Preventing Injuries to Children Through Compulsory Automobile Safety Seat Use

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ABSTRACT. Effects of Michigan's law requiring all young children to be restrained when traveling in automobiles were assessed. Data on all reported residents of the state who were involved in crashes from 1978 through 1983 were examined using times-series analysis methods. Reported restraint use among injured children younger than 4 years of age involved in crashes increased from 12% before to 51% after the law was implemented. More importantly, a 25% decrease in the number of children younger than 4 years 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, because similar changes did not occur among any of the comparison age groups. The 25% reduction in the number of young children injured means that an estimated 522 children per year are protected from injury because of Michigan's compulsory child restraint law. *Pediatrics* 1986;78:662–672; *injury, traffic crash, safety seat, child restraint law.*

Motor vehicle crashes are the leading cause of death and disability in the United States for those 1 to 45 years of age. Approximately 43,000 car occupants younger than 5 years and 80,000 5 to 15 years of age were injured or killed in 1983. The risk of death or serious injury from traffic crashes is reduced by at least half when children are properly restrained in approved child restraint devices or adult seat belts.[1]

Regardless of the exact effectiveness of child restraint devices and seat belts, there is little doubt that such occupant protection systems significantly reduce the risk of serious injury or death among children involved in motor vehicle crashes. In the middle 1970s, however, only 10% to 15% of motor vehicle occupants (including children) were restrained when traveling in an automobile. To increase use of child safety seats and seat belts, laws requiring the restraint of young children traveling in cars were implemented in several states in the late 1970s and early 1980s. By 1985, all 50 states and the District of Columbia had passed such legislation, with the laws varying from state to state but usually requiring restraint use among children younger than 4 years. These laws were an effort at primary prevention of child injury due to automobile crashes. Prevention of these injuries before they occur is clearly more desirable than treating children after they are casualties of car crashes.

Several studies of the effects of child restraint laws in the United States have appeared. Tennessee was the first state to mandate restraint use for young children. The law applied to children 3 years of age and younger and took effect in January 1978. Using convenience samples of young motor vehicle occupants, Perry and associates[2] found that implementation of the law was associated with an immediate increase in restraint use of about 6 percentage points, with the size of the increase decreasing to only about 1 percentage point 12 months after the law took effect. Child restraint use subsequently increased; 24 months after the law took effect, restraint use was 8 percentage points higher than prior to the compulsory-use statute. The researchers also examined Tennessee traffic crash data for the 1976 to 1979 period, using 6-month totals. No significant effect of the child restraint law on the frequency of minor, serious, or fatal injury crashes was found.

Williams and Wells[3] conducted an observational survey of child restraint use in four Tennessee cities. Restraint use was 8% 5 months before, 16% 4 months after, and 29% 29 months after imple-

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mentation of the law. Use was also observed in two Kentucky cities 5 months before and 29 months after the Tennessee law took effect, for comparison with Tennessee. Child restraint use increased in Kentucky from 11% to 14% during this period.

More recently, Decker and others[4] examined a sample of 991 Tennessee children younger than 4 years of age who were involved in crashes in 1982 and 1983. Child safety seats were used by 40% of the young children in 1982 and 48% in 1983. Comparison of these figures with the 29% reported by Williams and Wells for early 1980 indicate that restraint use in Tennessee continued to increase several years after the law initially took effect. Decker et al attribute this to increased child restraint enforcement efforts in the early 1980s.

Williams and Wells[5] also studied child restraint use in Rhode Island, where a mandatory child restraint law was implemented in July 1980. Use of child restraints increased from 22% before to 35% after the law took effect. Although the increased use of child restraints in Rhode Island may have been the result of the new law, use also increased (from 18% to 26%) in Massachusetts, which had not yet passed child restraint legislation.

North Carolina made use of a restraint system mandatory for children younger than 2 years of age beginning July 1982. Hall and Daniel[6] conducted observation surveys in June 1982 and July 1983. Restraint use among children younger than 2 years increased from 55% before the law to 75% after; figures for 2- and 3-year-old children were 25% before and 43% after the law. They also examined data on children involved in crashes from 1974 through the middle of 1983. Restraint use among these children younger than 2 years leveled off in the middle of 1983 at about 48%, slightly higher than the 44% level immediately after the law took effect. Crash data revealed a decrease in the percentage of all children involved in crashes who were seriously injured from 1.7% before to 1.0% after the law took effect.

Kentucky's child restraint law, which took effect in July 1982, applies to children 101.6 cm (40 in) or less in height. Agent[7] conducted statewide observation surveys before and after the law was implemented. Use of child safety seats among children younger than 4 years of age increased from 14% before to 23% 1 year after the law was enacted. In addition, the proportion of children restrained in seat belts increased from 1.0% to 1.5%.

Guerin and MacKinnon[8] used time-series modeling techniques to estimate the short-term effects of California's child restraint law. The law requires that children younger than 4 years of age or weighing less than 18 kg (40 lb) be transported in a child restraint device. The number of injuries to children younger than 4 years decreased 8.4% during the first 12 months the law was in place. There were no significant changes in the number of 4- to 7-year-old children injured in California or the number of 0- to 3-year-old Texan children injured, a state that had no child restraint law at the time of the study.

