the model. Estimates of the effect of the law on the 1-3 age group from the earlier report were a 26% decline assuming no trend and a 17% decline, assuming a deterministic downward trend. 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 1983 data.

The number of injured motor vehicle occupants of other ages were 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 injuries over the post-law period is to compare patterns across the 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 4.9 displays how the number of injuries among occupants age 4-15 have varied in recent years. Although the overall pattern is similar to that of the younger children,

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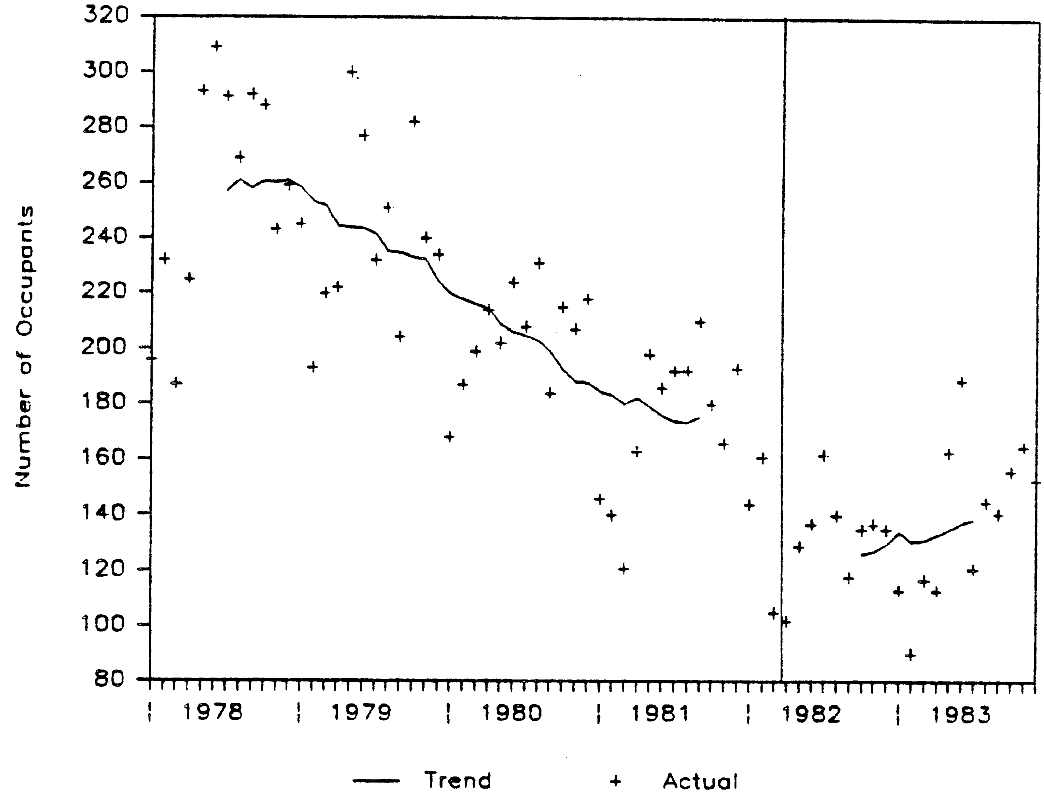
[5] All estimates of injury reductions associated with the child restraint law reported here are based on the **number of motor vehicle occupants injured**. As indicated in section 3.2, all analyses are based on counts of injured occupants; while many occupants in crashes sustain multiple injuries, each injury was not counted separately.

Figure 4.8

Number of Injured Occupants Ages 0-3



$$(1 - B)LnY_t = (1 - .378B - .437B^3)a_t - .291P_t - .323S_t$$

(.102) (.101) (.145) (.135)

Adjusted R^2 = .73

Legal Impact Percent Change = -28

Figure 4.9

Number of Injured Occupants Age 4-15

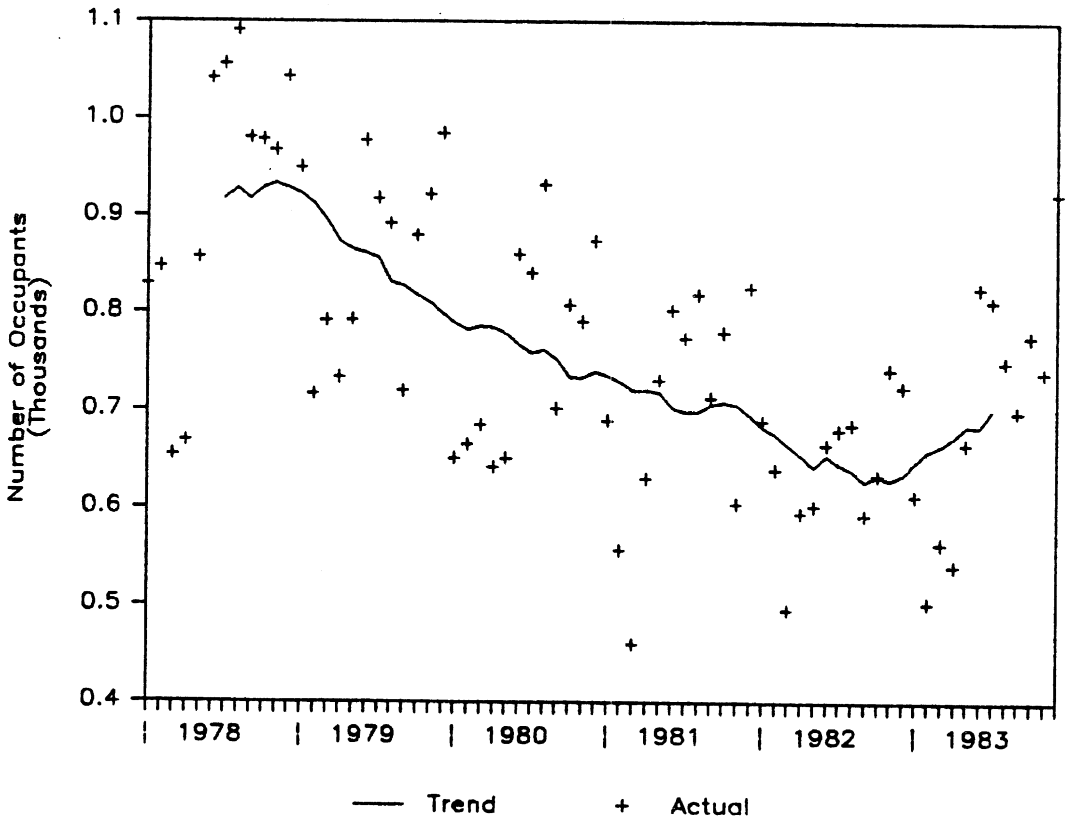


Figure 4.10

Number of Injured Occupants Age 16-17

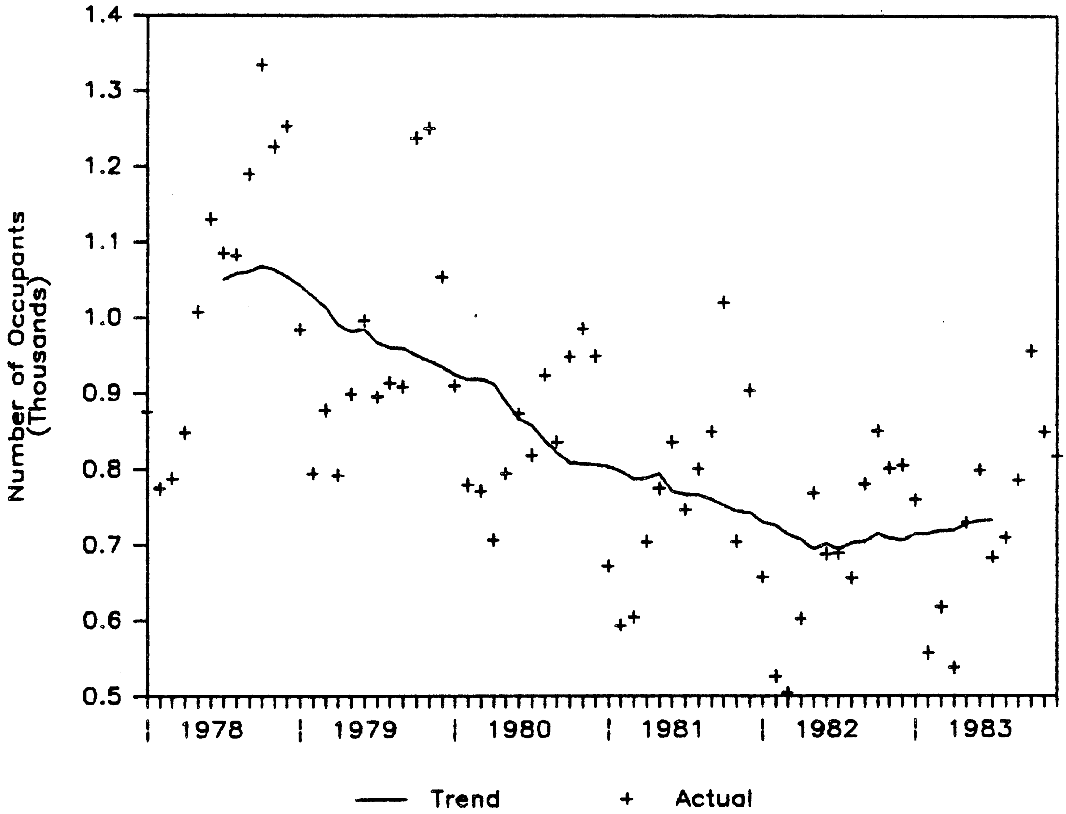


Figure 4.11

Number of Injured Occupants Age 18-24

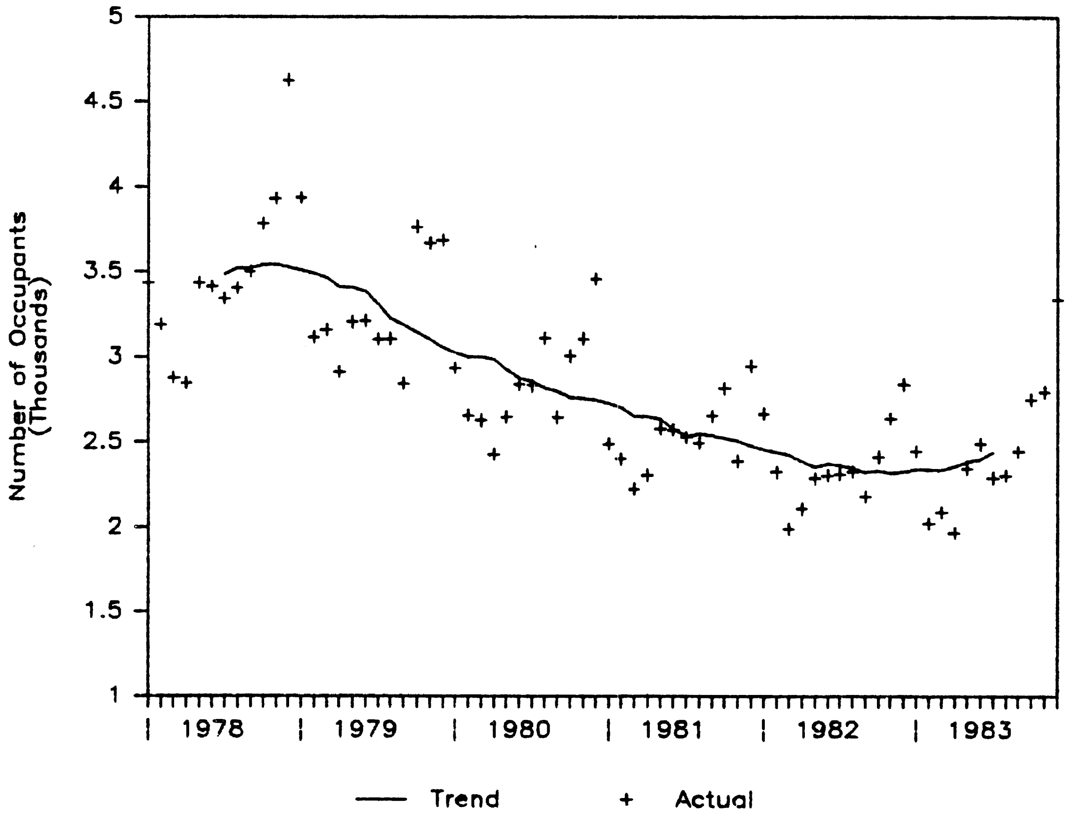


Figure 4.12

Number of Injured Occupants Age 25-34

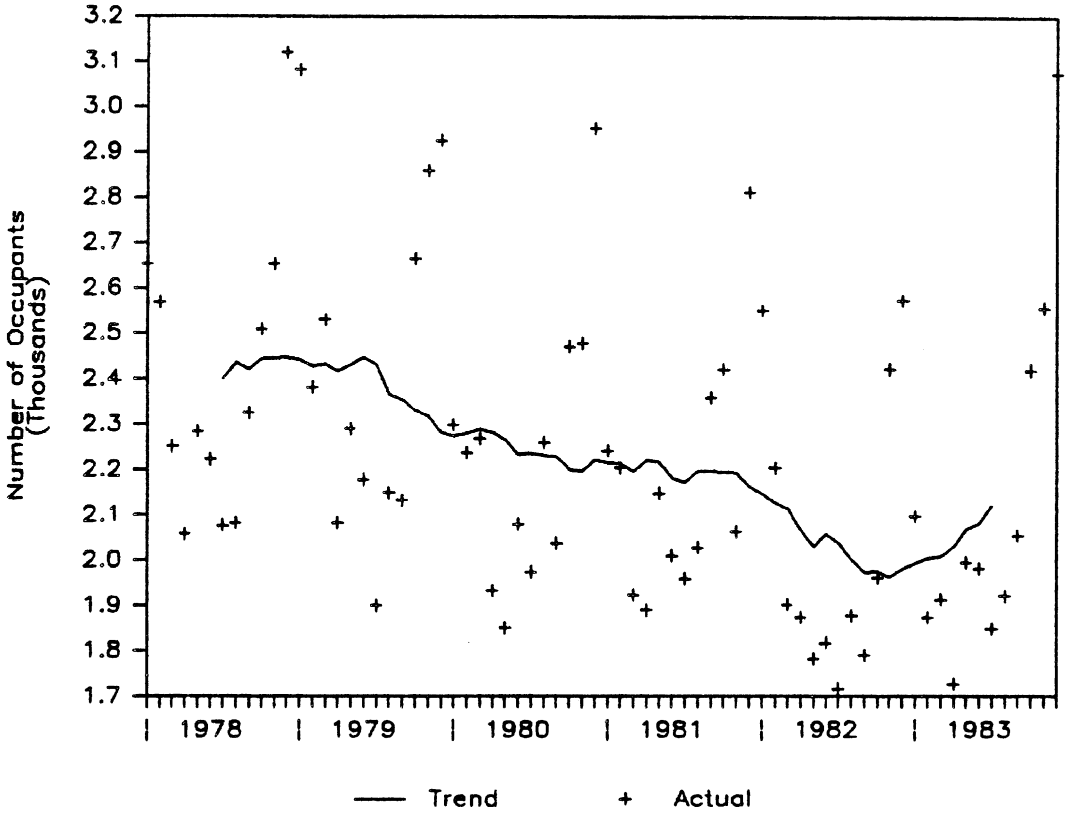


Figure 4.13

Number of Injured Occupants Age 35-54

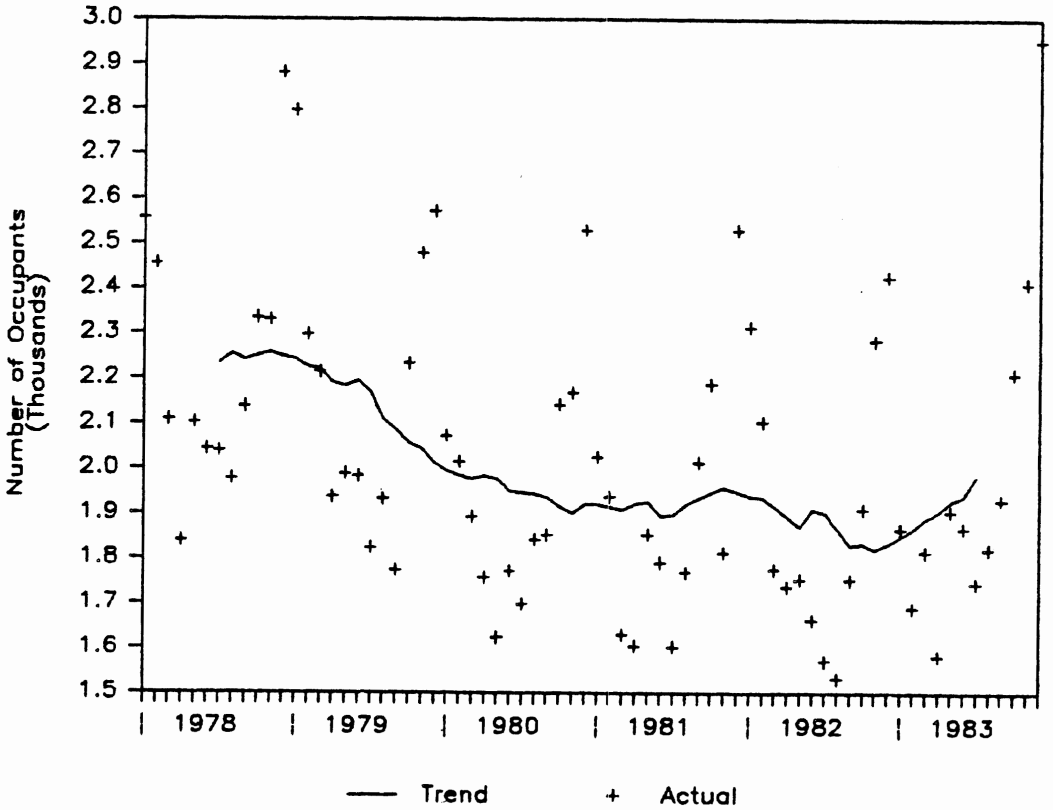
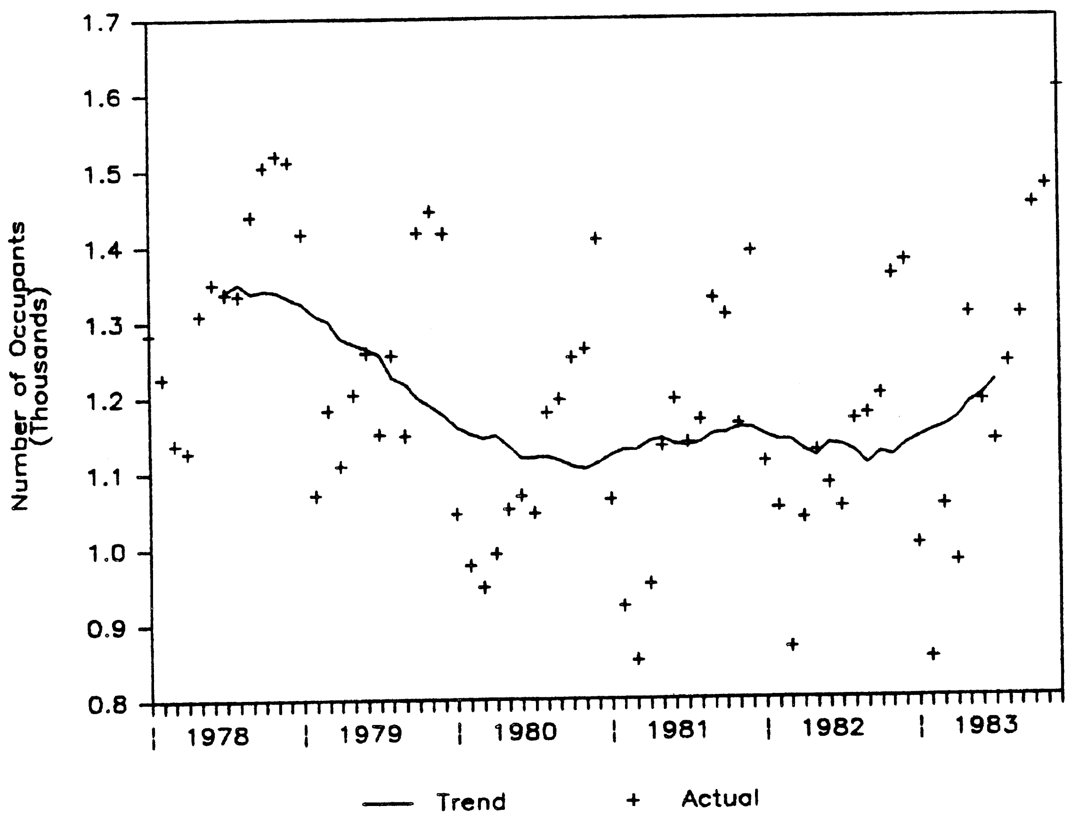


Figure 4.14

Number of Injured Occupants Age 55 and Over



the decline beginning in April, 1982, is much smaller, and the increase in the number of injuries during 1983 is more pronounced than for 0-3-year-olds.

