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The Effects of Safety Seat Legislation on Pediatric Trauma

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16. Abstract

This study was designed to study the impact of a child passenger safety law on pediatric motor vehicle trauma, as seen from the perspective of a hospital emergency room setting. The data was obtained from an ongoing monitoring system in hospital emergency rooms and the Coroner's Office. All children under the age of 15 years evaluated in the monitored emergency rooms after involvement in a motor vehicle incident were included. 1981-1982 constituted the pre-legislative years; 1983-1984 were the post-legislative years. Those children greater than 4 years, not covered by the legislation were the control population.

The major findings for children less than 4 years (covered by the law) were: 1) Restraint use increased from 26% pre-legislation to 50% in the post-legislation period among the hospital based sample. This was a significant increase. 2) A significant increase in those medically determined to be uninjured was documented. 3) Among those injured there was no significant change in the severe and critical injuries. 4) Head injuries decreased by 16%. 5) Hospital emergency room utilization did not decrease, however. 6) There was a significant decrease in the number of noncrash injured children in the post legislation period, 17% to 7%.

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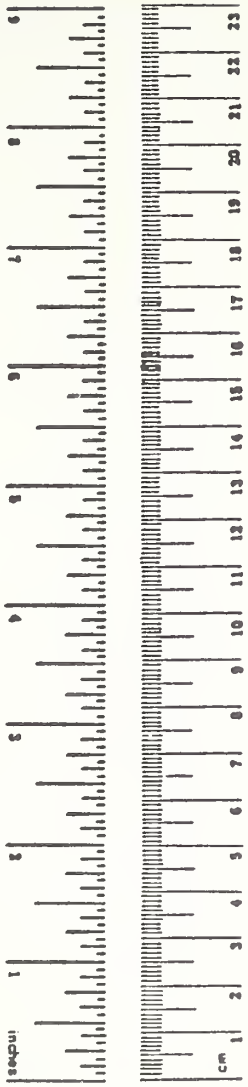
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

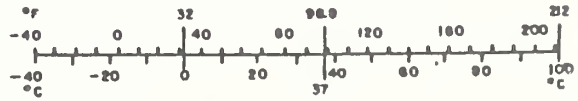
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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THE EFFECTS OF SAFETY SEAT LEGISLATION ON PEDIATRIC TRAUMA

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EXECUTIVE SUMMARY

A number of studies have found that mandatory child passenger safety laws, when enforced, are effective in reducing the overall number of injuries and fatalities for the legislated population (Hall and Daniel, 1983; Decker et al., 1984; Montague, 1984; Wagenaar and Webster, 1985; Guerin and MacKinnon, 1985). However, the effects of mandatory restraint use legislation on injury patterns and severity of injury or on the health care delivery system in terms of utilization rates have not been addressed. This study was designed to examine the effects of a mandatory restraint use law on trauma patterns and severity of injury of pediatric motor vehicle accident victims who were evaluated and treated in hospital emergency rooms in Orange County, California. The impact of the California Child Passenger Safety Act was analyzed in terms of 1) changes in injury patterns and injury severity measures; 2) changes in frequency and severity of head injuries, (the most common anatomic area of injury for children); 3) changes in the number of noncrash injured children; and 4) changes in utilization of emergency rooms by young children. Descriptive analyses of the mechanisms of injury and trauma patterns of restrained under four year olds who were injured were also done.

The data source used in this study was taken from an ongoing monitoring system established in 9 hospital emergency room facilities as well as the Coroner's Office in Orange County, California. The monitoring system was established in 1980 and has continued uninterrupted since that time. The data used in the analysis consists of all children through the age of 14 years who were involved in motor vehicle accidents and were subsequently evaluated in the monitored emergency rooms during the period 1981-1984. Case data has been combined for the two years prior to enactment of the California Child Passenger Safety Law (1981-1982) and for the two years following enactment of the law (1983-1984). A total of 1,757 children up through 14 years of age are included in the sample; 583 were less than 4 years of age.