Wagenaar,[9,10] using time-series modeling techniques, assessed the short-term effects of Michigan's child restraint law. That law, effective April 1, 1982, requires that children younger than 4 years of age be properly restrained by an approved child restraint device. Children 1 to 3 years may be restrained by a conventional adult seat belt, provided they are riding in the rear seat.[11] The study examined crash-related injury trends from January 1978 through December 1982, including the first 9 months after the law took effect. Results revealed a 50% decline in the number of infants (less than 1 year of age) injured and a 17% decline in the number of 1- to 3-year-old children injured following implementation of the law.

The present study is a follow-up to the initial assessment of Michigan's child restraint law and includes an additional 12 months of postlaw data, through December 1983. An evaluation of whether the beneficial effects of the law have persisted and an analysis of possible mediating factors affecting the impact of the law was intended by extending the follow-up period.

METHODS

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 injuries due to crashes reflected in multiyear trends, cycles, or other regularities. Second, multiple age groups were included for comparison, to increase confidence that observed changes in reported restraint use or injuries were in fact the result of child restraint law and not other coincidental factors. Age groups examined included 0- to 3-year-old children, who were directly affected by the new law, and 4- to 15-year-old children, potentially experiencing a "spillover" effect of the law. Comparison age groups not expected to be affected by the child restraint law included motorists aged 16 to 17 years, 18 to 24 years, 25 to 34 years, 35 to 54 years, and 55 years and older. Third, the availability of an extended 21-month period of postlaw data permitted analyses of the differential effects of the child restraint law by: (1) injury severity, (2) level of damage to the crashed vehicle, (3) seating position of the child, (4) age and sex of driver, (5) time of day and day of week, and (6) various areas

of the state stratified by population density and poverty level.

Information on occupants involved in motor vehicle crashes was obtained from the Michigan State Police. Records were available for all traffic crashes that occurred in the state between January 1978 and December 1983 reported to local or state police agencies. 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 the age and sex of uninjured occupants other than drivers is not recorded by police officers investigating traffic crashes in Michigan.

These comprehensive crash data files were used to construct monthly time series of the number of motor vehicle occupants for numerous subgroups of interest (eg, young injured children in right front seat positions in a vehicle experiencing extensive damage). The January 1978 through December 1983 time series were then analyzed using intervention analysis. These methods measured the degree to which restraint use and injury frequency in 1982 and 1983 (after the law went into effect) were different from the level expected, based on patterns during the previous 4 years. (Only passenger cars and light trucks driven by Michigan residents were included in the time-series analyses, because the law excludes other types of vehicles and all vehicles driven by nonresidents.)

Intervention analysis methods, developed by Box and Jenkins,[12] involve modeling autocorrelation in time-series variables to produce unbiased estimates of error variance in the presence of serially correlated observations. An assumption of most conventional statistical procedures is that the errors are independently distributed; most time series are serially correlated, violating that assumption. The use of intervention components with autoregressive integrated moving average models make these techniques the best currently available for the analysis of quasiexperiments such as implementation of the child restraint law.

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. This approach of intervention analysis was particularly appropriate for the present study, because the objective was to identify significant shifts in restraint use and injury rates associated with the child restraint law, independently of observed regularities in the history of each variable. The time-series models were developed iteratively, repeatedly going through cycles of specifying a model, estimating its parameters, and evaluating its adequacy in terms of the multiple criteria established by Box and Jenkins.[12] Details concerning the statistical models used to estimate the significance and magnitude of the effects of the child restraint law are shown in the Appendix. All results discussed here were significant at $P < .05$.

Results do not include a detailed discussion of separate analyses of child fatalities, despite the emphasis on fatalities by policymakers, mass media, and others. Fatal crashes involving children are obviously a significant public health problem deserving the attention of pediatricians and others. However, when the effects of a program or policy, such as the child restraint law, that apply to only one segment of the population are carefully evaluated, the number of fatalities is too small to reliably assess the effects of that program or policy.

The random variation from year to year in the number of young children in Michigan who are fatally injured in traffic crashes is larger than the expected effect of the child restraint law. Data from the Fatal Accident Reporting System were used to examine the number of Michigan 0- to 3-year-old automobile occupants (excluding nonoccupants such as pedestrians) killed in crashes 3 years before and 1 year after the child restraint law took effect. Twelve young child occupants were killed during the first year the law was in effect (April 1982 through March 1983). In the year immediately prior to implementation of the law (April 1981 through March 1982), nine child occupants were killed. Two years before the law took effect (April 1980 through March 1981) 20 child occupants were killed. Finally, 3 years before the law took effect (April 1979 through March 1980) 10 child occupants were killed. Thus, the number of child occupants killed increases or decreases 30% to 50% from year to year, without any major change in policy or program. The expected effect of a child restraint law is only in the 20% to 30% range. One could imply that the Michigan child restraint law is detrimental, because child fatalities increased 33% during the first year the law was in effect. However, few researchers or physicians would, upon reflection, base a conclusion concerning the effectiveness of the law on three additional fatalities during a 1-year period. To avoid such problems with small numbers of cases, each of the variables analyzed in this study were grouped in such a way to ensure adequate frequencies to reliably estimate significant changes over time. Most noteworthy was the inclusion of the much larger number of child injuries as well as fatalities.