Figure 4.10 shows that the number of injured occupants 16 and 17 years old declined more gradually than the 0-3 or 4-15 age groups between 1978 and 1982. The increase in 1983 was also less dramatic. Figure 4.11 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 4.12 reveals a more pronounced drop in 1982 than any of the other age groups not covered by the child restraint law. However, there was a noticeable increase in the number of 25-34-year-olds injured in 1983. The number of injuries among age 35-54-year-old occupants (Figure 4.13) and occupants age 55 and over (Figure 4.14) show a similar pattern of decline during 1978-81 and increase in 1983.

The most 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 of injured motor vehicle occupants in 1983. The increased number of injured children under four, therefore, does not represent a diminishing effect of the child restraint law. Instead, the slight rise in the number of 0-3-year-olds injured in 1983 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 4.15 shows that the number of miles traveled declined from late 1978 through early 1981, held steady from mid-1981 through mid-1982, and increased in late 1982 and 1983. 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, the rate of injuries per 10,000 crashed vehicles was 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 4.16 depicts the trend in the total number of motor vehicle crashes in Michigan from 1978 through 1983.

Time-series modeling of the rate of children injured per 10,000 crashed vehicles revealed an estimated 27% reduction following implementation of the child restraint law; the PI&E program was associated with a 18% reduction (see Figure 4.17). In comparing the 27% reduction in the rate of children injured with the 28% reduction in the raw frequency of

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[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 very small.

Figure 4.15

Estimated Number of Vehicle Miles Traveled

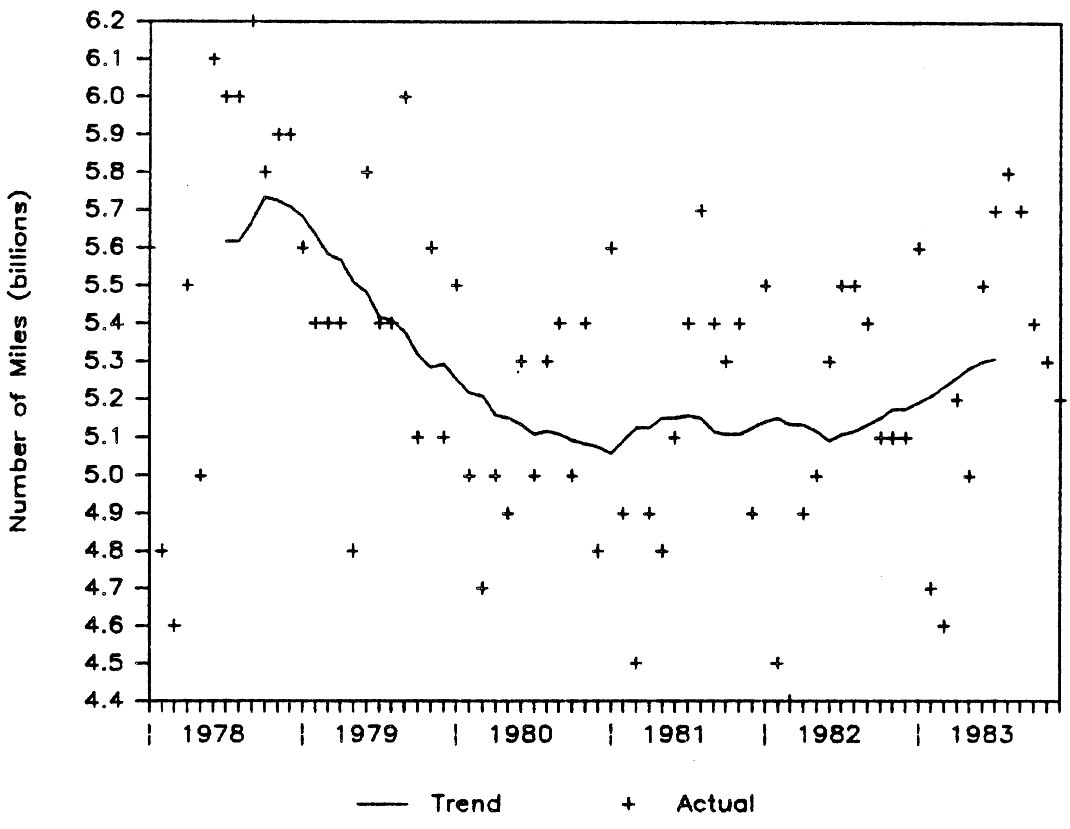


Figure 4.16

Total Number of Vehicles Involved in Traffic Crashes

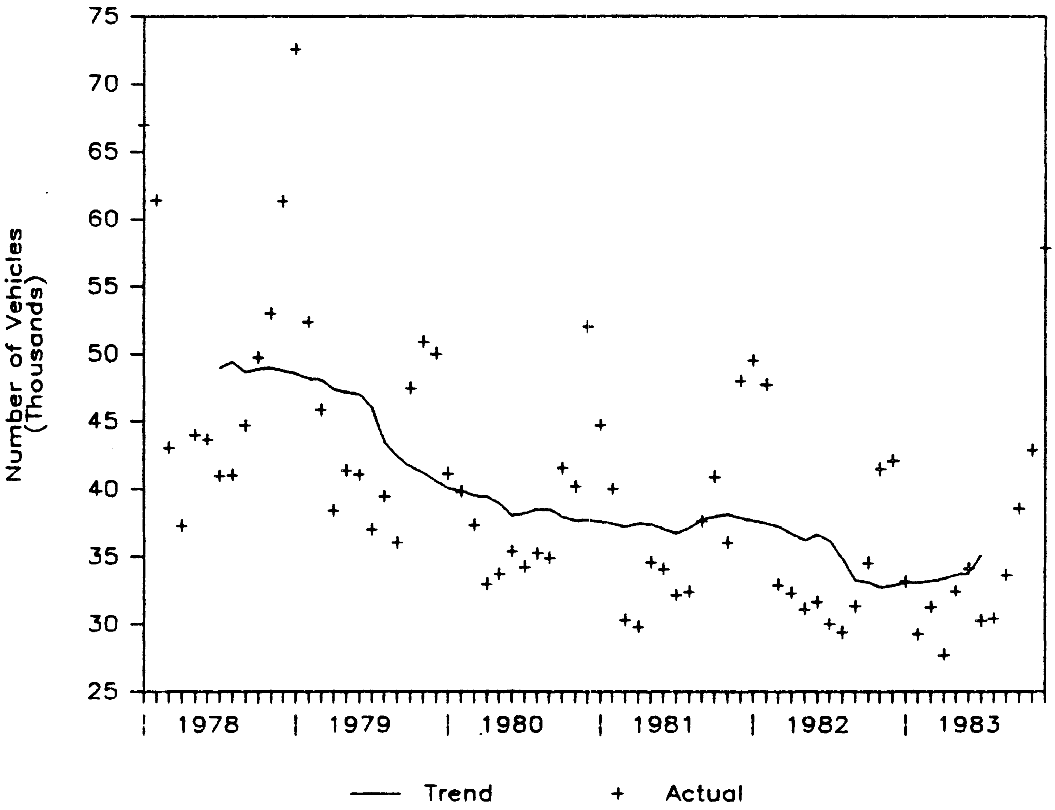
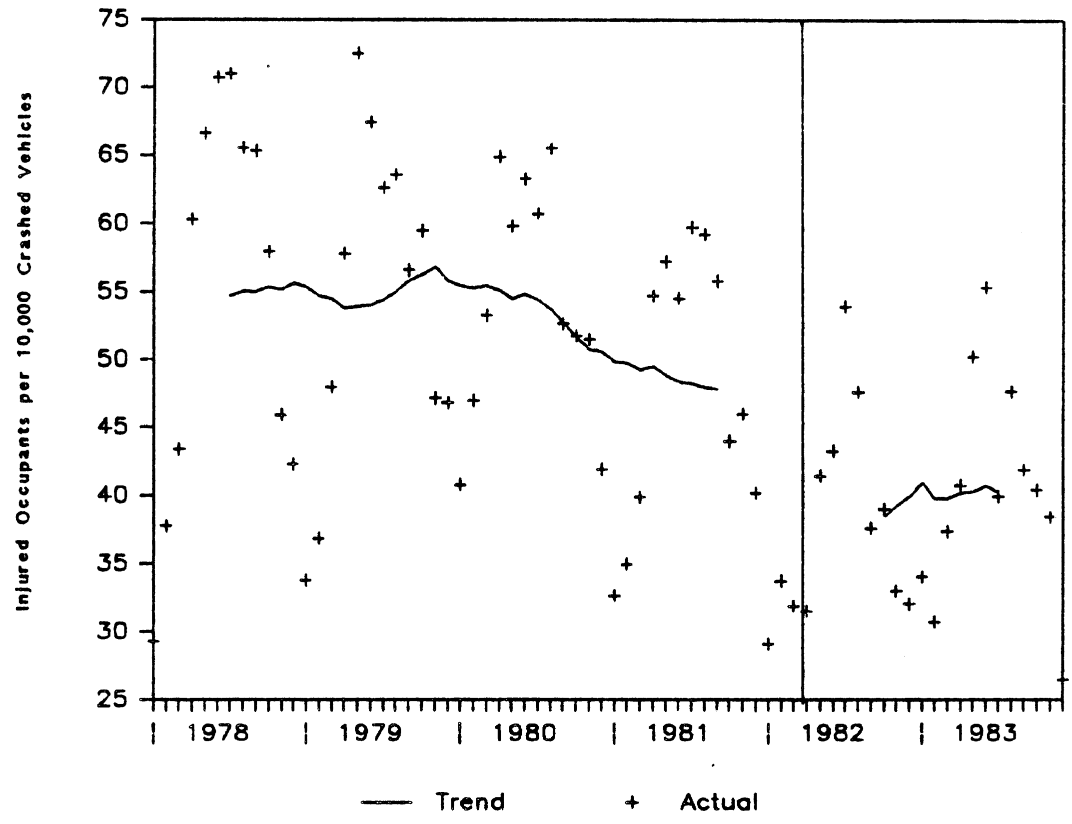


Figure 4.17

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



$$(1-B^{12})LnY_t = (1+.359B+.334B^2+.305B^5)(1-.792B^{12})a_t-.208P_t-.314S_t$$

(.102) (.112) (.108) (.051) (.079) (.045)

Adjusted R^2 = .84

Legal Impact Percent Change = -27

child injury (Figure 4.8), it is clear that controlling for the effects of broader conditions influencing the number of crashes does not appreciably change the estimated effect of the child restraint law. A small part of the 28% decline in the number of children injured after the child restraint law took effect may be due to reduced numbers of young children in Michigan. The number of children under age 5 decreased 3.1% from 1982 to 1983.[8] Subtracting the 3% population decrease from the 28% reduction in the number of children injured leaves a 25% reduction that apparently resulted from implementation of the child restraint law.

There were no substantial 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 4.18 to 4.23). An estimated 5% decline in the rate for occupants age 18-24 was statistically significant, though the decline was clearly very 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%, and the 55-and-over age group increased 13%. These increases in injury rates among occupants not affected by the law provide further support for the hypothesis that the decline in the rate of children injured is 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 four years old. The PI&E program only (January-March) was associated with an 18% decline in the rate of injured 0-3-year-olds. Only the 24% decline in the injury rate among 16- and 17-year-old occupants was more dramatic. The decline in the rate of occupants injured associated with the PI&E program for the 4-15, 18-24, and 25-34 age groups was between 9 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 4.24). The time-series modeling results revealed an estimated 28% reduction associated with the child restraint law.

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 4.25). Statistical analyses indicated a 29% decrease after the law took effect, and a 16% decrease during the PI&E-only period.

These alternative estimates of the effect of the child restraint law in reducing the number of children injured are remarkably similar. Analyses revealed a 28% reduction in the frequency of injured children, a 27% reduction in the rate of occupants injured per crashed vehicle, a 28% reduction in the rate of children injured per vehicle mile traveled, and a 29% reduction in the number of children injured as a percent of injured occupants of all ages.

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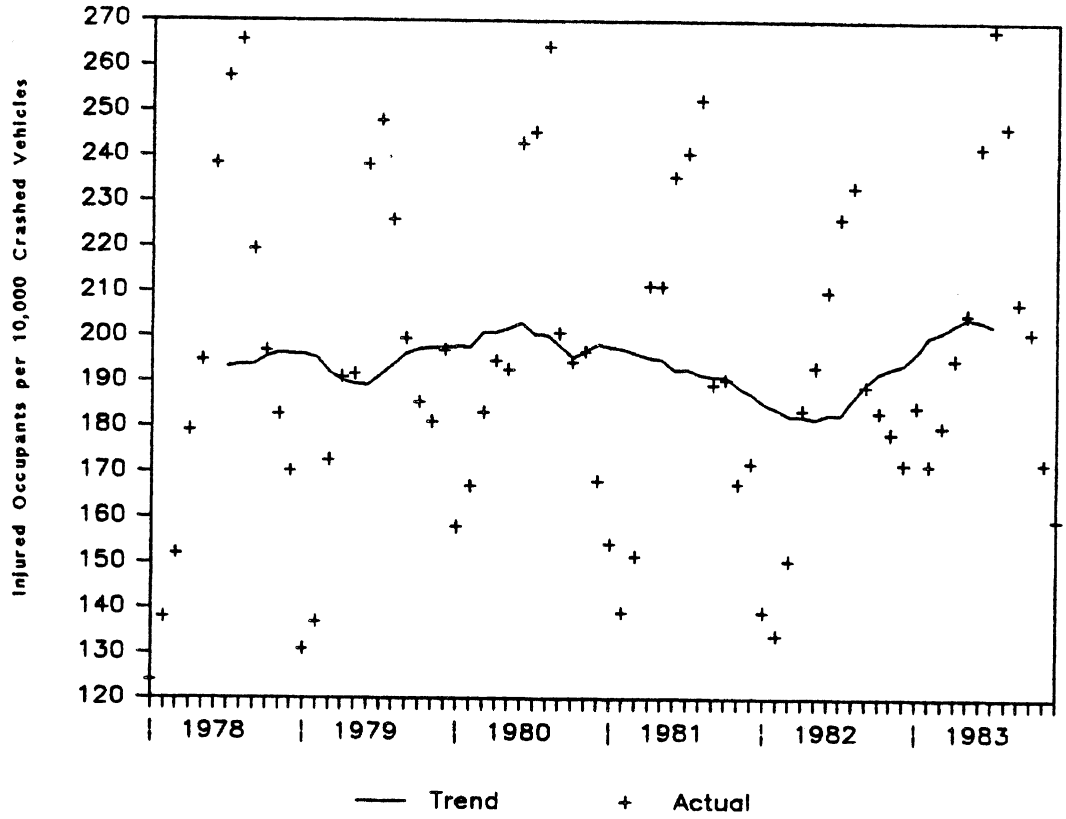
[8] Population data obtained from the Michigan Department of Public Health, Office of Vital Statistics.