The major findings from this study are summarized. It should be re-emphasized that the conclusions noted below focus solely on children evaluated in a hospital emergency room setting. All children were passengers involved in motor vehicle accidents and were presumed to be injured in the accident.

Restraint use significantly increased in the sample of under four year olds in the hospital monitoring system following enactment of the law. In the context of the emergency room setting, a major change in restraint use among children less than 4 years coming for evaluation of injuries secondary to involvement in a motor vehicle crash was observed. The percent of restrained under four year olds significantly increased from 26% in the two years before the law to 50% in the two year period following enactment of the law.

A significantly higher proportion of under four year olds were medically determined to be uninjured after enactment of the mandatory restraint legislation. The percent of uninjured under 4 year olds significantly increased from a pre-legislation baseline of 30% to 42% uninjured in the

post-law period. While the phenomenon of the uninjured young child coming to an emergency room for evaluation following a motor vehicle crash was apparent even in the pre-legislation period, the analysis indicated that restraint use rather than a rise in parental concern was a cause of the increase in uninjured in the post-legislative period.

While there was an increase in uninjured under four year olds evaluated in hospital emergency rooms, no significant change was seen in the frequency of those sustaining serious or critical injuries. The majority of injuries among children in both the pre- and post-legislation periods were in the minor and moderate injury severity categories. Few serious injuries were observed in the under four year olds in either the pre- or post-legislation period of time. The increase in restraint use appears to have had its major effect in shifting injuries from the minor and moderate severity categories to the category of 'no injury'. There appeared to be little effect on the reduction of the more serious injuries.

In the two years following implementation of the child passenger safety law, a significant reduction in the number of head injuries was documented in the children less than 4 years of age. The analysis indicated that there was a 16% reduction in the number of under four year olds who sustained head injuries in the post-legislation period. There was no change in the number of head injuries among those not covered by the law.

While head injuries decreased for the under four year olds in the post-legislation period, there was no accompanying increase in injuries to other body areas. Although there was a reduction in head injuries in the post-legislation period, this reduction was not associated with an increase in injuries to other body areas in the post-legislation period. The major change in trauma patterns for the under four year olds in the post-law period was from head injury to no injury rather than from head injury to injury to another body area.

Utilization rates of hospital emergency rooms for under four year olds involved in motor vehicle crashes did not decrease significantly after enactment of the law. For the young child it appears to be the norm for the parent/guardian to bring the child in to the emergency room to be checked following involvement in a motor vehicle accident, even in the absence of a visible injury. Children in this age cohort are less verbal regarding their injuries and parents are more likely to take a conservative approach and have the child medically examined. Restraint use does not appear to have altered this behavior. This finding indicates that mandatory restraint use legislation is unlikely to dramatically reduce emergency room use among very young children involved in motor vehicle crashes.

Utilization rates of hospital emergency rooms for under four year olds involved in motor vehicle noncrashes, however, did decrease significantly after enactment of the law. In a noncrash accident, the child is injured as a result of sudden stops, swerves, loss of balance or falling out of the vehicle in the absence of vehicle impact with another vehicle or object. Unrestrained under 4 year olds are particularly prone to noncrash accidents because they can easily lose their balance in the vehicle or, because of their level of cognitive development, they may be more likely to open a door

in a moving vehicle or lean against an improperly latched vehicle door. A dramatic decrease in noncrash cases was seen in the post-law period. While 17% of under four year olds involved in motor vehicle accidents and evaluated in the emergency rooms had been involved in noncrash accidents in the pre-law period, in the two years after the enactment of the law, only 7% were involved in noncrash accidents. With increased restraint use as a result of legislation, the expectation is the eventual near elimination of noncrash injuries.

Based on the analyses performed in this study we also conclude that injury reduction in motor vehicle crashes can be maximized by increased proper use of age appropriate restraints. However, the currently available restraint use technology, even in the face of 100% use, will not totally eliminate injuries in motor vehicle crashes. As has been documented in this study, trauma can occur even in the face of proper restraint use. A certain degree of mobility is allowed even with proper use of the CSS. This is particularly noted with respect to the head of the child which can hit against the side of the restraint itself. Seat belts also allow some lateral movement of the body and, in the case of lap only belts, jackknifing over the belt. Such movement can cause head injuries if there is impact with the vehicle interior or abdominal injuries from loading against the belt. In the case of severe crashes, injuries can occur which are unavoidable and unrelated to the use of a restraint, e.g., intrusion into the passenger compartment from lateral impacts or rollovers, flying glass. Additional technologies in the areas of restraint systems and vehicle designs will have to be instituted in order to reduce further death and injury.