RESULTS

The proportion of injured children involved in crashes traveling restrained at the time of the crash increased from 12% before and child restraint law to 51% after (a 299% increase; Fig 1). The increased rate of child restraint use after the law took effect was confirmed by direct observation of child car occupants at a probability sample of 240 intersections throughout Michigan.[13] The December 1984 survey of children not involved in crashes younger than 4 years of age revealed that 60.8% were restrained either by a child safety seat or seat belt.

A slight spillover effect of the law on restraint use among 4- to 15-year-old children was also found. Restraint use among this group increased significantly, from 6% before to 14% after the law (a 131% increase). Although important, the spillover effect was small compared with the change among 0- to 3-year-old children. Only small changes in seat belt use were found among the five older age groups. Because of the extensive database and powerful analytical procedures used, increases in restraint use among occupants 16 to 17 years of age and 18 to 24 years of age were statistically significant. The magnitude of those changes, however, was only about 2 percentage points (ie, from 8% to 10%), small when compared with the changes observed among young children directly affected by the new law.

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 drivers involved in crashes who report that their child was restrained when in fact the child had not been, because reporting that a child younger than 4 years of age was not restrained is admitting a violation of law.

Correct *v* incorrect use of child restraints is another complicating factor. The degree to which restraint devices are used correctly is not assessed and recorded by police officers. Incorrect use significantly reduces the protection provided by child seats. Surveys have indicated that as many as 70% of all child restraint devices are used incorrectly.[14] A recent survey in Michigan revealed that at least 20% of child seats were being used in an obviously incorrect manner.[13]

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, therefore resulting in an increase in police-reported child seat use, independently of any change in actual use rates. To avoid inferences based only on recorded 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.

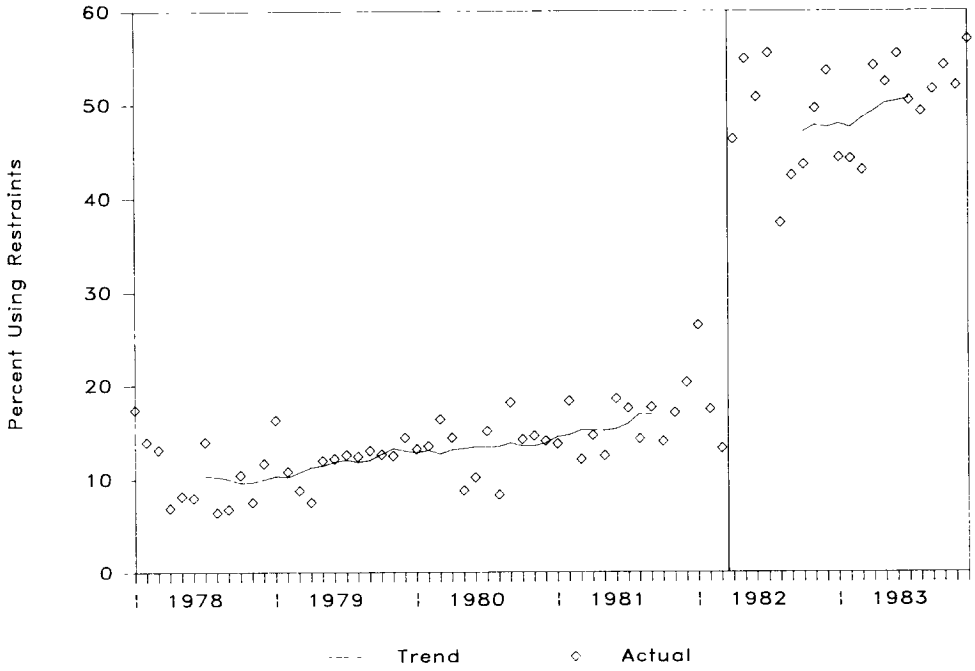

Fig 1. Restraint use among injured motor vehicle occupants 0 to 3 years of age.

The number of children younger than 4 years who were injured in traffic crashes declined 28% (from 180 to 130 per month) after the child restraint law was implemented (Fig 2). The slight increase in the number of 0- to 3-year-old children injured in 1983 seen in Fig 2 does not mean the effect of the law deteriorated. Rather, this increase is consistent with increased exposure to risk of injury among all age groups in 1983, due to increased travel mileage. To control for changes in the amount of motor vehicle travel, the rate of young children injured per billion miles traveled was analyzed (Fig 3). Results indicated a 28% decrease associated with implementation of the child restraint law.