Figure 4.18

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



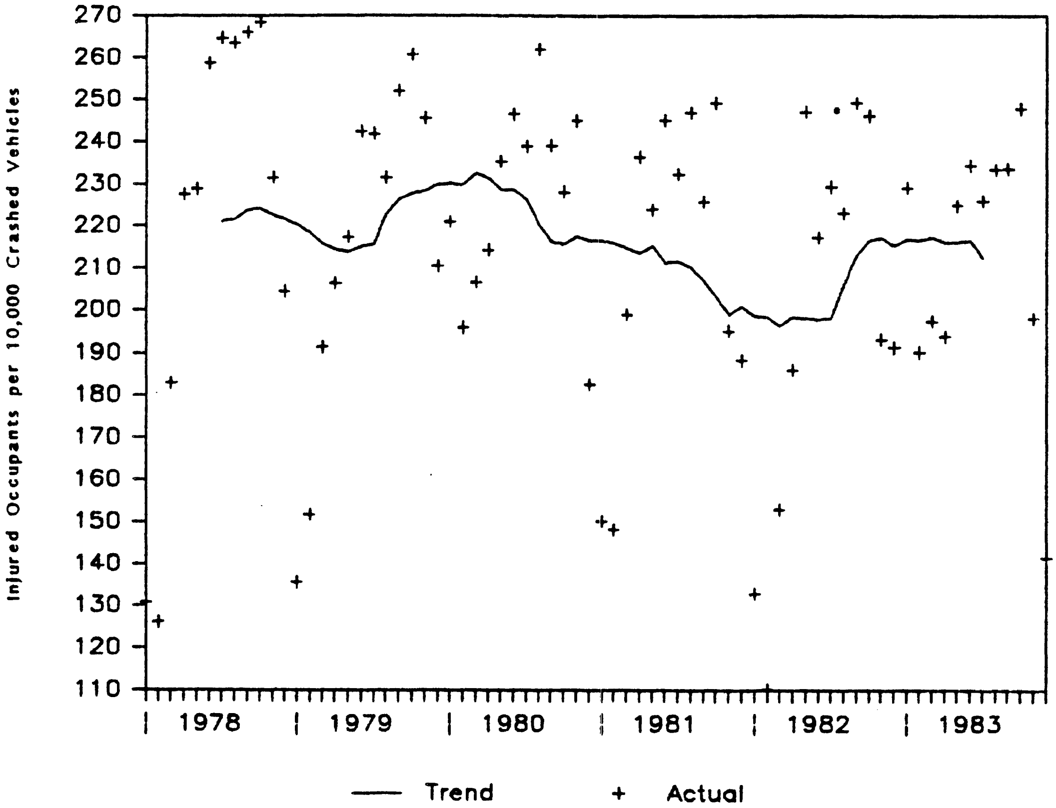
$$(1-B^{12})\, LnY_t = (1 + .440B)\,(1 - .777B^{12})a_t - .099P_t + .006S_t$$

(.106) (.048) (.049) (.024)

Adjusted $R^2 = .86$

Figure 4.19

Injured Occupants Age 16–17 per 10,000 Crashed Vehicles



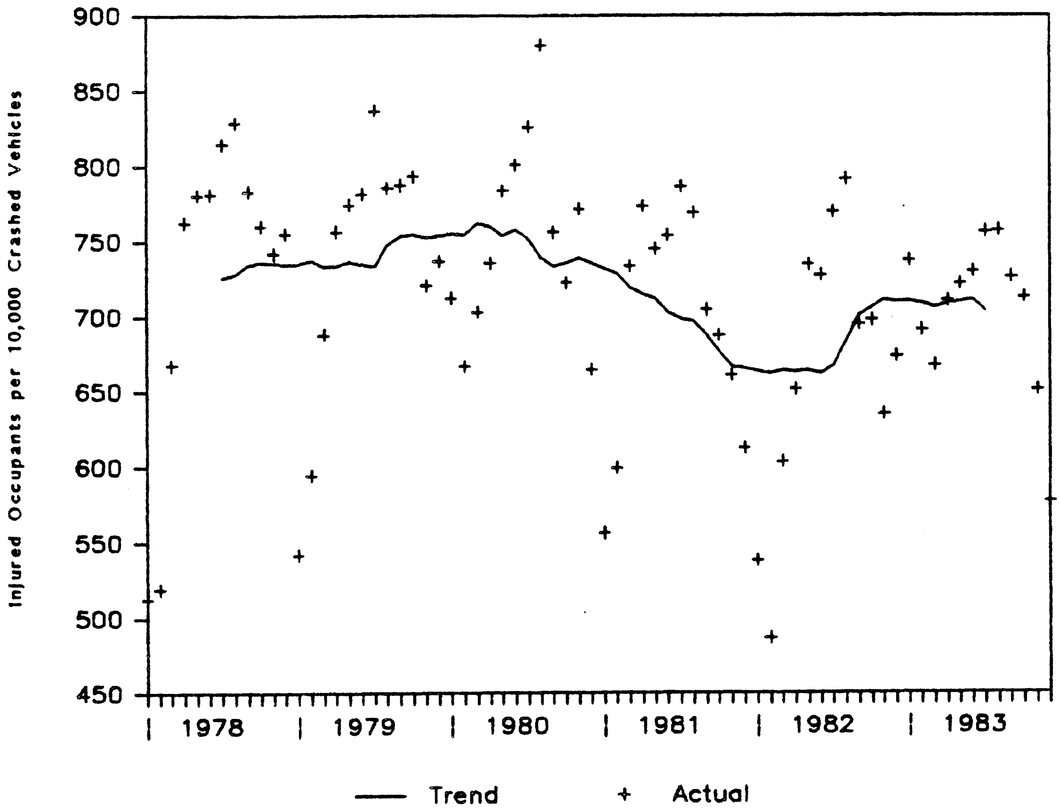
$$(1-B^{12})\ LnY_t = (1 + .368B)\ (1 - .758B^{12})a_t - .271P_t - .038S_t$$

(.116) (.048) (.074) (.036)

Adjusted R^2 = .72

Figure 4.20

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



$$(1-B^{12})\ LnY_t = (1 + .513B)\ (1 - .761B^{12})a_t - .095P_t - .044S_t$$

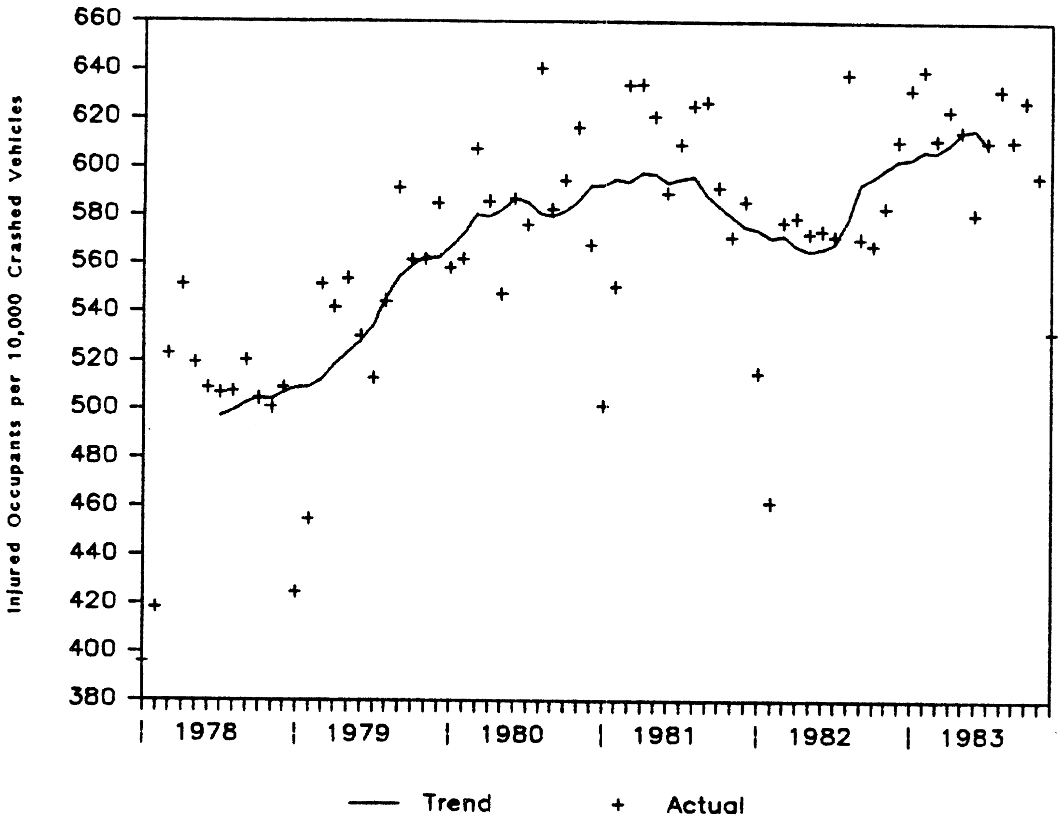
(.113) (.046) (.051) (.025)

Adjusted $R^2 = .70$

Legal Impact Percent Change = -5

Figure 4.21

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



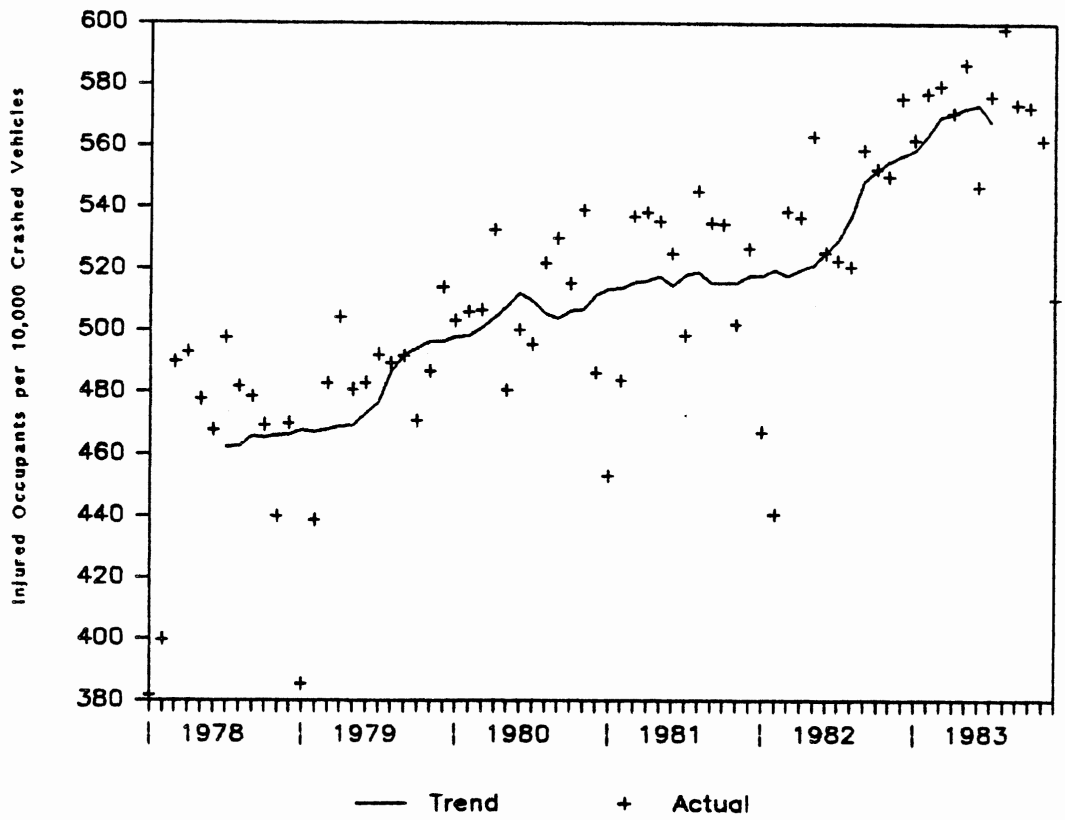
$$(1-B)(1-B^{12})\ LnY_t = (1 - .519B)\ (1 - .785B^{12})a_t - .107P_t - .064S_t$$

(.099) (.046) (.052) (.068)

Adjusted R^2 = .66

Figure 4.22

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



$$(1-B^{12})\ LnY_t = (1 + .439B + .357B^2)\ (1 - .768B^{12})a_t + .011P_t + .108S_t$$

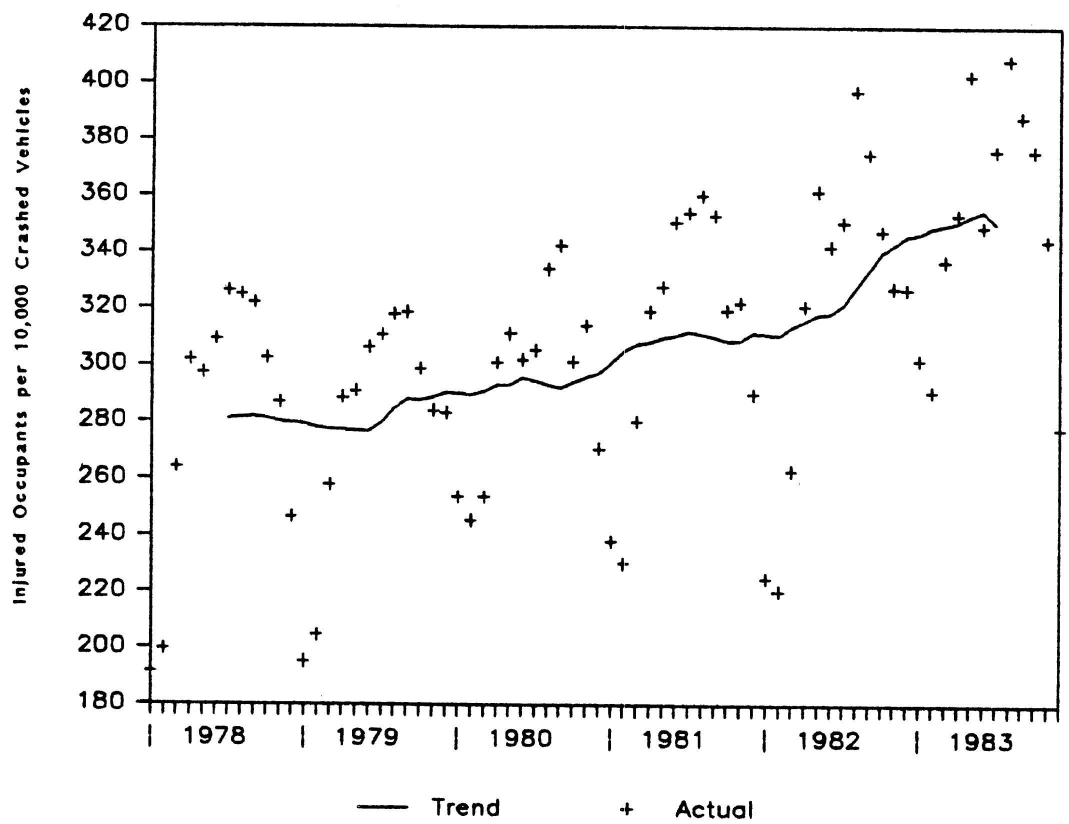
(.118) (.113) (.051) (.044) (.025)

Adjusted R^2 = .65

Legal Impact Percent Change = +11

Figure 4.23

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



$$(1-B^{12})\ LnY_t = (1 + .569B)\ (1 - .654B^{12})a_t - .029P_t + .140S_t$$

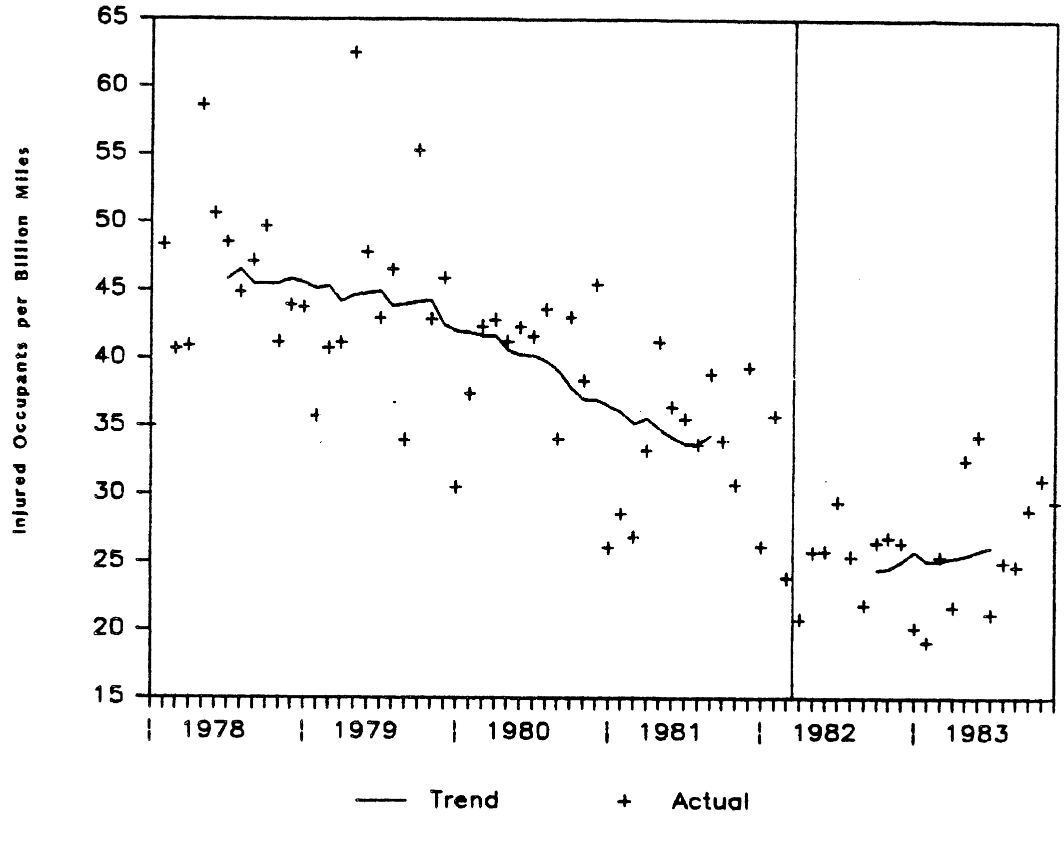
(.107) (.092) (.044) (.027)

Adjusted R^2 = .86

Legal impact Percent Change = +13

Figure 4.24

Injured Occupants Age 0-3 per billion vehicle miles traveled



$$(1-B)\ LnY_t = (1 - .871B)\ (1 + .417B^{12})a_t - .035P_t - .335S_t$$

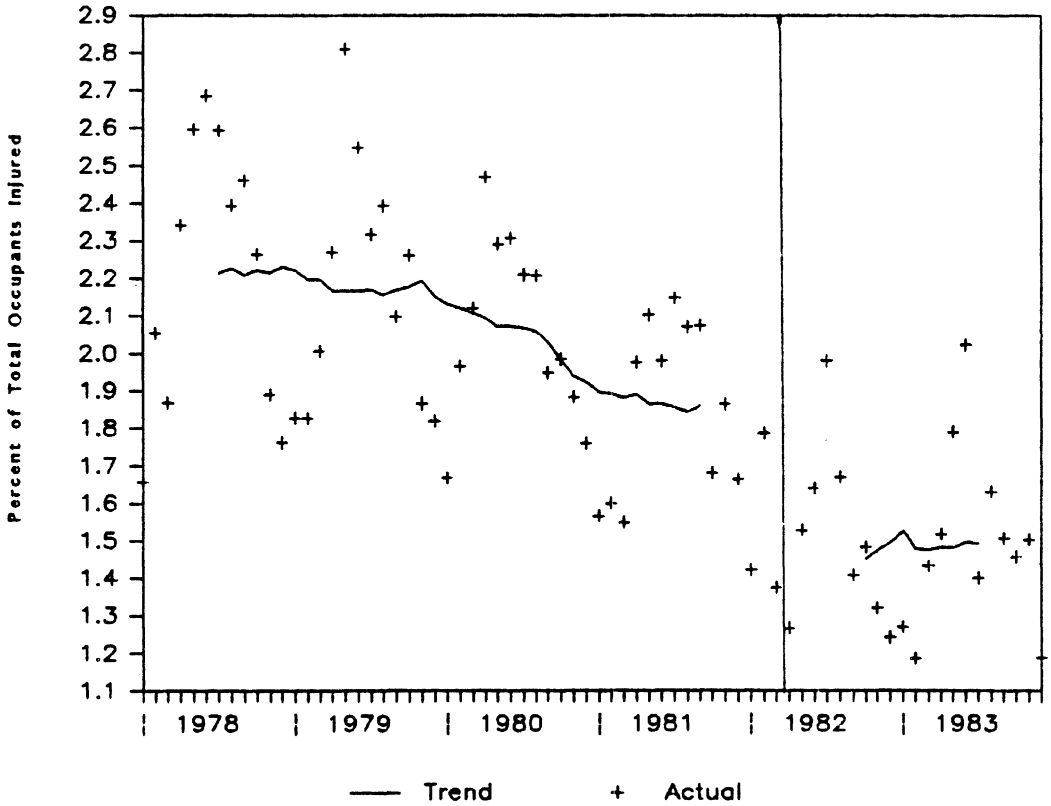
(.062) (.131) (.104) (.091)

Adjusted $R^2 = .67$

Legal Impact Percent Change = -28

Figure 4.25

Injured Occupants Age 0-3 as Percent of All injured Occupants



$$(1-B^{12})\ LnY_t = (1 + .265B + .413B^5)\ (1 - .815B^{12})a_t - .148P_t - .344S_t$$

(.111) (.107) (.056) (.061) (.037)

Adjusted R^2 = .81

Legal Impact Percent Change = -29

After taking into account a 3% decline in the number of children in the state, all of these estimates indicate that the child restraint law is associated with about a 25% reduction in the number of children injured in motor vehicle crashes.