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CHAPTER 1

INTRODUCTION

The intended benefits of mandatory restraint use laws are a reduction in trauma and death, and secondarily a reduction in medical costs incurred and resources utilized in treating injured motor vehicle occupants. Over the past five years, all fifty states have enacted child passenger safety laws. In addition, mandatory restraint use legislation designed to include all age groups has been enacted in 17 states. This wide diffusion of restraint use laws necessitates a critical evaluation of the legislative approach regarding restraint/seat belt use and the effects on trauma.

Studies conducted in Australia (Henderson and Wood, 1973; Trinca and Dooley, 1977; McDermott and Hough, 1979), Sweden (Norin et al, 1984), Canada (Jonah and Lawson, 1984) and Great Britain (Pye and Waters, 1984; Freedman, 1984) have consistently found that mandatory seat belt use legislation has increased restraint usage and decreased injury rates for adults. However, high levels of restraint use must be maintained in the population in order to sustain a measurable impact on trauma. McCarthy et al. (1984), after reviewing accident data from several countries, concluded that mandatory seat belt usage made a measurable impact on safety only after the passenger belt usage rate rose above 60%.

Research specifically directed towards mandatory child restraint legislation has also demonstrated positive outcomes from the legislation. Observational studies conducted in Rhode Island (Williams and Wells, 1981) and Tennessee (Williams and Wells, 1981) demonstrated that the enactment of a mandatory child restraint use law did, in fact, lead to an increase in the number of children restrained and, in the case of Tennessee, a decrease in

traffic fatalities (Decker et al, 1984). Similarly, the results from a survey conducted in 19 U.S. cities also documented an increase in restraint use following the enactment of mandatory restraint use laws (Goryl and Cynecki, 1984). Based on a review of police reports in North Carolina, Hall and Daniel (1983) found that there had been a large increase in child safety seat usage rates for infants and a decline in serious and fatal injury rates for the same age group after enactment of the child passenger safety law. Similarly, Wagenaar and Webster (1985), in an analysis of the effects of the 1982 Michigan Mandatory Child Restraint Law, using data from police accident reports from 1978 through 1983, documented a four-fold increase in restraint use among crash involved injured children under four years of age and a 25% decrease in the number of children injured. A comparison of pre- (1982) and post- (1983) legislation accident data in Virginia found a 16.5% decline in vehicular injury rates for children 0-4 while there was a 15.8% increase for all other ages (Montague, 1984). Guerin and MacKinnon (1985), utilizing accident statistics, also found a significant reduction in injury rates for children covered by the law (under 4 years of age) in California.

Along with the increased observed use of restraint systems among children under four as the result of state laws is the documentation of substantial improper use of child safety seats (CSS). For example, children often are not properly harnessed into the restraint; the restraint is not secured to the vehicle with the seat belt. Reports of up to 60 to 75% improper use have been published (Shelness and Jewett, 1983; Cynecki and Goryl, 1984). The implications of such improper use of child restraint systems in terms of injury have been documented in crash testing as well as in some real-life crashes (Weber and Melvin, 1984; McDonald, 1979).

The evaluation of the effectiveness of a mandatory restraint use law is complex, and as the review of existing studies indicates, it requires a variety of measures and methods. No one method can provide an assessment of the total impact of these laws. This particular study, however, adds to the existing research on the effects of restraint use legislation by focusing on the impact of the California Child Passenger Safety Act on pediatric motor vehicle trauma -- specifically, types of injury, anatomic areas of injury, severity of injury, injury related to certain types of motor vehicle incidents, i.e., the noncrash event, and injuries incurred by various types of restraint use, including improper use. Secondarily, this study also investigates the impact of restraint legislation on hospital emergency room utilization.