In addition to changes in total vehicle miles traveled, there are other factors that may influence the risk of crash-induced injury, such as changes in the **type** rather than total amount of travel (eg, recreational travel tends to be more hazardous than work-related travel). To control for such factors, rates of occupants injured per 10,000 crashed vehicles were analyzed for each age group. (The rates are the number injured in a given age group per 10,000 total crashed vehicles in the state; the denominator of the rate is not age specific because age of uninjured occupants is not recorded.) This indicator is particularly appropriate, because the child restraint law is expected to reduce the risk of injury to children who are involved in crashes, but not affect the number of crashes. Controlling for the total number of crashes does not appreciably change the estimated effect of the child restraint law. The rate of injured 0- to 3-year-old occupants per crashed vehicle declined 27% during the postlaw period (Fig 4).

To increase confidence that observed reductions in the injury rate among young children were the result of the child restraint law, injury rates for several comparison age groups were also analyzed. A statistically significant 5% decline in the injury rate for occupants 18 to 24 years of age was found; this decline is small when compared with the 27% decrease among young children. The rate of injured occupants 35 to 54 years of age increased 11% in the postlaw period, and the injury rate among those 55 years and older increased 13%. Increased injury rates among those 35 years and older provide further support for the hypothesis that the substantial decline in the rate of children injured is the result of the restraint law and not other broader factors influencing rates of injury among occupants of all ages.

Finally, broader trends in crash-induced injuries were controlled by analyzing the number of injured children younger than 4 years of age as a percentage of the total number of injured occupants across all age groups (Fig 5). Results revealed a 29% decrease attributable to the child restraint law.

The findings clearly indicate that compulsory use of child restraint devices significantly reduced injuries among young children. The various estimates of the magnitude of the law's effect are remarkably similar: a 28% reduction in number of children injured, a 28% reduction in the rate of children injured per vehicle mile traveled, a 27% reduction

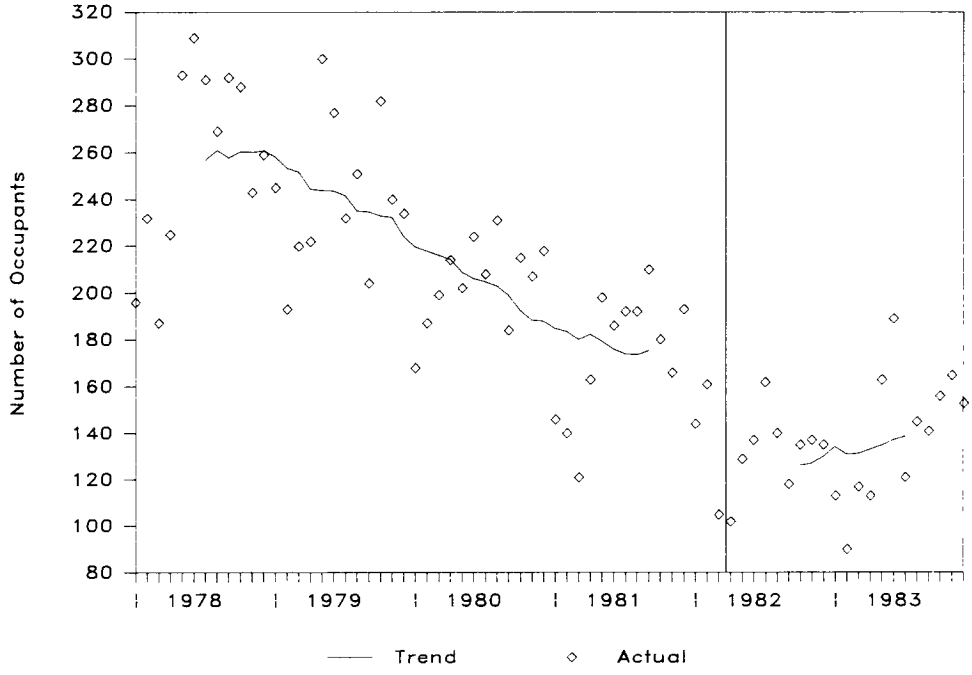

Fig 2. Number of injured motor vehicle occupants 0 to 3 years of age.