4.3 Differential Effects of the 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 4.26 shows a significant 32% decline in the number of moderately injured 0-3-year-olds after the child restraint law took effect. Although the decrease in the number of severely injured occupants depicted in Figure 4.27 is less obvious than the decrease in the number of moderately injured occupants, time-series analyses revealed a significant 22% decline in the number of severe injuries. Thus, the child restraint law had its largest impact on number of children experiencing moderate injuries, but also had an appreciable effect on the number of children seriously injured.

Figures 4.28 through 4.30 illustrate how the number of injured children has changed from 1978 through 1983 for low-, medium-, and high-damage crashes. The child restraint law was associated with a 50% reduction in the number of occupants injured in low-damage crashes, compared to declines of 25% and 33% for medium- and high-damage crashes, respectively. These estimates are based on time-series models that did not include trend parameters. Some analysts might argue that inclusion of a trend parameter is appropriate, especially for the high-damage crash time series, given the consistent downward trend during the baseline period. The three models were therefore re-estimated with the inclusion of trend parameters. Results indicated estimated a 37% reduction in the number of children injured in low-damage crashes, 27% in medium-damage crashes, and no significant reduction in high-damage crashes.[9] All of these results indicate that 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 of a larger effect of the law in reducing the number of children experiencing moderate injuries than the number experiencing severe 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

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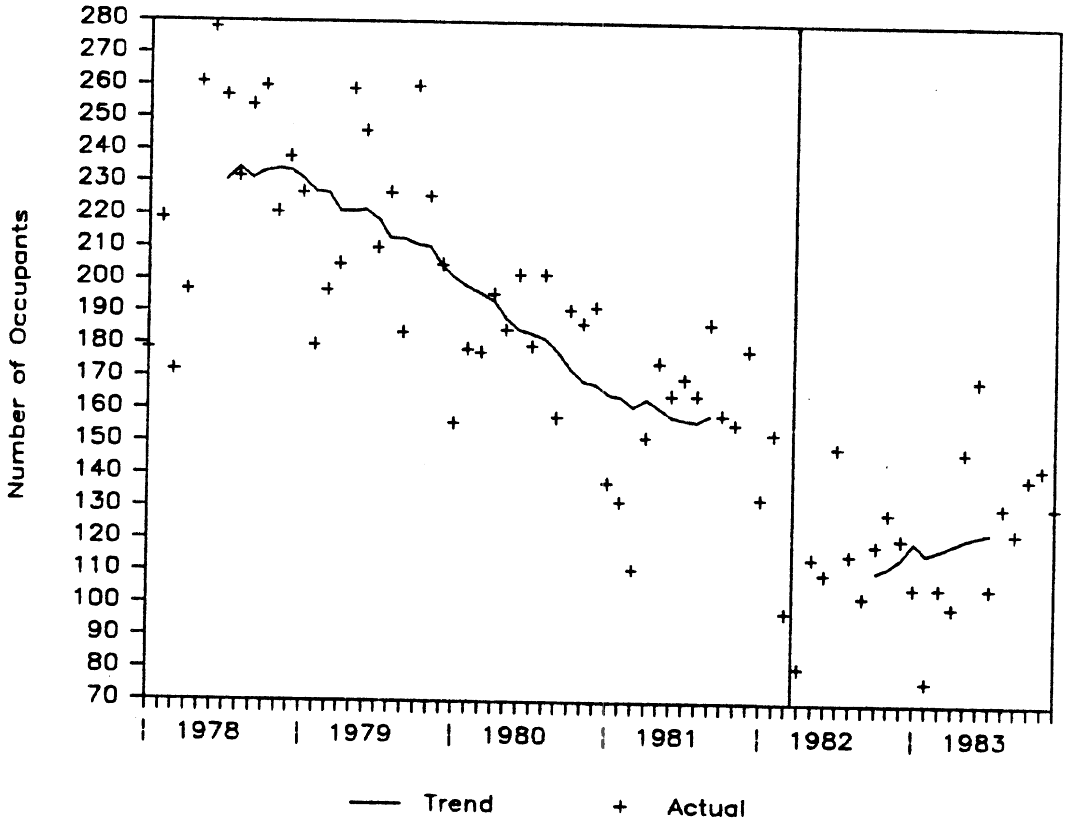
[9] The earlier study included trend parameters in the time-series models and found estimated reductions in the number of injured children associated with the law of 41% for low-damage crashes, 20% for medium-damage crashes, and 12% for high-damage crashes.

Figure 4.26

Moderately Injured Occupants Age 0-3



$$(1-B)\ LnY_t = (1 - .460B - .362B^3)a_t - .251P_t - .384S_t$$

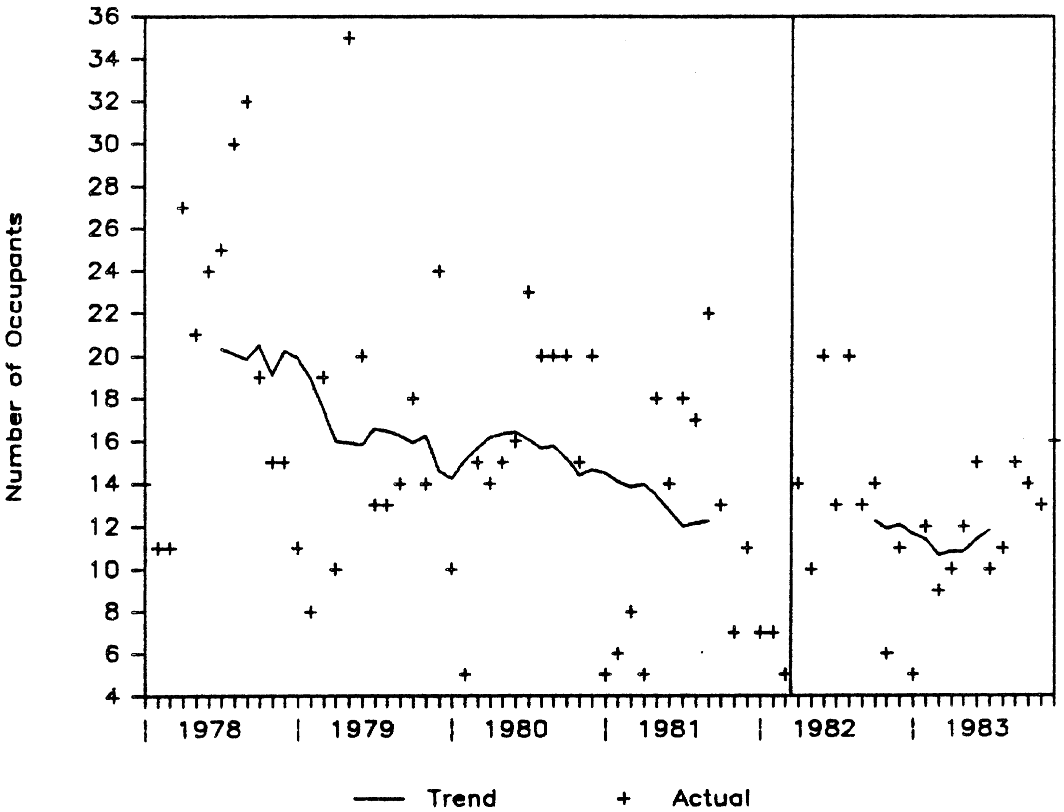
(.102) (.102) (.145) (.134)

Adjusted $R^2 = .72$

Legal Impact Percent Change = -32

Figure 4.27

Severely Injured Occupants Age 0-3



$$(1-B^{12})\ LnY_t = (1 - .853B^{12})a_t - .433P_t - .255S_t$$

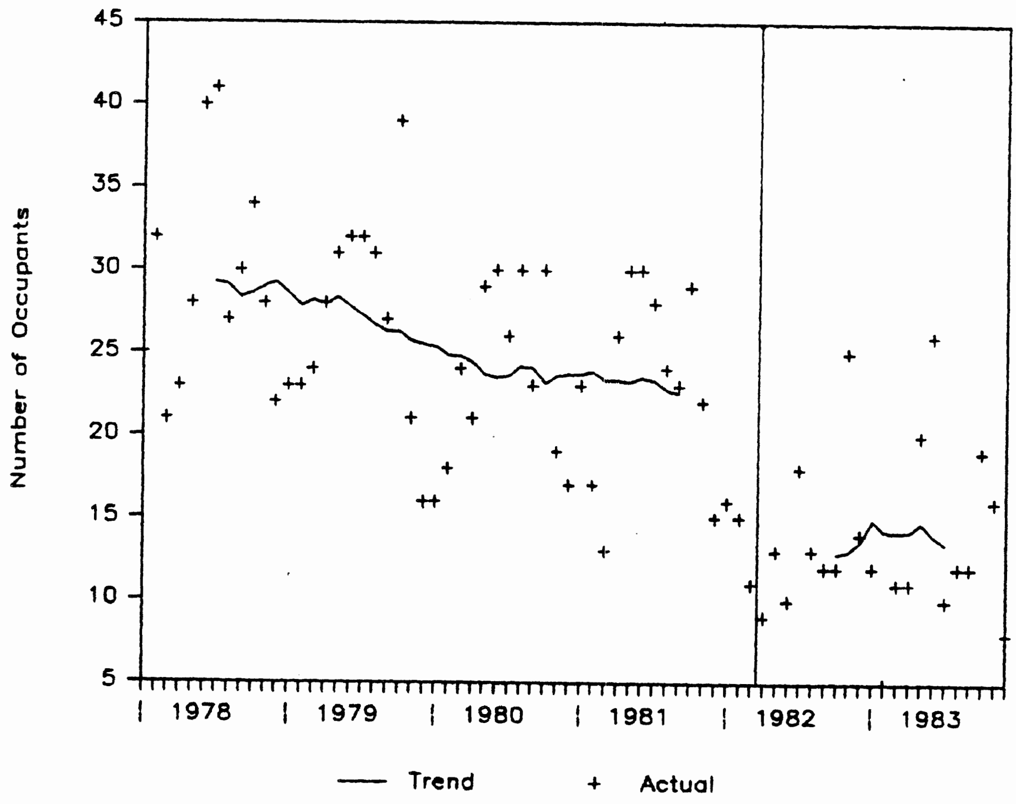
(.047) (.210) (.085)

Adjusted R^2 = .42

Legal Impact Percent Change = -22

Figure 4.28

Injured Occupants Age 0-3 in Low Damage Vehicles



$$(1-B^{12})\ LnY_t = (1 - .788B^{12})a_t - .356P_t - .693S_t$$

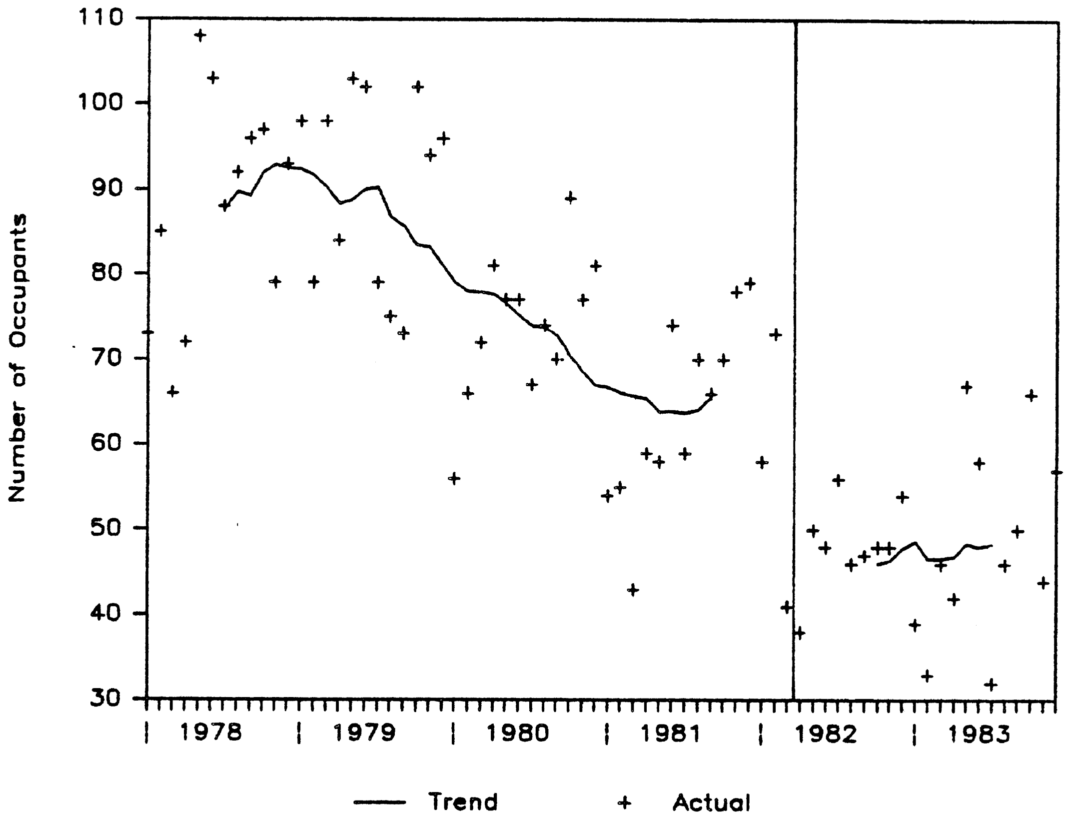
(.049) (.146) (.063)

Adjusted R^2 = .65

Legal Impact Percent Change = -50

Figure 4.29

Injured Occupants Age 0-3 in Medium Damage Vehicles



$$(1-B)(1-B^{12})\ LnY_t = (1 - .845B)\ (1 - .806B^{12})a_t \ + .042P_t - .283S_t$$

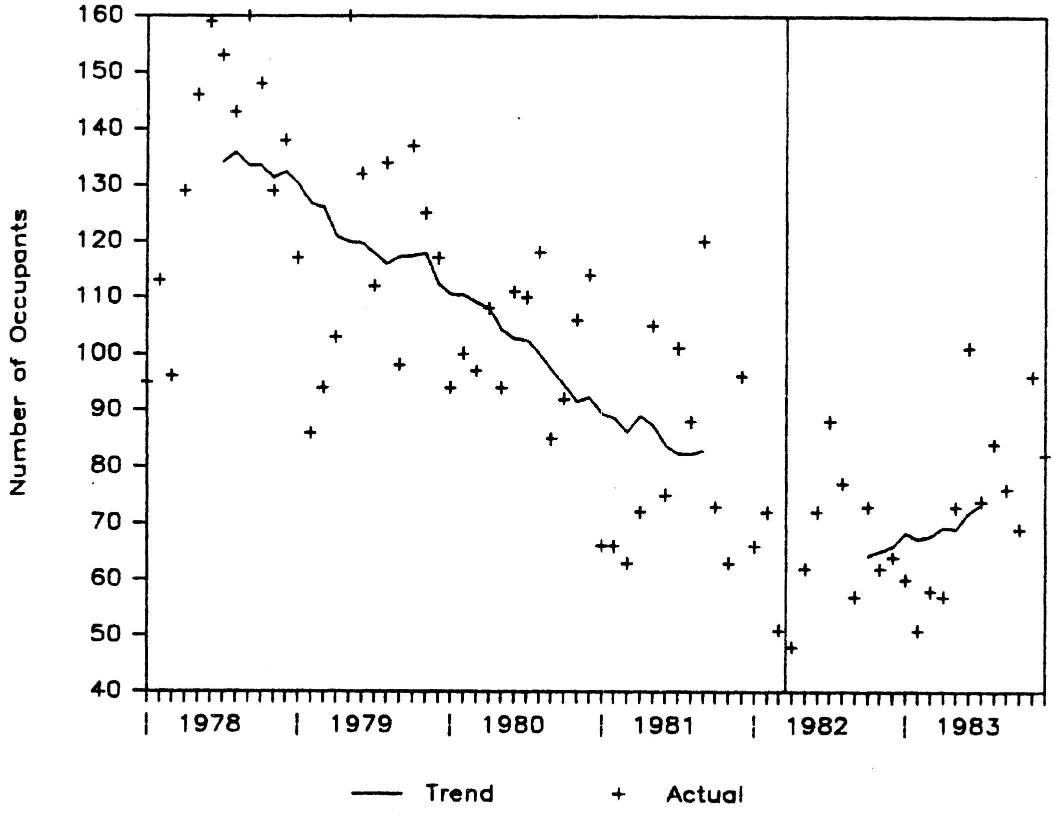
(.069) (.053) (.113) (.106)

Adjusted R^2 = .70

Legal Impact Percent Change = -25

Figure 4.30

Injured Occupants Age 0-3 in High Damage Vehicles



$$(1-B^{12})\ LnY_t = (1 + .610B^5)\ (1 - .841B^{12})a_t \ - .336P_t - .404S_t$$

$$(.099) \qquad (.057) \qquad (.093) \qquad (.068)$$

Adjusted R^2 = .66

Legal Impact Percent Change = -33

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.[10] 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 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.[11]

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 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%.[12] 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.

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[10]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, 1983). 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.

[11]Furthermore, the small fine is infrequently imposed.

[12]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 conducted.

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 four 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 4.31 through 4.35 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 43%, and the number of front right occupants decreased 39%. The number of children injured in the rear center position, generally considered the safest seating position, declined by 55% after the law took effect. However, there were slight increases in the number of children injured in rear-left and rear-right seating positions, though these increases were not statistically significant. Given that there is no measure of the number of uninjured occupants in these various seating position, 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 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 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 1979-79, 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 four 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.