Although hospital-based data systems are not useful for assessing restraint usage rates in a community nor for assessing the degree to which injury has been prevented, since only those presumed to be injured are included in the target population, hospital-based data systems do provide detailed and reliable trauma data with respect to numbers, types and severity of injuries. Such systems can provide evidence for changes in usage rates among those seeking care in medical facilities after enactment of a law, as well as changes in patterns and severity of injuries. This is a different issue than testing whether or not restraints are effective in preventing injury. This has been well-documented in previous studies (Williams and Zador, 1977; Thomas et al., 1980; Huelke, 1981).

Very few studies have been able to provide detailed descriptions of the types and kinds of injuries which occur when using restraint systems. Furthermore, few studies can address the impact of mandatory restraint use

legislation on changes in and reduction of trauma which are the intended benefits of this type of public health policy.

This study was designed to assess the effects of mandatory restraint use legislation on pediatric motor vehicle occupant trauma in the hospital emergency room setting. Specifically, the major objectives are:

1. To compare pre- and post-legislative periods of time with respect to types of injuries sustained and severity of injury.
2. To assess the impact of legislation on the incidence of noncrash injuries.
3. To describe severity and types of injuries of properly CSS restrained, improperly CSS restrained, and seat-belted children under four years of age.
4. To identify mechanism of injury in relation to mode of restraint use.

OUTLINE OF REPORT

In Chapter 2, the nine hospital county-wide emergency room monitoring system is described along with the methods utilized to collect medical and accident data on children up through the age of 14.

Chapter 3 contains the set of analyses regarding the observable effects of the California Child Passenger Safety Act on the hospital emergency room. We have divided this chapter into various topical areas, each of which is a self-contained analysis of the effects of the California Child Passenger Safety Act on hospital emergency room pediatric use. The following provides abstracts of the various topical areas. Section 1 contains general measures obtained from emergency room data which are tested for the pre- and post-legislative periods in order to ascertain which aspects of injury patterns,

severity and disposition of the patient following emergency room evaluation may have changed. All analyses involve dichotomous contrasts between the two-year pre-legislation period (1981-1982) and the two-year post-legislation period (1983-1984). The 4-14 year olds are used as the control group for the under 4 year old age group. Section 2 focuses on injuries to the head which is the most frequent anatomic area injured in the pediatric population, and it considers the question: What is the impact of legislation and increased restraint usage on head injury in the targeted age group? Section 3 presents an analysis of changes in hospital emergency room rates of noncrash injuries. Previous research on noncrash related injuries has demonstrated that hospital emergency rooms are a better system for monitoring noncrash rates than official police statistics. In addition, the prototype noncrash victim tends to be under four years of age. The impact of the Child Passenger Safety Legislation on this specific type of trauma will be analyzed. Finally, Section 4 addresses the issue of the effects of the legislation on emergency room utilization.

Chapter 4 contains data regarding the associations between restraint use and trauma. Restraint systems have consistently been found to reduce injuries in motor vehicle accidents when used properly. However, improper use of child safety seats can potentially result in injury. Furthermore, there are circumstances in which restraint systems may also fail to prevent injury. Not all restrained crash victims are uninjured in a crash situation. This chapter will take a different approach from the previous chapter in that all cases of injured restrained under four year olds from both the pre- and post-legislative period will be combined. The potential problems associated with various modes of restraint use and trauma patterns of the injured restrained children will be analyzed.

Chapter 5 presents the conclusions and summary of the findings of this report along with a series of expectations on child passenger safety stemming from the analyses contained in Chapters 3 and 4.