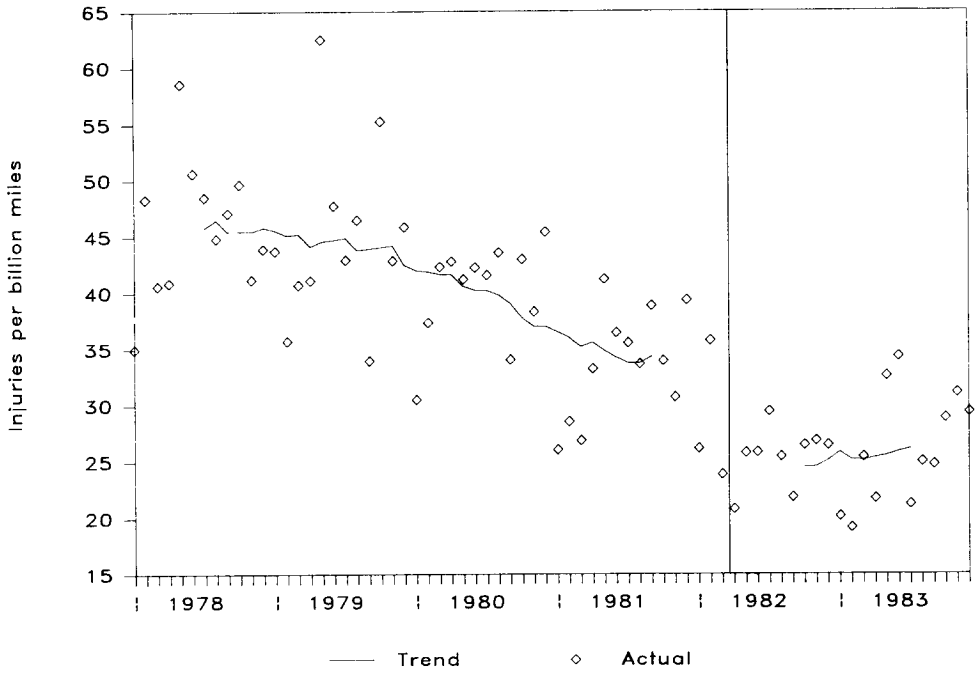

Fig 3. Injured motor vehicle occupations 0 to 3 years of age per billion vehicle miles traveled.

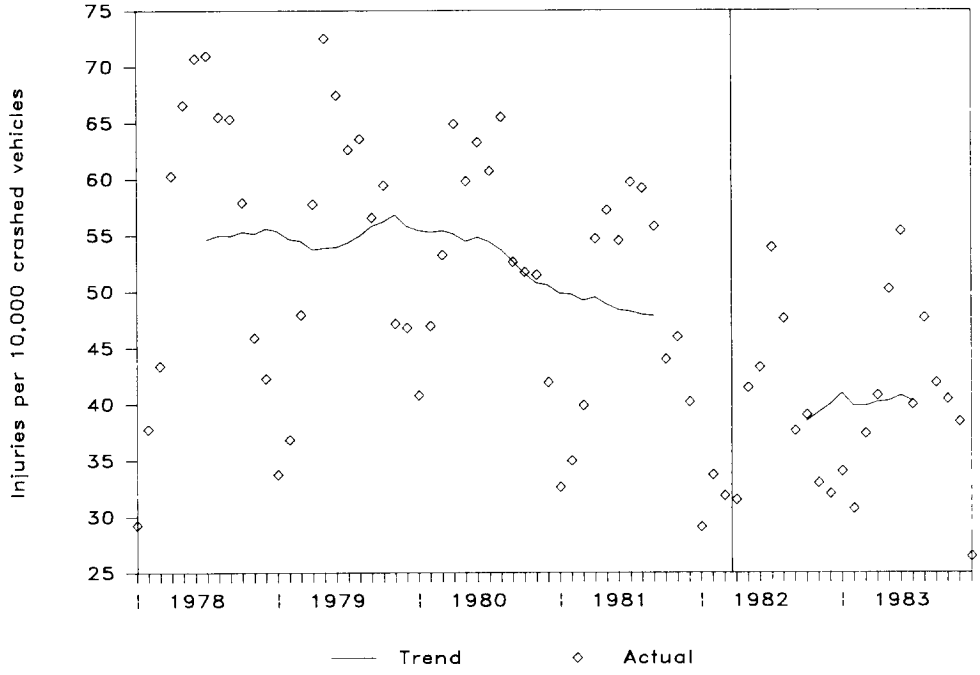

Fig 4. Injured motor vehicle occupants 0 to 3 years of age per 10,000 crashed vehicles.

in the rate of children injured per crashed vehicle, and a 29% reduction in the percentage of all injured motor vehicle occupants accounted for by young children. In addition, comparisons with other age groups revealed that these substantial declines in injuries only occurred among young children, the focus of the new law.

The number of children younger than 4 years of age residing in Michigan declined 3% from 1981 to 1982. Subtracting this population decrease from the estimated 28% decrease in number of children injured leaves a 25% reduction attributable to the mandatory child restraint law. A 25% decrease means 522 children per year are apparently protected from injury by Michigan's child restraint law. (The number of children saved from injury is based on the number of children injured in 1981, the last full year before the law went into effect.)