Prior studies have found differences in restraint use according to the type of trip, time of day, and day of week (Kielhorn and Westphal, 1980). These differences are important to officials responsible for enforcing the law and to those designing programs promoting child restraint use. To determine if the law had varying effects according to time of day or day of week, the number of children injured was stratified into four groups: (1) weekday daytime crashes, (2) weekday nighttime crashes, (3) weekend daytime crashes, and (4) weekend nighttime crashes (See Figures 4.36 through 4.39).[13] Although there were no substantial

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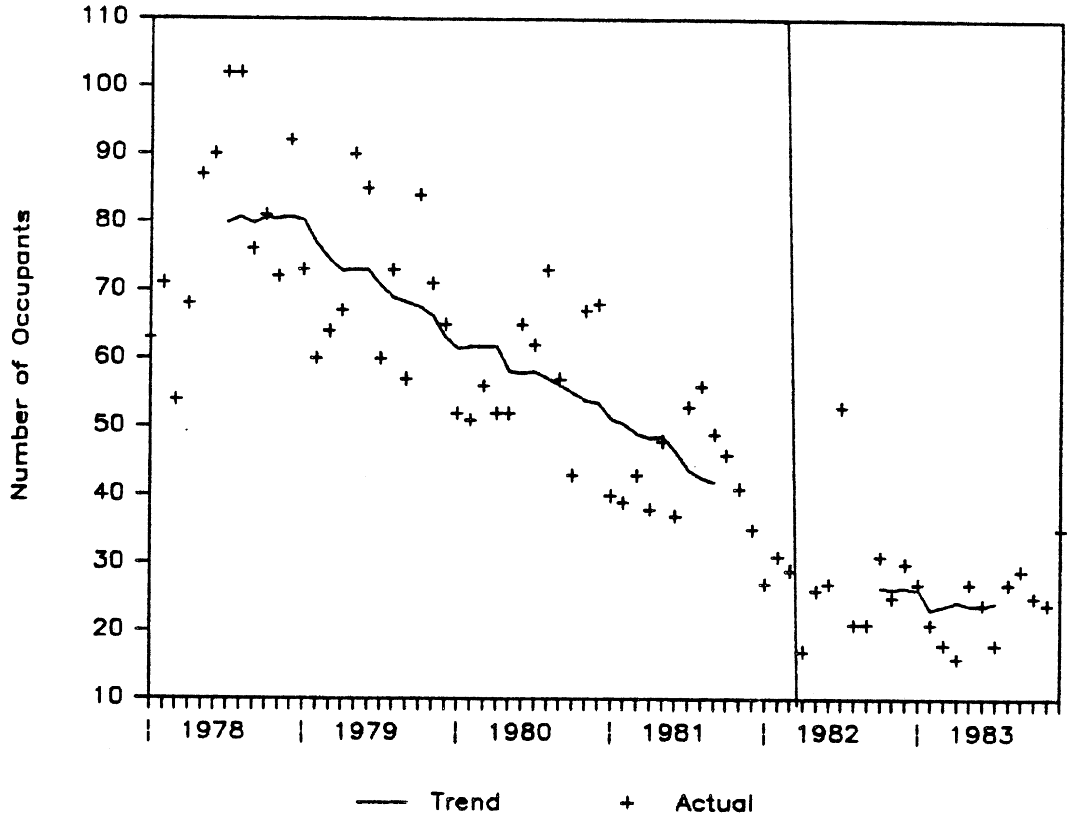
[13]See Section 3.2 for a detailed description of variable definitions.

Figure 4.31

Injured Occupants Age 0-3 in Front Center Position



$$(1-B)\ LnY_t = (1 - .753B)a_t - .399P_t - .564S_t$$

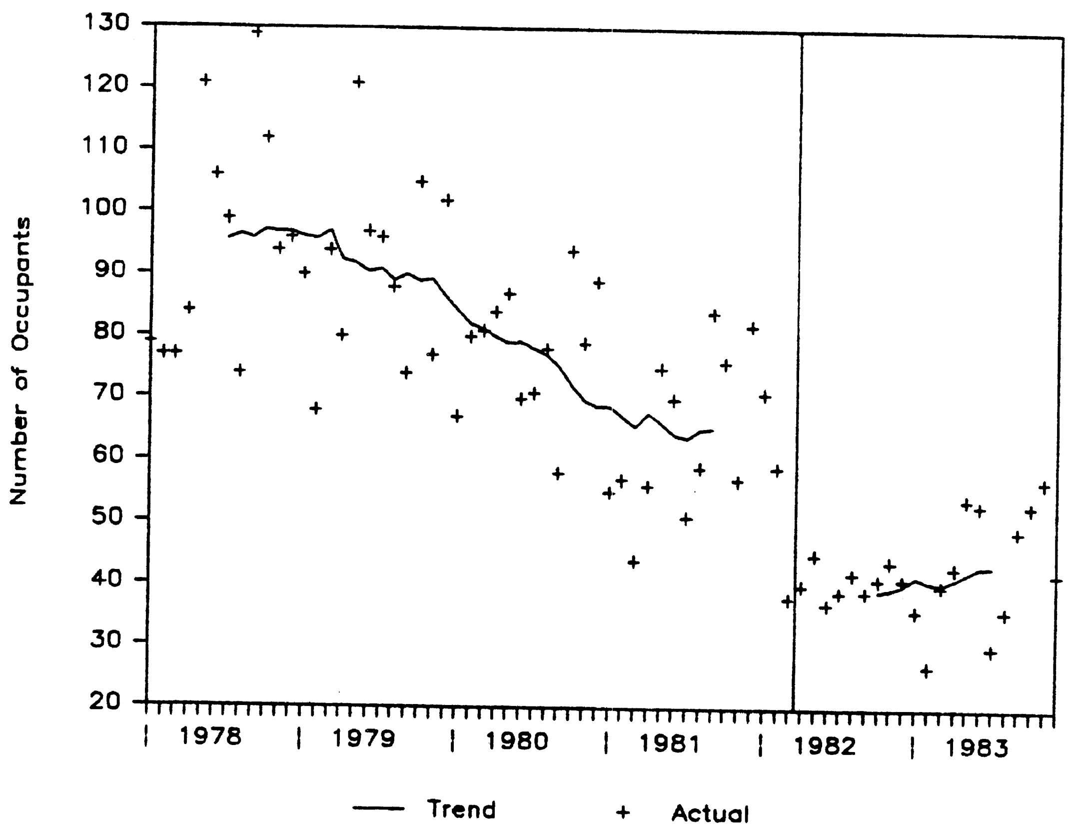
(.081) (.170) (.181)

Adjusted R^2 = .79

Legal Impact Percent Change = -43

Figure 4.32

Injured Occupants Age 0-3 in Front Right Position



$$(1-B)\ LnY_t = (1 - .824B)a_t - .219P_t - .499S_t$$

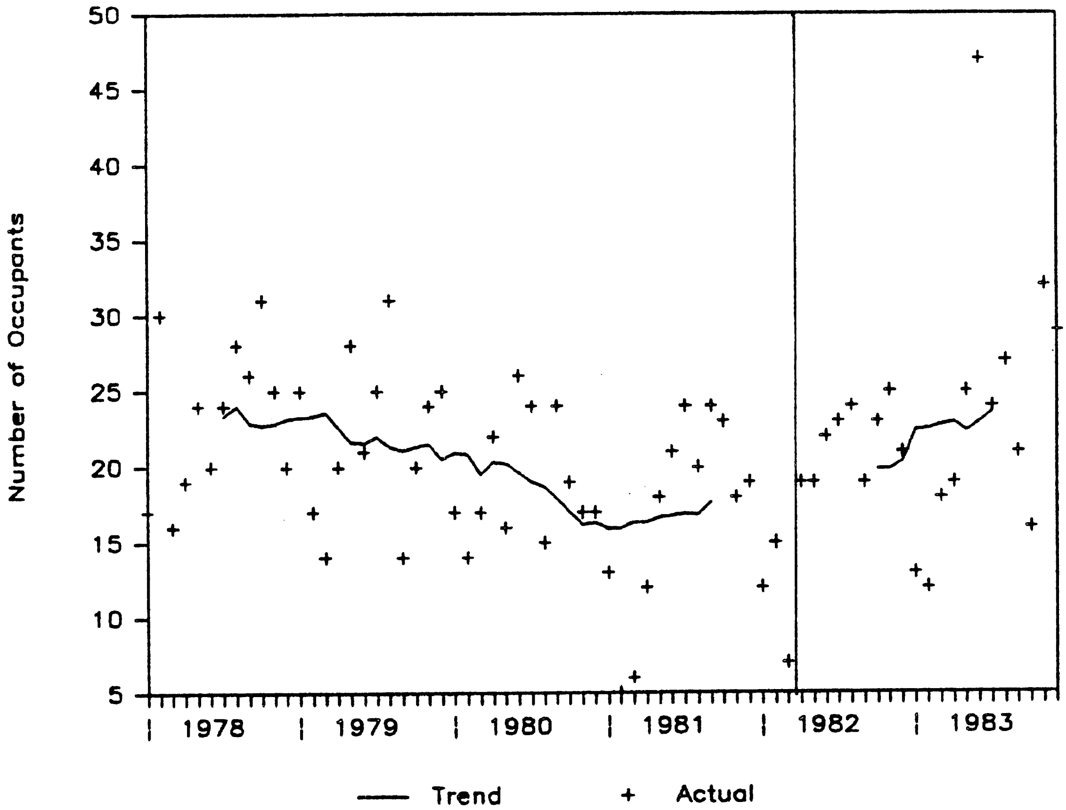
$$(.069) \quad (.141) \quad (.132)$$

Adjusted $R^2 = .69$

Legal Impact Percent Change = -39

Figure 4.33

Injured Occupants Age 0-3 in Rear Left Position



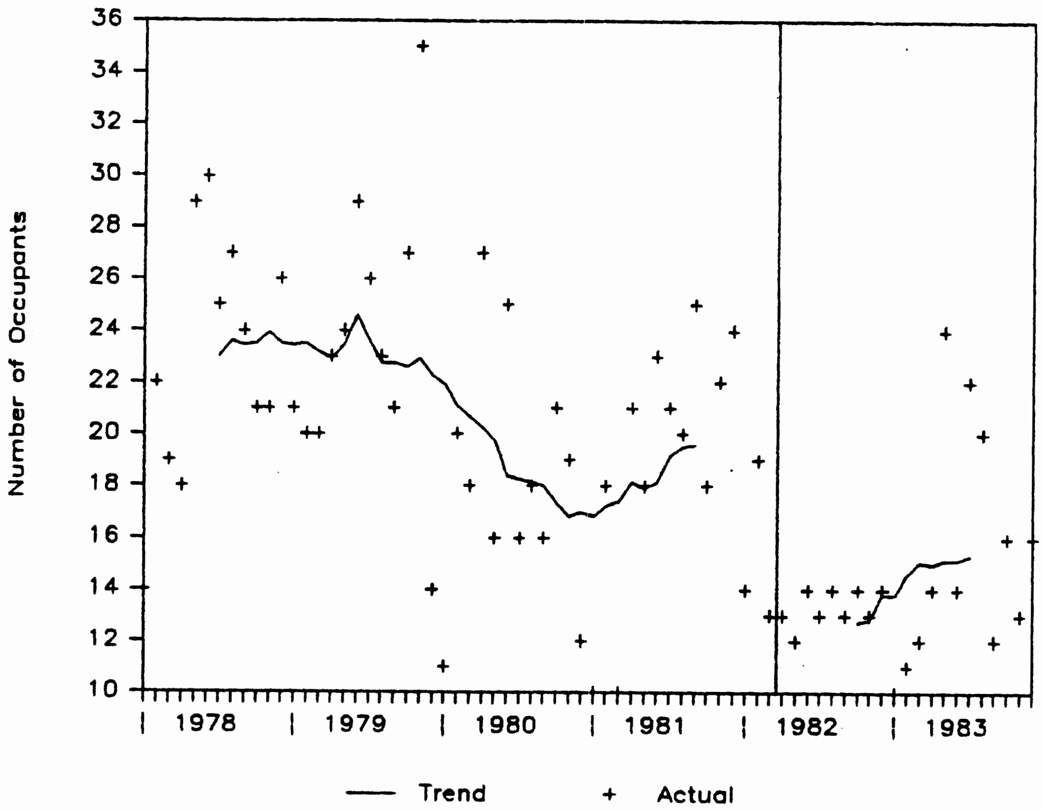
$$(1-B^{12})\ LnY_t = (1 + .361B)\ (1 - .819B^{12})a_t - .348P_t + .104S_t$$

(.114) (.046) (.210) (.096)

Adjusted $R^2 = .35$

Figure 4.34

Injured Occupants Age 0-3 in Rear Center Position



$$(1-B)\ LnY_t = (1 - .771B)\ (1 + .795B^{12})a_t - .143P_t - .799S_t$$

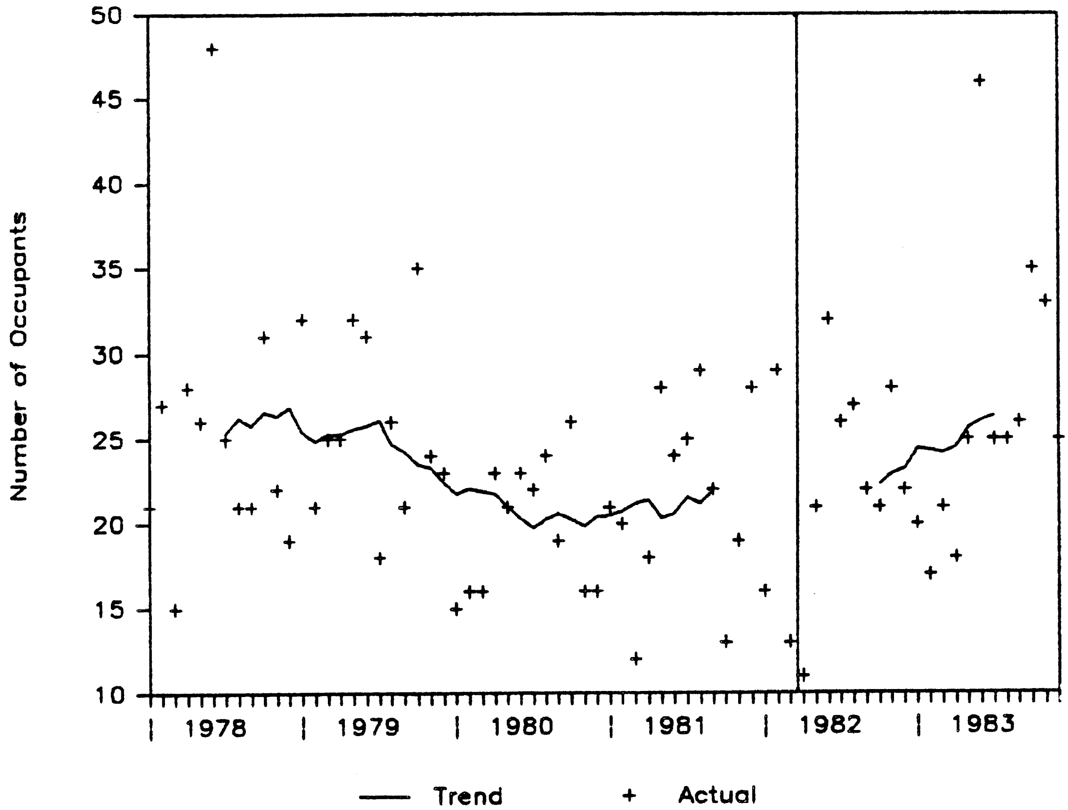
(.074) (.047) (.133) (.145)

Adjusted R^2 = .47

Legal Impact Percent Change = -55

Figure 4.35

Injured Occupants Age 0–3 in Rear Right Position



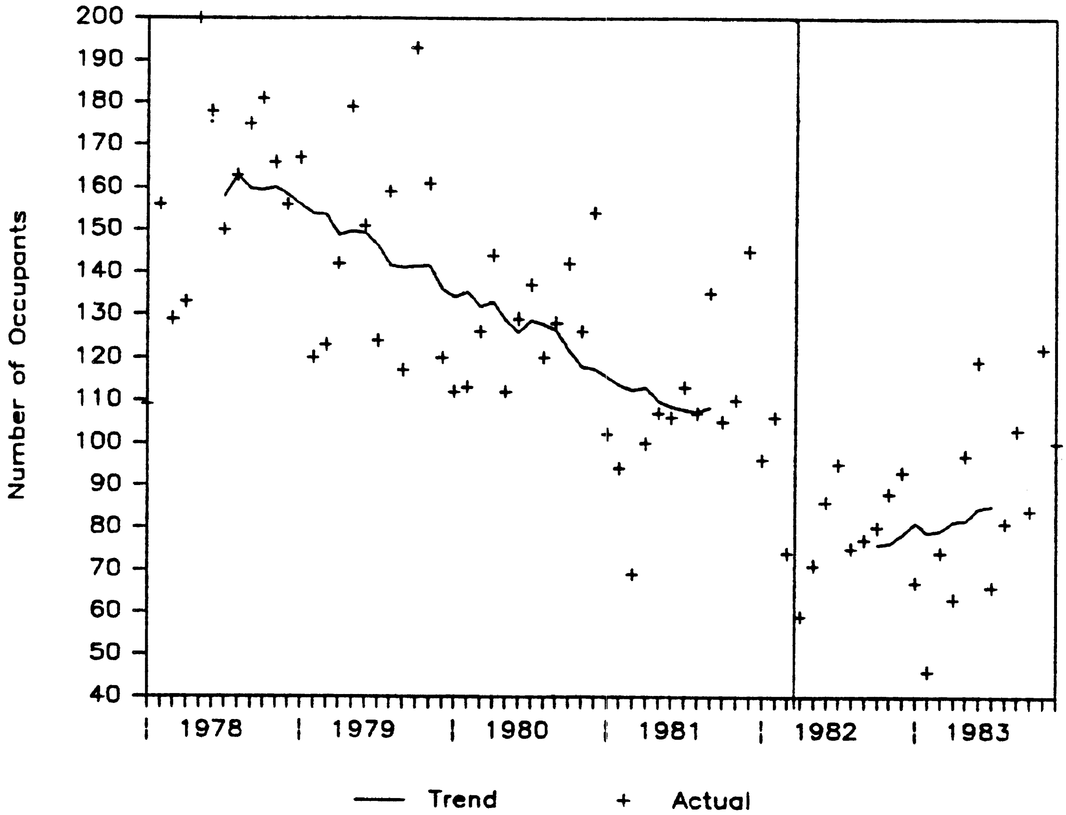
$$(1-B^{12})\ LnY_t = (1 - .842B^{12})a_t - .036P_t + .064S_t$$

$$\qquad\qquad (.052) \qquad\qquad (.154) \quad (.063)$$

Adjusted $R^2 = .13$

Figure 4.36

Injured Occupants Age 0-3 in Weekday Daytime Crashes



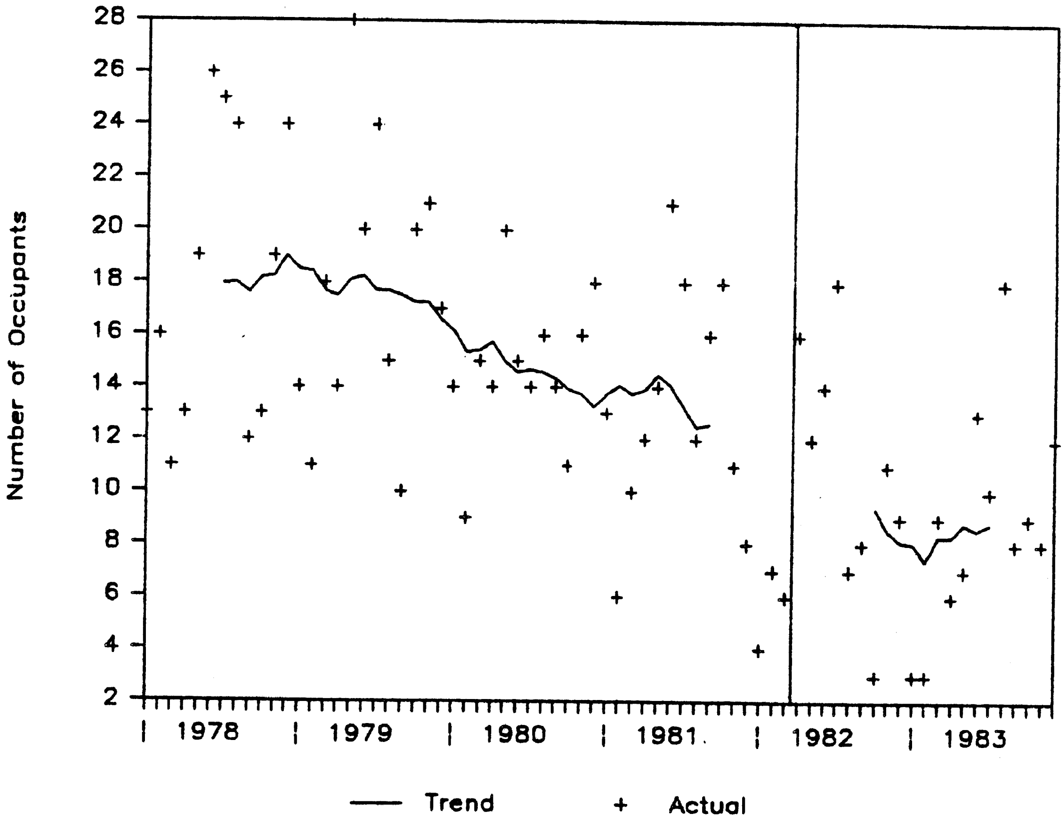
$$(1-B)\ LnY_t = (1 - .770B)a_t - .251P_t - .444S_t$$
$$(.079) \quad (.147) \quad (.152)$$