CHAPTER 2

RESEARCH METHODOLOGY

The data on pediatric motor vehicle trauma for this report was collected through an ongoing monitoring system in nine hospital emergency rooms as well as the Coroner's Office in Orange County, California. The medical facility monitoring system was initiated in April 1980 and has been in continuous operation since that time. All child passengers 0-14 years of age involved in motor vehicle accidents and taken for medical evaluation and treatment to the nine monitored hospitals are identified through this system. Data from January 1981 through December 1984 (two years pre-legislation and two years post-legislation) was selected from the monitoring system's Motor Vehicle Injury To Children Master Database for the analysis of the effects of the California Child Passenger Safety Act on pediatric trauma. In this chapter are descriptions of 1) the hospital monitoring system, 2) the data collection methods, 3) the data coding methods, and 4) the research strategy and analysis techniques utilized in the remainder of this report.

I. EMERGENCY ROOM MONITORING SYSTEM

The medical facility monitoring system exists in nine of the 37 hospital emergency rooms in Orange County, California. The hospital monitoring system is confined to a single county for several reasons. First, Orange County (population 1.9 million), which is the connecting freeway link between San Diego in the south and Los Angeles in the north, has developed over the past ten years as a distinct urban setting with its own industry, entertainment, county newspapers, and culture. Consequently, the majority

of motor vehicle accident victims (especially pediatric victims in this sample) are residents of Orange County. Second, the medical system is distinct from that of both Los Angeles County and San Diego County. A county-wide trauma system was instituted in 1980. Severe automobile accident victims (as well as other types of trauma cases) are transported to one of 4 county designated trauma hospitals.[1] Finally, by confining the system to a single county, child safety activities, i.e. public information and education campaigns, which may promote increased restraint use in motor vehicles might also be tracked.

The selection of the nine medical facilities for the monitoring system was primarily guided by the need to maximize the number of pediatric motor vehicle accident cases. The thirteen hospitals in Orange County which had the largest number of annual emergency room visits were contacted to participate in the monitoring system (Orange County Health Planning Council, 1980). Nine of the 13 hospitals agreed to participate by distributing a standardized questionnaire and allowing researchers to review medical charts of all children 0 - 14 years of age who were injured as passengers in motor vehicle accidents. Only one of the 5 original county-designated trauma centers refused to participate in the monitoring system. Fortunately, that trauma center is located in the less developed southern portion of the County and also serves a large elderly population due to the close proximity of a large retirement community.

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[1] Originally, 5 hospitals were designated as trauma centers. In 1983, one hospital dropped out because of insufficient trauma cases to warrant the high economic investment necessary for sustaining a trauma center.

In Table 1 are displayed the nine participating hospitals and selected characteristics of each. Figure 1 graphically displays the geographic location of the nine monitoring system hospitals. Figure 1 may be misleading in that it shows a concentration of the monitored hospitals in the central and northern portions of Orange County with no representation of the southern portion of the County. However, the bulk of the County's population is concentrated in the northern and central portions of the county; much of the southern portion of the county, adjacent to San Diego County, has yet to be developed.