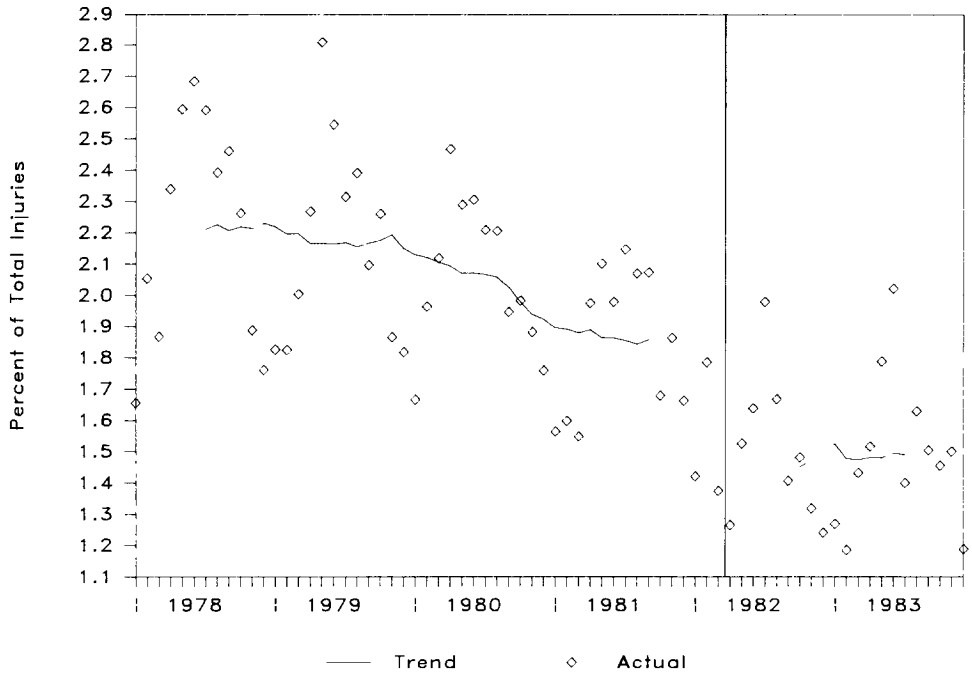

Fig 5. Injured motor vehicle occupants 0 to 3 years of age as percentage of all injured occupants.

These impressive reductions in the number of children injured would be less dramatic if the law were most effective in preventing minor injuries and had less effect on fatal and incapacitating injuries. Therefore, injured children were separated into two groups for analysis. The first group consisted of children classified as having a possible (no visible injury but complaint of pain or momentary unconsciousness) or nonincapacitating (any injury not incapacitating but evident to others at the scene) injury. The second group consisted of children classified as having an incapacitating (any injury other than fatal that prevents normal activities and generally requires hospitalization) or fatal injury (any injury that results in death). (In terms of the injury coding scheme used by most police agencies in the United States, children experiencing K and A injuries were compared with those experiencing B and C injuries.) Injuries were grouped into these two categories to ensure a sufficient number of cases for reliable time-series analyses.

The child restraint law was slightly more effective in reducing the number of children experiencing less severe injuries than the number experiencing incapacitating or fatal injuries. A decline of 32% in the number of children experiencing moderate injuries was associated with the law, whereas the decrease in the number of children severely injured was 22%.

When crashes were stratified by the level of damage to the vehicle, the child restraint law was associated with a 37% decrease in number of children injured in vehicles with low levels of damage, a 27% decrease in the number injured in medium-damage vehicles, and no significant decrease in the number of children injured in high-damage vehicles. (Alternative statistical models revealed significant decreases in number of children injured in high-damage vehicles. Regardless of the specific model used, however, the decrease in the number of children injured in high-damage vehicles was always smaller than the decrease for low-damage vehicles.) One possible explanation for larger effects of the child restraint law in reducing child injuries in low-damage crashes is that the postlaw increase in restraint use was more dramatic among children in less severe crashes. The rate of restraint use for children in low-damage vehicles increased 204%; children in medium-damage vehicles increased 179%, whereas children in high-damage vehicles increased (only) 151%. (These estimates are based on comparisons of restraint use during April to December 1982, after the law was implemented, with use during April to December 1981, before the law took effect.)

A second explanation of lowered effectiveness of the law in reducing serious injury may be related to the high rates of improper use of child restraint devices. A child safety seat that is used incorrectly may protect children in minor crashes from injury but fail to protect children in serious crashes.

Michigan's child restraint law requires front seat passengers younger than 4 years of age to be restrained in a child safety seat, whereas rear seat

passengers 1 to 3 years of age may be restrained either with an adult seat belt or a child safety belt. In addition, much of the publicity surrounding the law emphasized the increased safety of rear seat positions for young children. Therefore, effects of the law were also examined separately by seating position. The number of children injured in the front center position decreased 43%, and the number in the front right position decreased 39%. The number of children injured in the rear center position, generally considered the safest position, declined by 55% after the law went into effect. There were no significant changes in the number of children injured in rear left or rear right seat positions.

Because there was no measure of the number of uninjured occupants in each seating position, it was not possible to determine the reason for the pattern found. The differences may be the result of changes in restraint use by seating position, differences in the protection provided by restraint devices in different seating positions, differences in the protection provided by child safety seats in the front seat *v* the protection of a lap belt in the rear seat position, or to a shift in seating patterns of children following implementation of the child restraint law.

There is some evidence that child restraint laws may be associated with a decrease in the number of children riding in the front seat. Surveys of occupant restraint use in 19 cities in the United States in 1978 to 1979, before most child restraint laws were implemented, and in 1982 to 1983, after many states passed child restraint laws, showed that the proportion of infants riding in the front seat declined from 64% in 1978 to 1979 to 50% in 1982 to 1983. Of toddlers 1 to 3 years of age, 44% occupied front-seating positions in 1978 to 1979, whereas only 35% were in the front seat in 1982 to 1983.[15,16] An observational survey of restraint use in Michigan in December 1984 revealed that only 33% of children younger than 4 years of age rode in the front seat.[13] These studies indicate that the larger decline of injured children in front seat positions is, in part, the result of a decrease in the proportion of children riding in more dangerous front seat positions.