Adjusted R^2 = .63

Legal Impact Percent Change = -36

Figure 4.37

Injured Occupants Age 0-3 in Weekday Nighttime Crashes



$$(1-B^{12})\ \mathrm{Ln}Y_t = (1 - .809B^{12})a_t - .656P_t - .601S_t$$

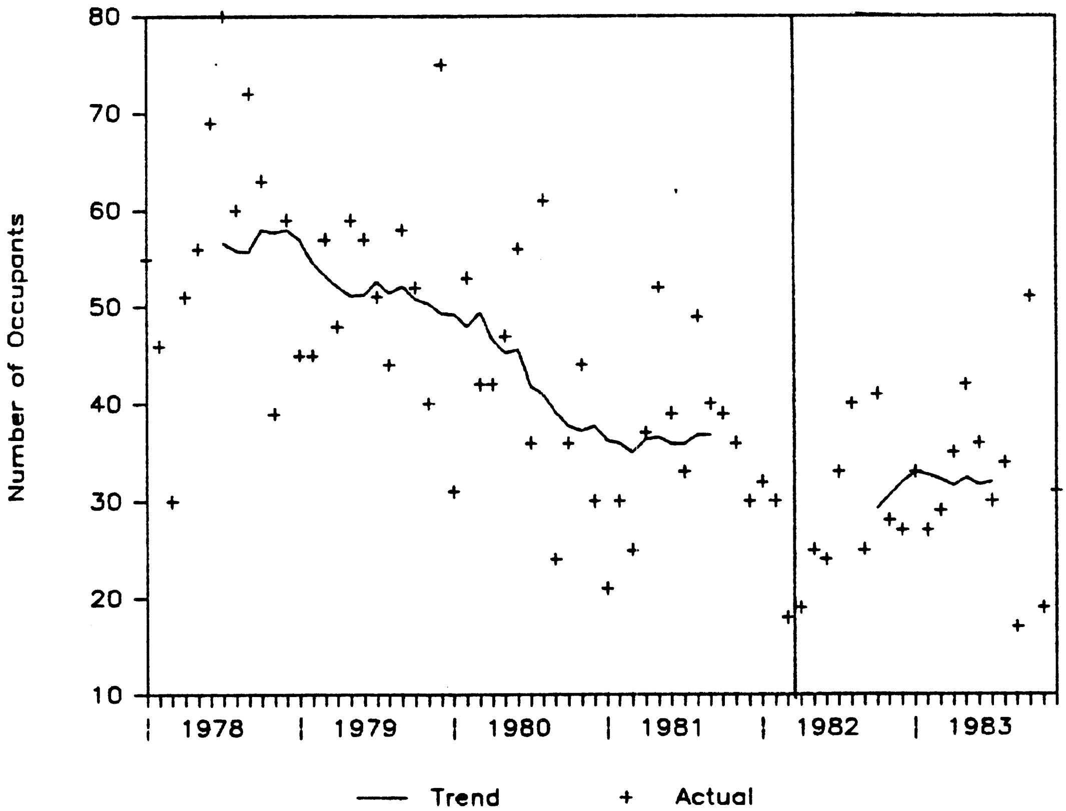
(.050) (.212) (.090)

Adjusted $R^2 = .46$

Legal Impact Percent Change = -45

Figure 4.38

Injured Occupants Age 0-3 in Weekend Daytime Crashes



$$(1-B)(1-B^{12})\, LnY_t = (1 - .783B)a_t - .124P_t - .372S_t$$

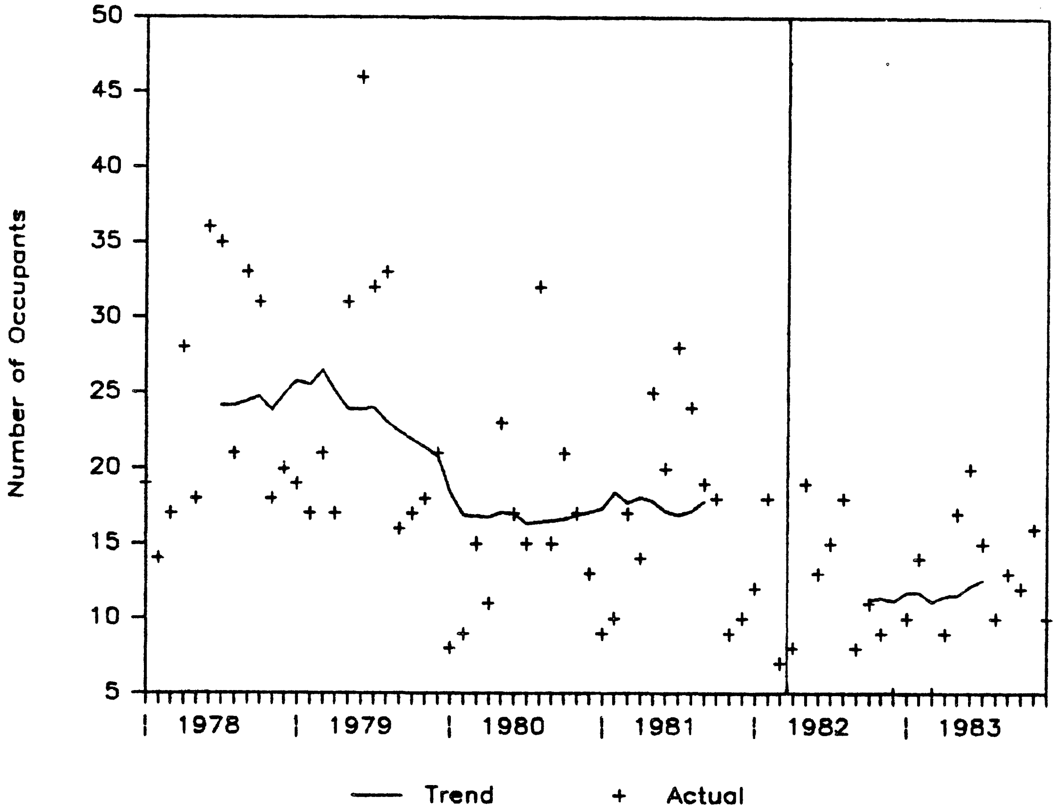
(.086) (.174) (.186)

Adjusted R^2 = .08

Legal Impact Percent Change = -31

Figure 4.39

Injured Occupants Age 0-3 in Weekend Nighttime Crashes



$$(1-B^{12})\ LnY_t = (1 - .825B^{12})a_t - .197P_t - .515S_t$$

$$(.051) \qquad (.202) \qquad (.085)$$

Adjusted R^2 = .45

Legal Impact Percent Change = -40

differences found in the impact of the law on the number of occupants injured across the four groups, two noteworthy patterns emerged. The number of children injured in weekday crashes declined 5% more than the number injured in weekend crashes following passage of the child restraint law. Second, the law is associated with a 9% larger decline in the number of child occupants injured in nighttime crashes than daytime crashes.

Time-series analyses revealed little difference in the estimated effect of the child restraint law on the number of children injured according to the sex of the driver with whom they were riding. The number of child occupants injured declined 26% in crashes with male drivers and 29% with female drivers (See Figures 4.40 and 4.41).

Although the sex of the driver was not related to the magnitude of the effect of the child restraint law, the age of the driver was. Based on separate time-series analyses of four age groups of drivers, a significant 35% decline in the number of children injured occurred among children riding with drivers 25-34 years old (See Figures 4.42 through 4.45). While slight decreases are evident in the time-series plots for other age groups, the decreases were not statistically significant. Drivers in the 25-34 age group are the most likely to be traveling with young children. Furthermore, drivers in that age group are most likely to be a parent of the child, while drivers in the other age groups are less likely to be the parent of the child. Prior studies have indicated that children are more likely to be properly restrained when the driver of the vehicle is the child's parent (Philpot and others, 1978; Williams and Wells, 1981; Hall and Daniel, 1983).

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 cut-points 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 socio-ecological factors.[14]

The present study found that the most densely populated areas experienced the smallest declines in injuries associated with the law (See Figures 4.46 through 4.50). The child restraint law was associated with the following reductions in the number of children injured: 34% in low-density counties, 38% in medium-density counties, 35% in high-density counties, 20% in very-high-density counties, and 24% in Wayne County. However, even in very-high-density counties (including Wayne County) a significant reduction in the number of

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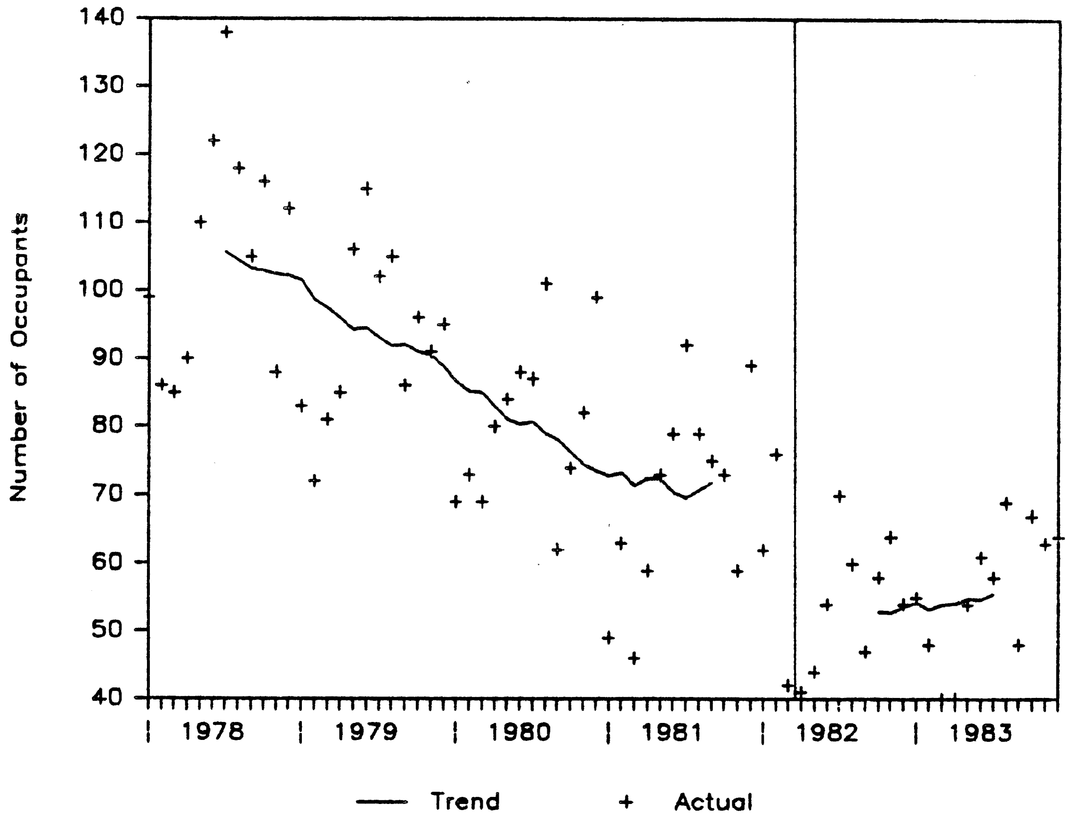
[14]Population densities for the groups are as follows (in people per square mile of land area: low-density counties ranged from 3.7 to 69.9, medium-density counties ranged from 78.2 to 235.5, high-density counties ranged from 267.7 to 387.2, very-high-density counties ranged from 491 to 1440, and Wayne 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 4.40

Injured Occupants Age 0-3 in Vehicles with Male Drivers



$$(1-B^{12})\ LnY_t = (1 + .266B^4 + .209B^5 + .318B^7)a_t + .037P_t - .306S_t$$

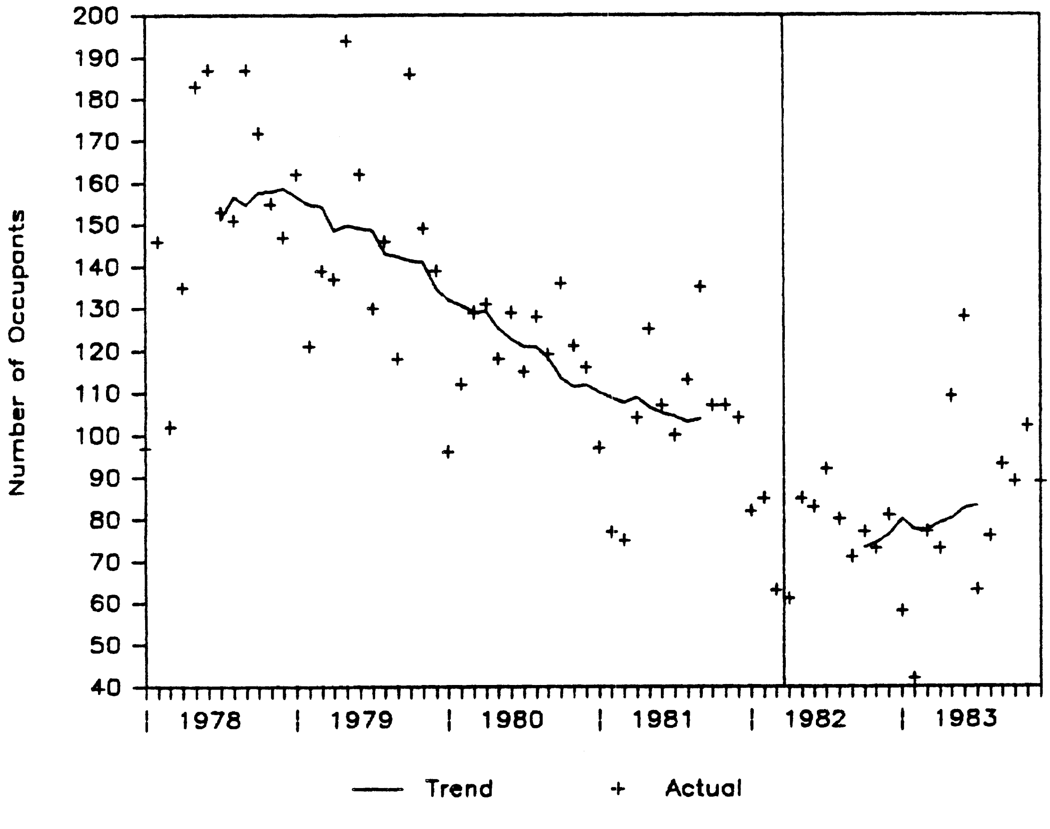
(.114) (.113) (.106) (.074) (.074)

Adjusted $R^2 = .71$

Legal Impact Percent Change = -26

Figure 4.41

Injured Occupants Age 0-3 in Vehicles with Female Drivers



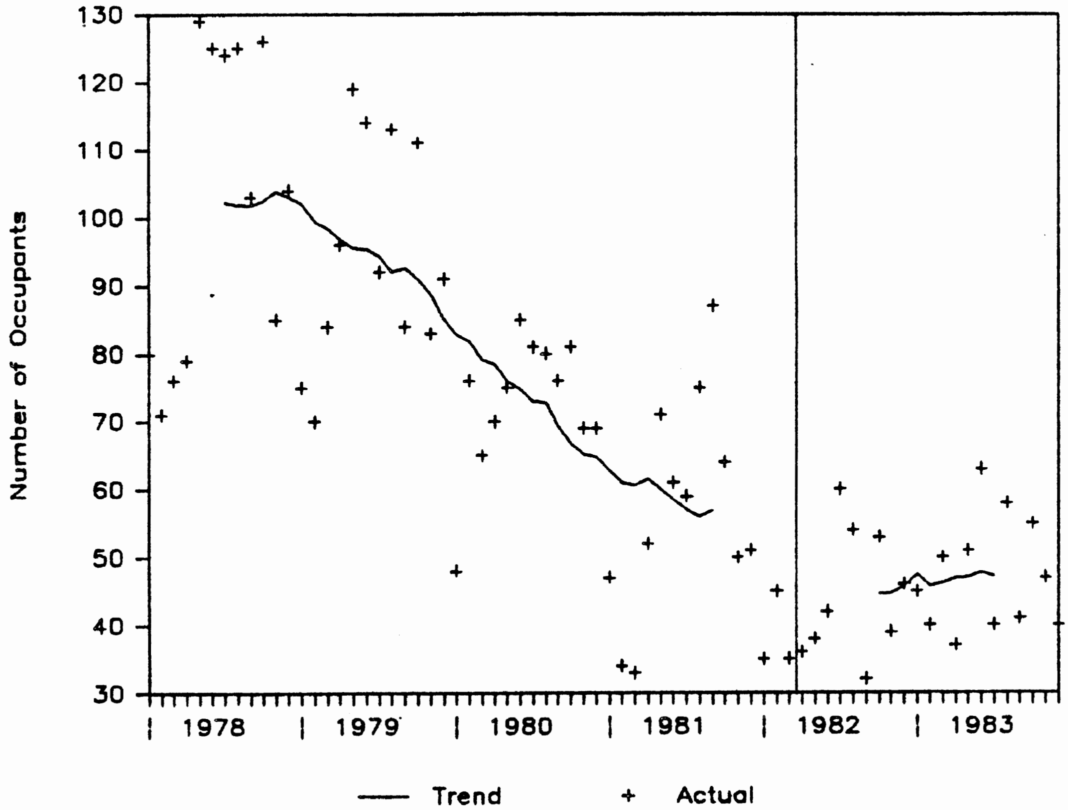
$$(1-B)\ LnY_t = (1 - .743B)a_t - .346P_t - .345S_t$$
$$(.076) \qquad (.149) \qquad (.163)$$

Adjusted R^2 = .60

Legal Impact Percent Change = -29

Figure 4.42

Injured Occupants Age 0-3 in Vehicles with Drivers Age 16-24



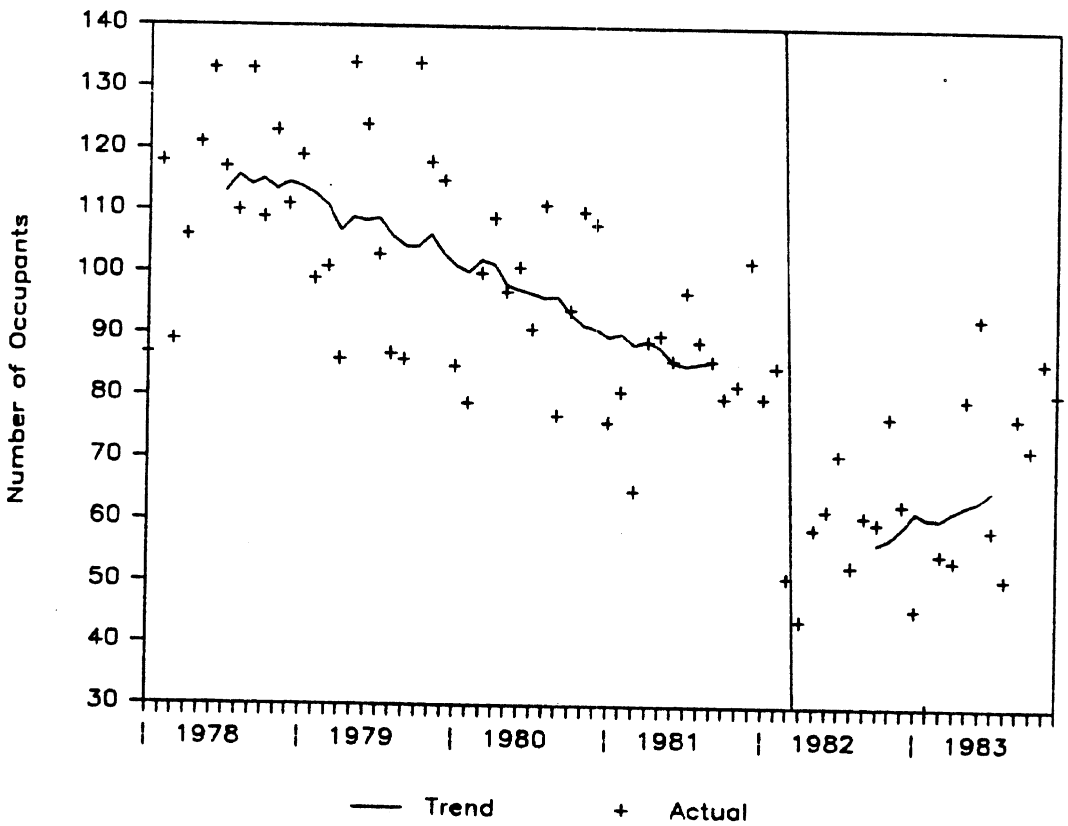
$$(1-B)\ LnY_t = (1 - .597B - .243B^3 + .239B^{12})a_t - .222P_t - .170S_t$$

(.092) (.097) (.075) (.175) (.164)

Adjusted $R^2 = .69$

Figure 4.43

Injured Occupants Age 0-3 in Vehicles with Drivers Age 25-34



$$(1-B)\ LnY_t = (1 - .897B)\ (1 + .754B^{12})a_t + .031P_t - .426S_t$$

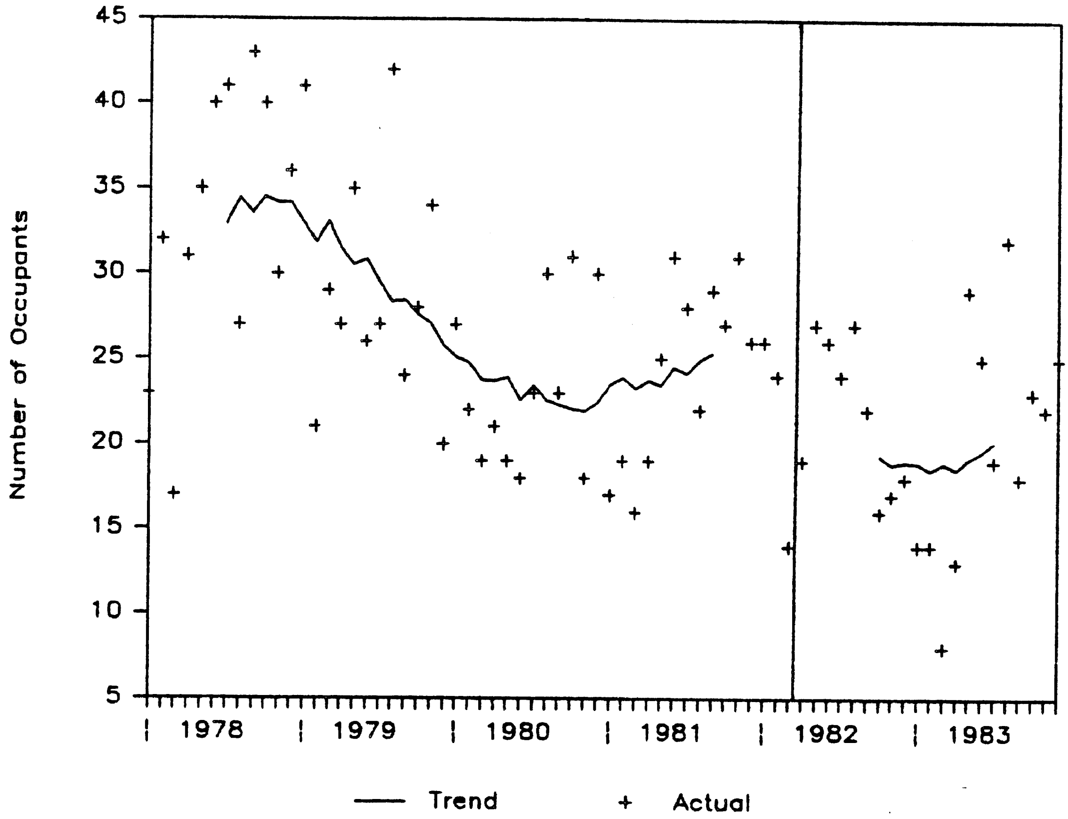
$$(.061) \qquad (.052) \qquad (.098) \qquad (.094)$$

Adjusted R^2 = .65

Legal Impact Percent Change = -35

Figure 4.44

Injured Occupants Age 0-3 in Vehicles with Drivers Age 35-55



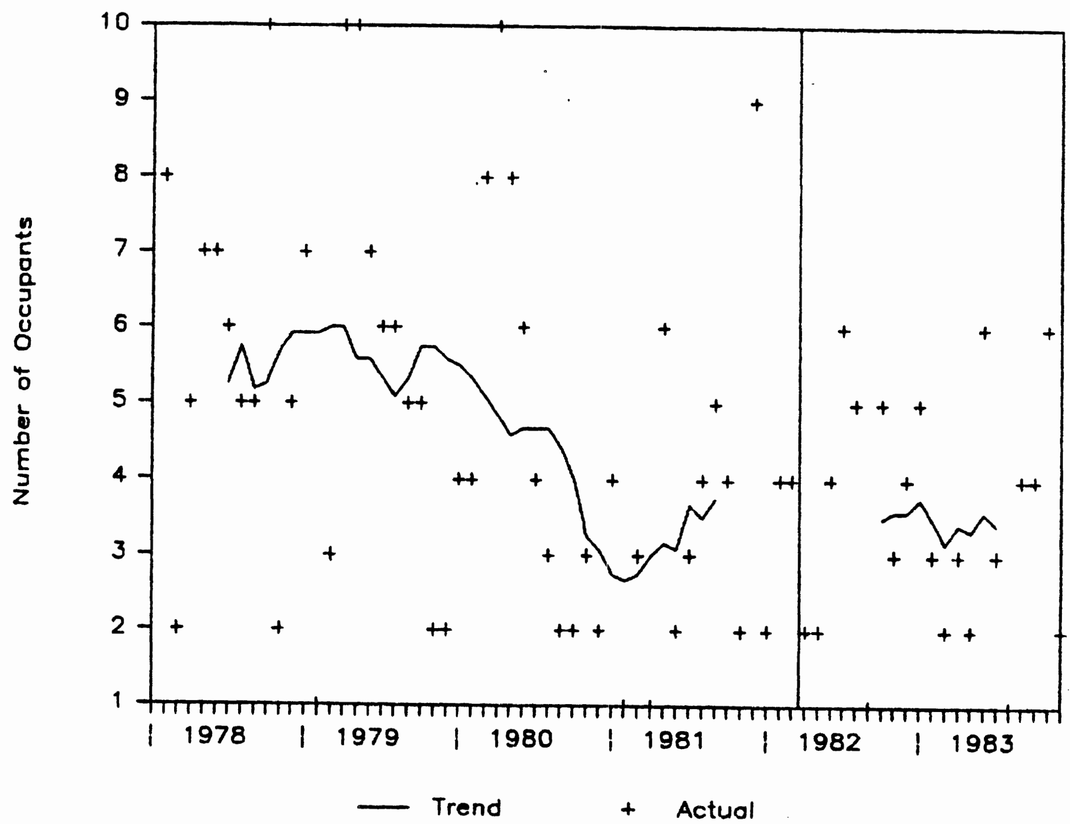
$$(1-B)\ LnY_t = (1 - .670B)a_t - .233P_t - .105S_t$$

$$(.090) \quad (.220) \quad (.258)$$

Adjusted $R^2 = .21$

Figure 4.45

Injured Occupants Age 0-3 in Vehicles with Drivers Age 56 and Over



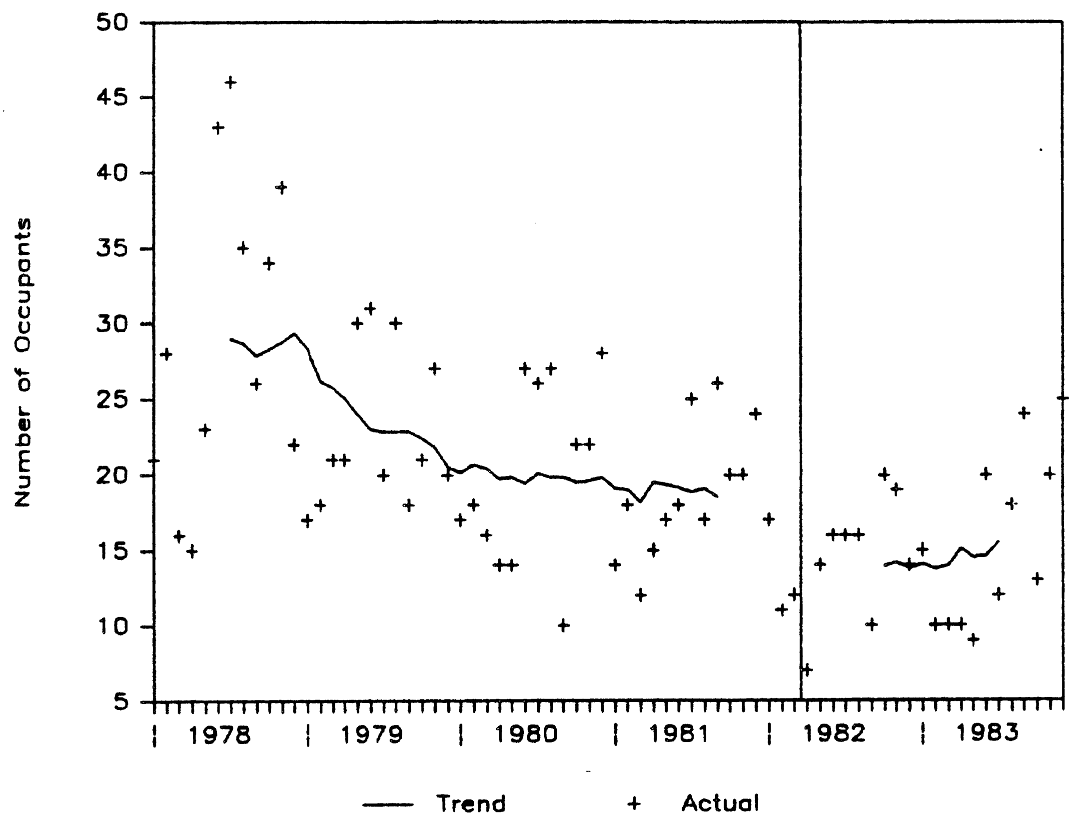
$$(1-B)\ LnY_t = (1 - .973B)a_t - .181P_t - .219S_t$$

(.012) (.363) (.178)

Adjusted $R^2 = .04$

Figure 4.46

Injured Occupants Age 0-3 in Low Density Counties



$$(1-B^{12})\ LnY_t = (1 - .813B^{12})a_t - .285P_t - .419S_t$$

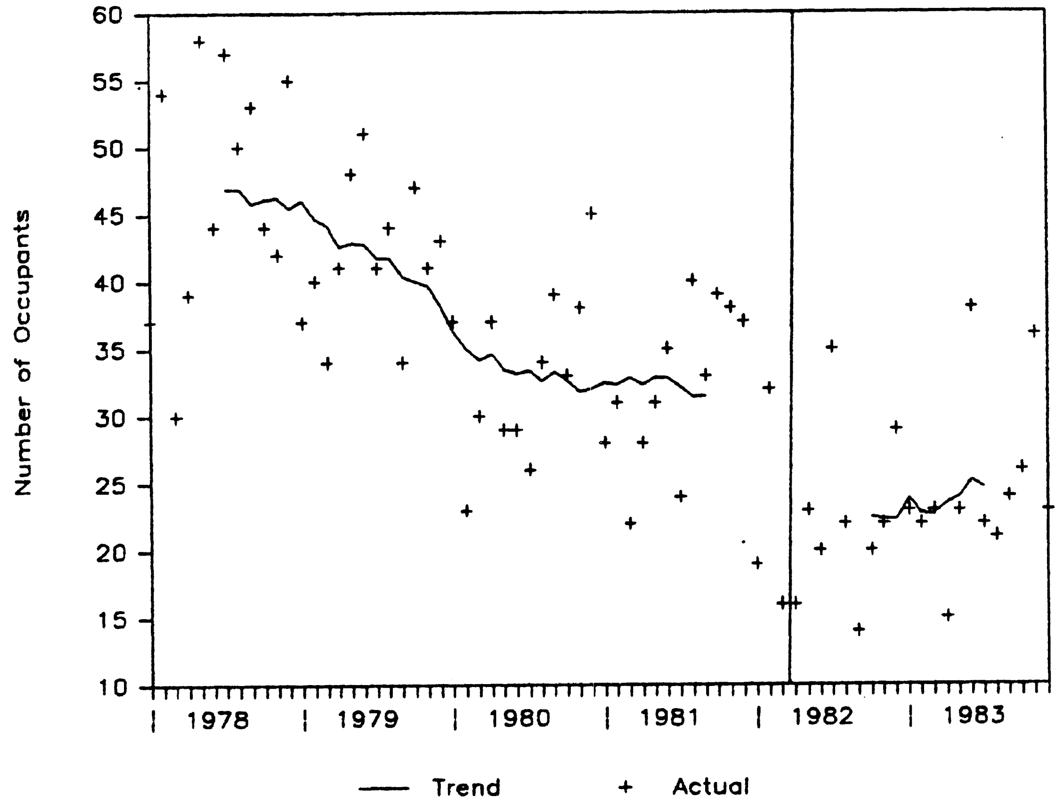
(.046) (.159) (.068)

Adjusted R^2 = .49

Legal Impact Percent Change = -34

Figure 4.47

Injured Occupants Age 0-3 in Medium Density Counties



$$(1-B^{12})\ LnY_t = (1 + .492B^5)\ (1 - .799B^{12})a_t - .521P_t - .479S_t$$

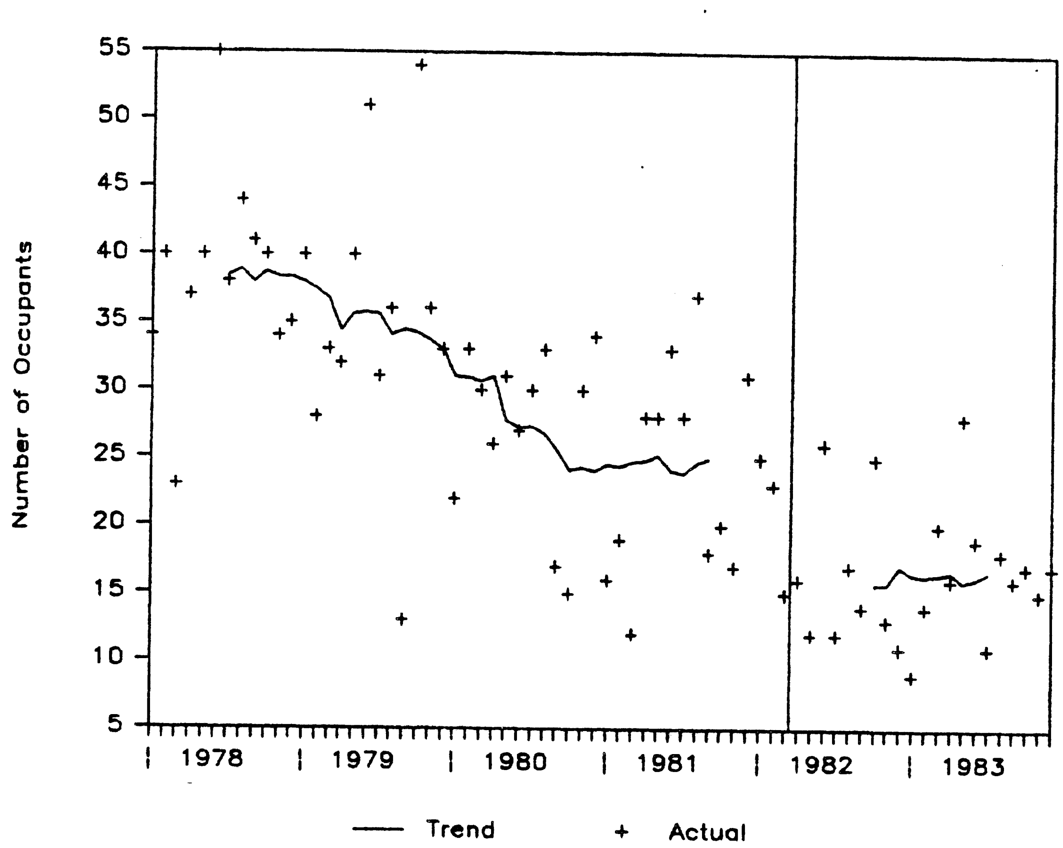
(.112) (.054) (.124) (.077)