The age of the driver was also related to the magnitude of the effect of the child restraint law. When drivers were separated into four age groups, significant reductions in the number of children injured were found only among children riding with drivers 25 to 34 years of age. Drivers in this age group are those most likely to be traveling with young children. Furthermore, drivers in the 25 to 34-year age group are more likely to be a parent of the child they are transporting, whereas drivers in other age groups are less likely to be a parent of the child. Prior studies have indicated that children are more likely to be restrained when the driver of the vehicle is the child's parent.[4,6,17]

Effects of the child restraint law in urban and rural areas of the state were also examined. The 83 Michigan counties were ranked according to population density and were then divided into five categories for separate analyses. The most densely populated counties experienced the smallest declines in the number of children injured after the law took effect (20%).

Effects of the child restraint law varied little with respect to sex of the driver, day and time of the crash, and proportion of residents below the poverty level in the county where the crash occurred.

DISCUSSION

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 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 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[18,19] found that driver self-reports reveal more crashes than are indicated in police reports. Bull and Roberts[20] reported that 30% of injury-producing crashes in England had not been reported to police. Greenblatt and others,[21] using a telephone survey, estimated that 21% of injury-producing crashes are not reported to police. A survey of records from hospital emergency departments in northeastern Ohio found that 43% of the crash-related injuries were not recorded in police reports.[22]

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 that do not get into police records should be 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. However, there is little incentive for a driver involved in a crash to lie about injured children, because the penalty for failure to restrain a child in Michigan is a maximum of $10 and citations for failure to restrain a child are infrequent.

If it is assumed that 43% of all crash-injured occupants are not included in police records, the estimate, based on police records, of 522 children per year saved from injury by the child restraint law is an underestimate of the total number of occupants who avoided injury. 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. Therefore, it seems likely that the number of unreported children who were injured decreased at least as much as the 25% reduction in the number of reported children who were injured. If so, there is a further reduction in the number of children injured associated with the child restraint law of 394 children per year.

The use of police-reported injury data also results in a conservative estimate of the beneficial effects of the law because they do not include the number of child occupants injured from noncrash motor vehicle incidents. Hall and Council[23] estimated that approximately 25% of child occupants injured in motor vehicles are injured in such noncrash events as sudden stops and sharp turns. Many such noncrash injuries would be recorded in hospital data systems. Significant increases in restraint use among children not involved in crashes following passage of the child restraint law have been documented.[13] As a result, 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.

One reason the Michigan child restraint law had such clear beneficial effects may be the extensive public information and education program implemented along with the law.[24] The public information and education program began in January 1982, 3 months before the law took effect. The prelaw program was associated with a 30% decrease in the number of infants younger than 1 year of age injured in crashes and a 20% reduction in the number of children age 1 to 3 years of age injured in crashes.[9] Because the public information and education program and the law were implemented at approximately the same time, it is difficult to measure the independent effects of each. Nevertheless, it appears that the public information and education program contributed to the beneficial effects of the child restraint law.

In conclusion, Michigan's mandatory child restraint law was clearly effective in improving child health in the state, reducing the number of children injured in motor vehicle crashes by 25%. The benefits of child restraint laws may be enhanced by passage of legislation requiring motor vehicle occupants of all ages to travel restrained. Adult seat belt laws have already taken effect in several states (including Michigan). Because child restraint use is correlated with seat belt use by the driver with which they are traveling, increased seat belt use among drivers after mandatory seat belt laws take effect may also lead to further increases in the proportion of children traveling restrained.[4,7,13]

Nevertheless, 40% of young children continue to travel in automobiles unrestrained. Of the child seats in use, a substantial proportion are being used incorrectly. There are two major dimensions of correct use. First, the device must be carefully installed in the car, with the seat secured by the automobile seat belt correctly routed through the frame of the child safety seat. Second, the child must be secured to the child restraint device by correctly fastening the safety seat harness over the child.

A high priority of pediatricians should be education of patients concerning the importance of correct child safety seat use. At a minimum, child restraint issues need to be directly addressed by practicing pediatricians at three stages of the child's development. The first is immediately postpartum, when new parents are first faced with the requirement of transporting a child. The second is at the

first-year check-up, when the child has outgrown a child restraint device designed specifically for infants or when a convertible child restraint device must be changed from a rearward-facing reclined position to a forward-facing upright position. The third is when the child is approximately 4 years of age, when the child outgrows a child restraint device designed for toddlers, and parents need to be reminded of the importance of consistent use of an automobile seat belt to restrain the child whenever traveling in a motor vehicle. Finally, pediatricians should continue to strongly advocate policies and programs to significantly reduce injuries to children and others, such as (1) expansion of child restraint laws to motor vehicle occupants of all ages, (2) regulations requiring vehicles be designed in such a way to prevent injury, including mandating the installation of automatic restraint systems, and (3) requirements for construction of roads in such a way to minimize the risk of crash-induced injury. Although compulsory use of child restraint devices has significantly reduced child injury, efforts on the part of pediatricians and others must continue on many fronts to provide adequate protection to all children and adults traveling in automobiles.

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APPENDIX

Combination autoregressive integrated moving average/transfer function models used to assess the statistical significance and magnitude of hypothesized effects of the child restraint law were of the form: $(1 - \phi_1 B - \ldots \phi_p B^p)(1 - B)^d(1 - B^s)^D \operatorname{Ln} Y_t = \alpha + (1 - \theta_1 B - \ldots \theta_q B^q)(1 - \Theta_1 B^s)u_t + \psi P_t + \omega S_t$, where B is the backshift operator such that $B(z_t)$ equals z_{t-1}, ϕ_1 to ϕ_p are the regular autoregressive parameters, d is the order of nonseasonal differencing, D is the order of seasonal differencing, s is the seasonal span, $\operatorname{Ln} Y_t$ is the natural logarithm transformation of the dependent time series, α is a constant, q is the order of the moving average process, θ_1 to θ_q are the regular moving average parameters, Θ_1 is the first order seasonal moving average parameter, and u_t is the random error component. The two intervention components added to the autoregressive integrated moving average model are ψP_t and ωS_t, where ψ and ω are parameters to be estimated. P_t is a pulse function with the value 1 for the 3 months of intensive public information activities (January to March 1982) and 0 otherwise. S_t is a step function with the value 0 prior to implementation of the child restraint law (April 1982) and the value 1 after the law took effect.

The specific time-series models were developed iteratively, repeatedly going through cycles of specifying a model, estimating it, and evaluating its adequacy in terms of accounting for all significant autocorrelation patterns in the series. The dependent variables were log transformed prior to parameter estimation to reduce heteroscedasticity. All of the resulting models met the multiple criteria for model adequacy established by Box and Jenkins.[12]

The estimates of ω, based on log transformed series, were converted to the percentage change in the series after the child restraint law was implemented from the levels expected, given baseline patterns. Legal impact percentage change = $(e^{\omega} - 1)\ 100$.

The statistical models for selected variables are listed below (models generated for other variables examined in the study can be found in reference 25). Adjusted R^2 statistics ranged from .67 to .88 for these models. Standard errors are shown in parentheses below each parameter estimate.

Restraint use among injured motor vehicle occupants 0 to 3 years of age:

$$\underset{(.113)}{(1 - .420B)}\operatorname{Ln} Y_t = \underset{(.057)}{2.529} + \underset{(.187)}{.297P_t} + \underset{(.102)}{1.38S_t} + u_t$$

Number of injured motor vehicle occupants 0 to 3 years of age:

$$(1 - B)\operatorname{Ln} Y_t = \underset{(.102)}{(1 - .378B} - \underset{(.101)}{.437B^3)}u_t - \underset{(.145)}{.291P_t} - \underset{(.135)}{.323S_t}$$

Injured motor vehicle occupants 0 to 3 years of age per billion vehicle miles traveled:

$$(1 - B)\operatorname{Ln} Y_t = \underset{(.062)}{(1 - .871B)}\underset{(.131)}{(1 + .417B^{12})}u_t - \underset{(.104)}{.035P_t} - \underset{(.091)}{.335S_t}$$

Injured motor vehicle occupants 0 to 3 years of age per 10,000 crashed vehicles:

$$(1 - B^{12})\operatorname{Ln} Y_t = \underset{(.102)}{(1 + .359B} + \underset{(.112)}{.334B^2} + \underset{(.108)}{.305B^5})\cdot\underset{(.051)}{(1 - .792B^{12})}u_t - \underset{(.079)}{.208P_t} - \underset{(.045)}{.314S_t}$$

Injured motor vehicle occupants 0 to 3 years of age as percentage of all injured occupants:

$$(1 - B^{12})\operatorname{Ln} Y_t = \underset{(.111)}{(1 + .265B} + \underset{(.107)}{.413B^5})\cdot\underset{(.056)}{(1 - .815B^{12})}u_t - \underset{(.061)}{.148P_t} - \underset{(.037)}{.344S_t}$$

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MASSACHUSETTS WILL PROVIDE DATA ON CAESAREAN SECTION

Pregnant women who register for care at Massachusetts hospitals will get detailed information about such birth practices and how frequently they perform Caesarean sections, under a law signed by Gov. Michael S. Dukakis.

Massachusetts is the first state to require such disclosure. The law arose out of concern among consumers, health officials and obstetricians that doctors are performing too many surgical births.

The law's advocates argued that avoidable Caesareans exposed women and infants to needless risks and emotional and physical trauma as well as increased the cost of giving birth without commensurate benefit.

Opponents countered that the requirement would burden hospitals and that expectant parents would not know how to interpret the information.

Submitted by Student

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