Adjusted R^2 = .58

Legal Impact Percent Change = -38

Figure 4.48

Injured Occupants Age 0-3 in High Density Counties



$$(1-B)\ LnY_t = (1 - .809B)\ (1 - .320B^3)a_t - .150P_t - .433S_t + a_t$$

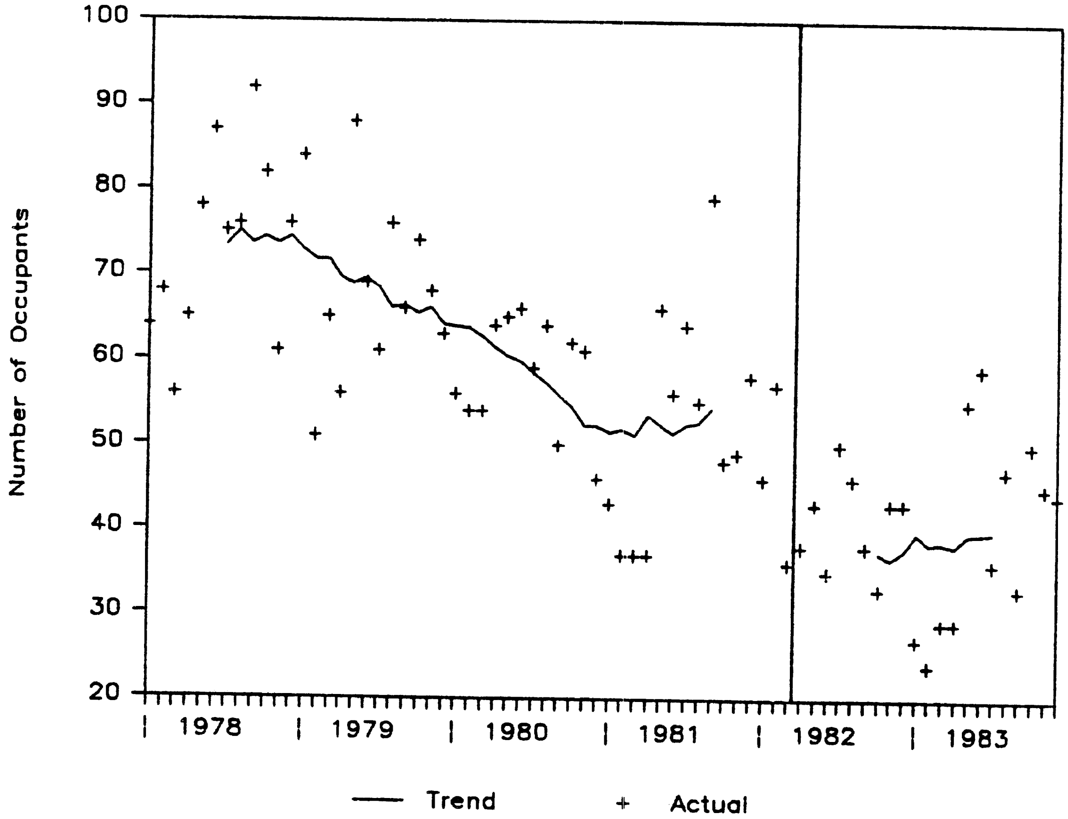
(.076) (.126) (.209) (.155)

Adjusted R^2 = .51

Legal Impact Percent Change = -35

Figure 4.49

Injured Occupants Age 0-3 in Very High Density Counties



$$(1 - B)(1 - B^{12})\ LnY_t = (1 - .877B)\ (1 - .801B^{12})a_t + .133P_t - .223S_t$$

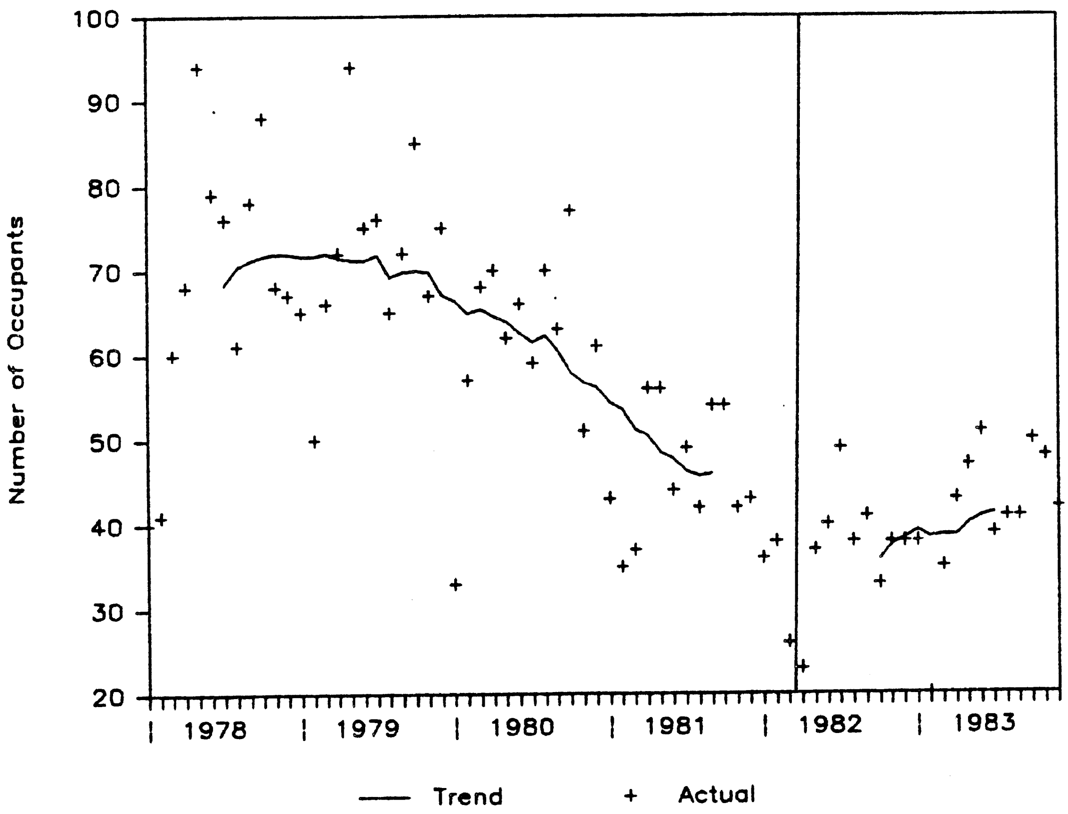
$$(.058) \qquad (.049) \qquad (.118) \qquad (.103)$$

Adjusted $R^2 = .66$

Legal Impact Percent Change = -20

Figure 4.50

Injured Occupants Age 0-3 in Wayne County



$$(1-B)\ LnY_t = (1 - .483B - .333B^3)a_t - .222P_t - .273S_t$$

(.100) (.099) (.196) (.195)

Adjusted $R^2 = .57$

Legal Impact Percent Change = -24

children injured was found.

Family income is another factor related to restraint use, which 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 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.[15]

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 after the child restraint law took effect: 24% in Wayne County, 33% in low-poverty counties, 27% in medium-poverty counties, and 40% in high-poverty counties (Figures 4.50 through 4.53).

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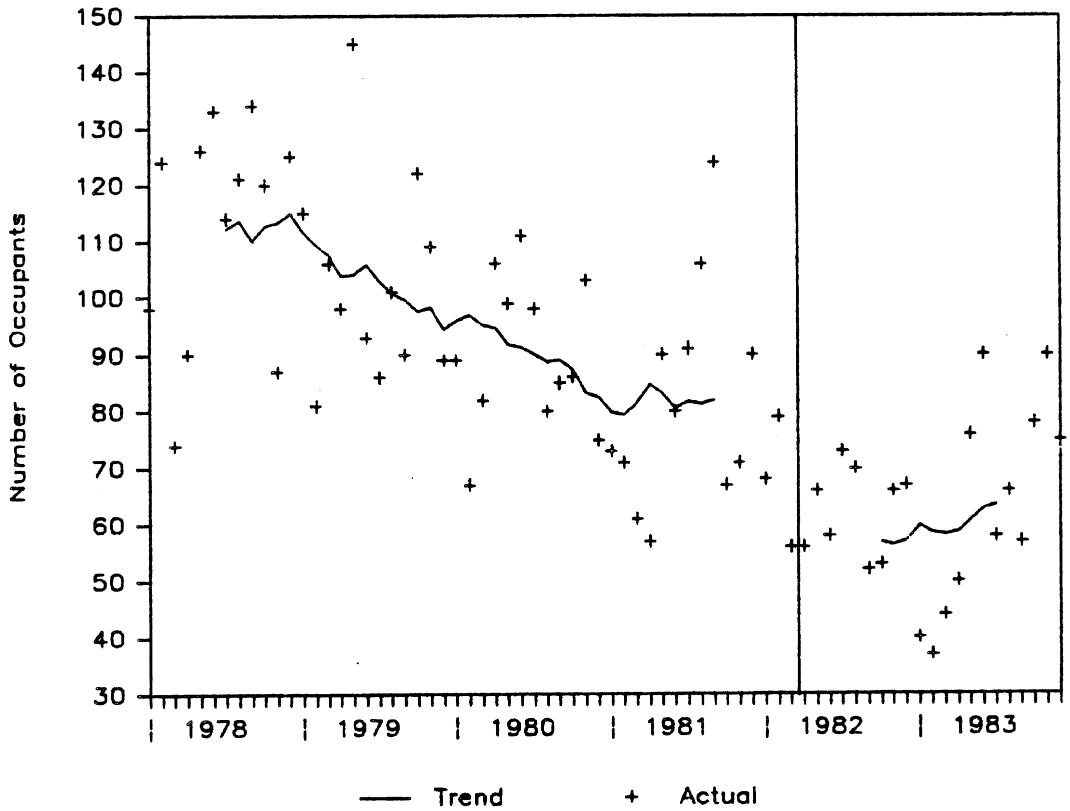
[15]Poverty data are from the *1983 County and City Data Book.*

Figure 4.51

Injured Occupants Age 0-3 in Low Poverty Counties



$$(1-B)\ LnY_t = (1 - .536B - .272B^2)\ (1 - .566B^9)a_t - .336P_t - .400S_t$$

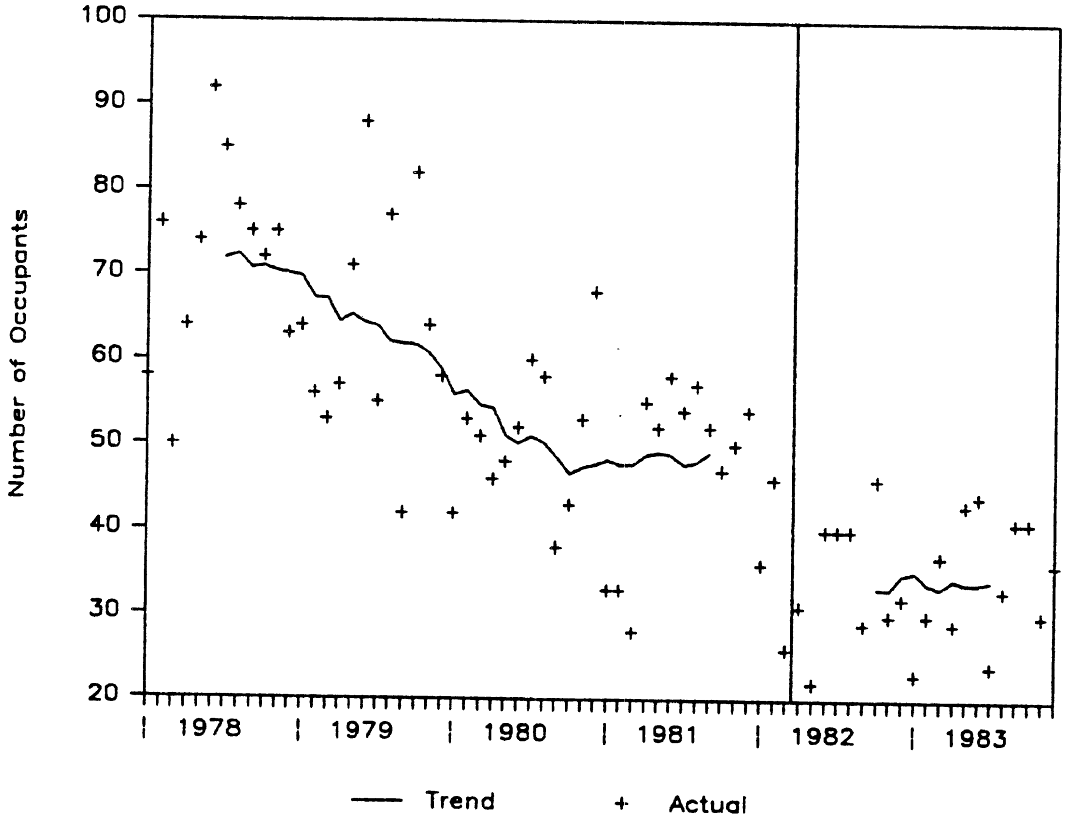
$$(.118) \quad (.123) \quad (.110) \quad (.128) \quad (.107)$$

Adjusted R^2 = .61

Legal Impact Percent Change = -33

Figure 4.52

Injured Occupants Age 0-3 in Medium Poverty Counties



$$(1-B)\ (1-B^{12})\ LnY_t = (1 - .855B)\ (1 - .789B^{12})a_t - .069P_t - .311S_t$$

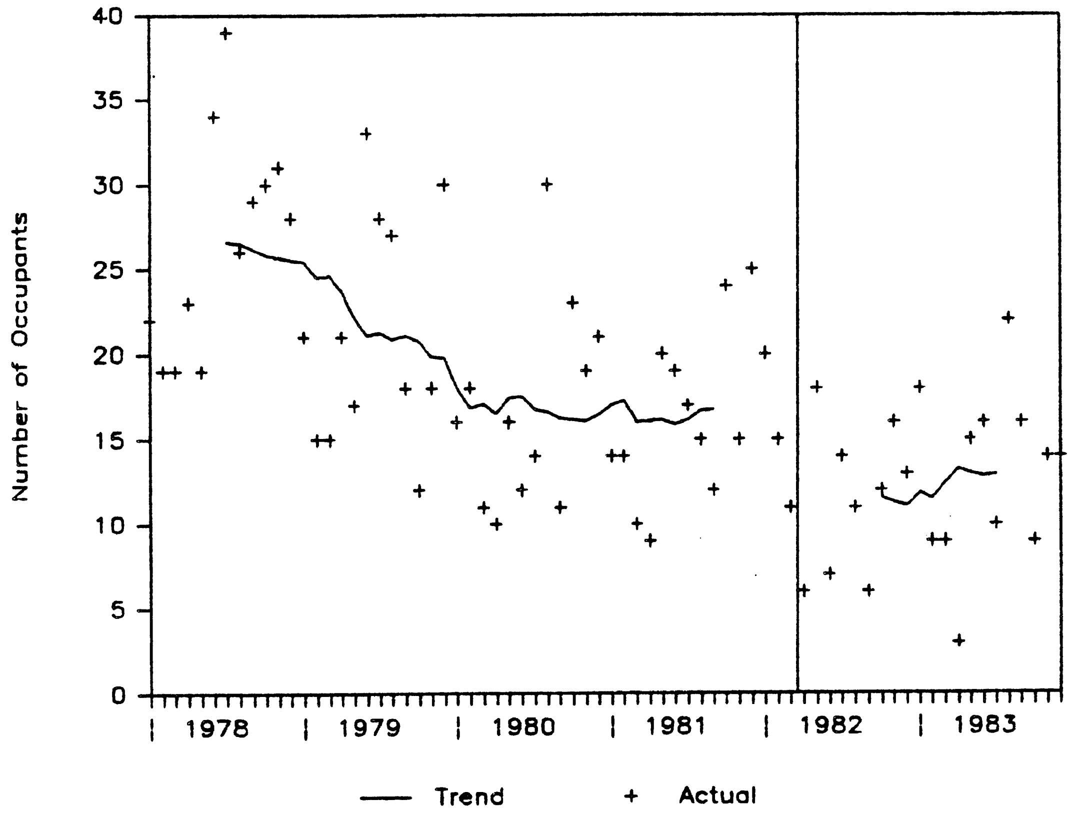
(.066) (.055) (.148) (.134)

Adjusted R^2 = .62

Legal Impact Percent Change = -27

Figure 4.53

Injured Occupants Age 0-3 in High Poverty Counties



$$(1-B^{12})\ LnY_t = (1 - .790B^{12})a_t - .094P_t - .519S_t$$

$$(.051) \qquad (.202) \qquad (.089)$$

Adjusted $R^2 = .42$

Legal Impact Percent Change = -40

Chapter 5

DISCUSSION

The major findings of this study are briefly reviewed in this section. Implementation of Michigan's mandatory child restraint law was followed by a 299% increase in restraint use among crash-involved children under four years of age. Use increased from 12% before to 51% after the law took effect. There appears to have been some spill-over effect of the law on 4-15-year-olds, with their use rate increasing from 6 to 14%. Much smaller increases in restraint use were found among motorists of other ages.

More importantly, results indicated that a 25% decline in the number of injured children under age four is associated with passage of the child restraint law. This 25% decrease means that an estimated 522 children per year are apparently saved from injury by the mandatory child restraint law. A decline in the number of children injured of this magnitude was consistently found, whether analyzing the raw number of children injured, 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 declines in the rate of occupants injured for other age groups, with the exception of a 5% decrease among 18-24-year-olds. A large decrease in the number of injured children under four, 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.

The child restraint law was slightly more effective in reducing the number of children experiencing less severe injuries than the number experiencing injuries which were incapacitating or fatal. A decline of 32% in the number of children experiencing moderate injuries was associated with implementation of the law, while the decrease in the number of children severe injured was 22%. The largest decline in number of children injured, 50%, was seen in crashes involving low levels of vehicle damage.

Significant reductions occurred in the rates of children injured while seated in the front-center, front-right, and rear-center postions; no significant changes in the injury rate were found for children sitting in either the right or left side of the rear seat. This finding may reflect a change in seating position associated with 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.

Results revealed that the number of children injured in weekday crashes declined slightly more than the number injured in crashes occurring on weekends. In addition, the number injured during nighttime declined slightly more than during daytime.

There was virtually no difference in the impact of the law depending on the sex of the driver. When stratifying by age of driver, however, the largest reductions in the number of children injured were found in crashes where the driver was in the 25-34-year-old age group.

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 20% decline in the number of children injured following the child restraint law, while lower-density counties experienced a 35% decline. Finally, 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.

The 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 use of state-of-the-art methods of data analysis and careful consideration of confounding variables. 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 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 the 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- 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.

Assuming that 43% of all crash injured occupants are not included in police records, the estimate of 522 children per year saved from injury by the child restraint law based on police records, is an underestimate of the total number of occupants who avoided injury because of the law. The majority of unreported injuries are minor and occur in less severe crashes. Results of the current study indicate that the child restraint law had a larger effect on children in minor crashes with low vehicle damage. It therefore seems likely that the number of unreported children injured decreased at least as much as the 25% reduction in the number of reported children injured. If so, there is a further 394-per-year reduction in the number of children injured associated with the child restraint law.

The use of police-reported injury data also results in a conservative estimate of the beneficial effects of the law, since it does not include the number of child occupants injured from noncrash motor vehicle incidents. Hall and Council (1980) estimated that approximately 25% of child motor vehicle injuries are caused by such noncrash events as sudden stops and sharp turns. Many such noncrash injuries would be recorded in hospital data systems. If the increased restraint use seen among crash-involved children following passage of the child restraint law also occurred among those not involved in crashes, sizable reductions in the number of children injured in noncrash incidents may also be associated with the mandatory restraint law. Finally, some children injured in motor vehicles (either from crash or noncrash events) may not be reported to police **or** visit a hospital. Nevertheless, prevention of a portion of such (presumably minor) injuries to children is also a likely benefit of the mandatory child restraint law.

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. Based on these findings, expansion of the law to include motorists of all ages is clearly warranted. Further studies, based on alternative sources of childhood injury data including hospital and physician records and occupant self-reports, are needed to clarify the total effects of the child restraint law in reducing damage to young children.

Chapter 6

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