Table 1 and Figure 1 About Here

II. DATA COLLECTION METHOD

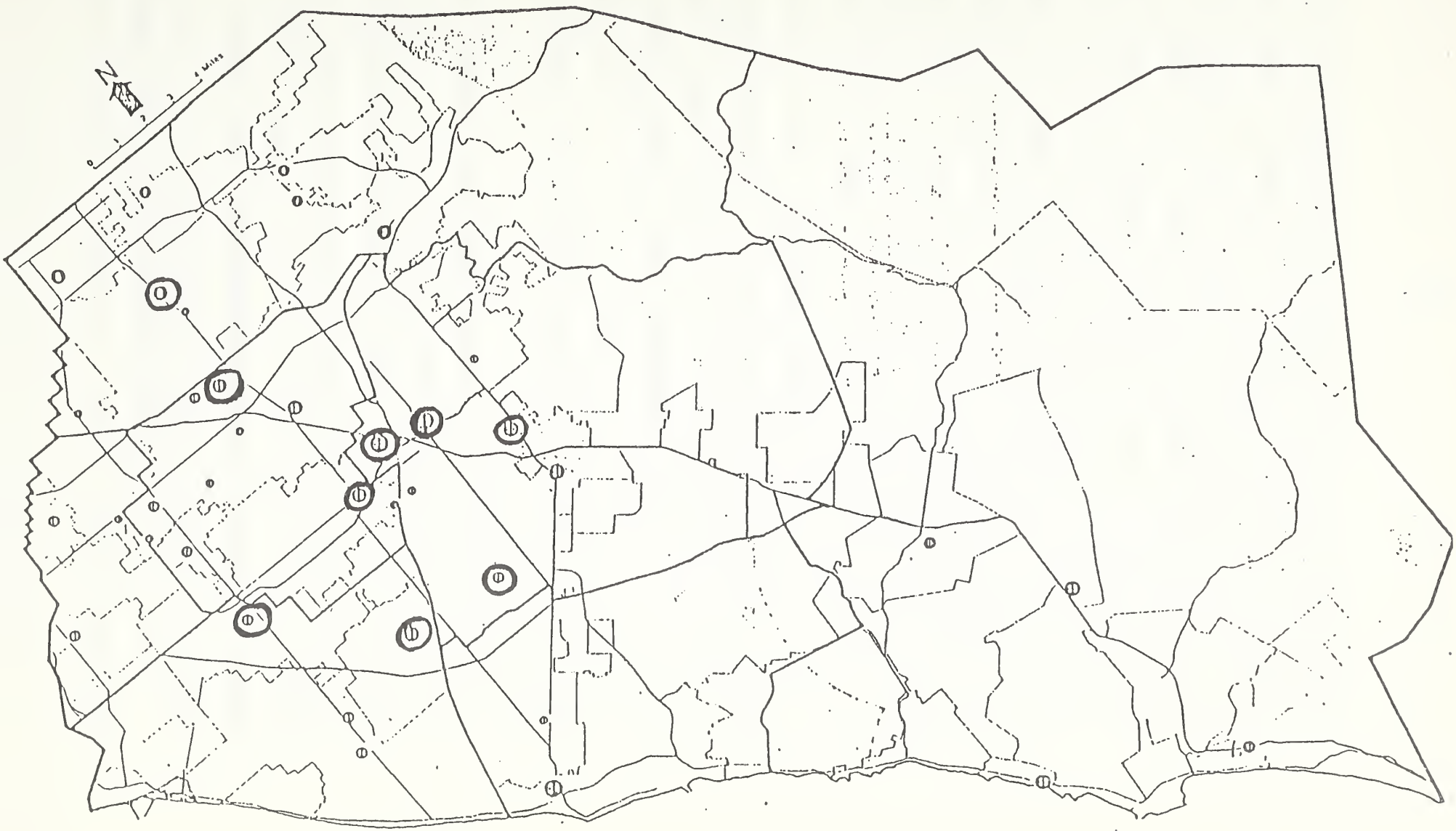
Data is collected in the monitored hospitals through the use of a standardized questionnaire consisting of questions on 1) a description of the accident, 2) a description of the child's manner of travel, e.g., restraint use, location in the vehicle, and 3) detailed medical information on the evaluation and treatment of the child. The questionnaire with only minor modifications has been in use since the implementation of the monitoring system. A copy of the questionnaire is in Appendix A.

Initially, medical personnel in the nine emergency rooms distributed the questionnaire to the parent or guardian at the time the injured child was being treated. During the first six months of the monitoring system it became apparent that this method would not work consistently in each of the nine emergency rooms. There were a variety of reasons for its failure. First, in some instances, the parent or guardian was also injured and consequently was unavailable to complete the questionnaire. Second, in some of the emergency rooms, there was a high turnover of personnel, and new

TABLE 1. DESCRIPTION OF EMERGENCY ROOM FACILITIES IN MONITORING SYSTEM

Facility Name	Type of Emergency Facility	1980 Visits
University of California Irvine Medical Center	trauma center and county-wide specialized trauma referral center; paramedic base station	53,498
Western Medical Center	trauma center paramedic receiving	22,721
Fountain Valley Community Hospital	trauma center paramedic receiving	21,944
Anaheim Memorial Hospital	trauma center (1981-1983); paramedic base station	24,000
St. Joseph Hospital	basic emergency; paramedic receiving	21,573
Children's Hospital of Orange County (CHOC)	first aid; basic emergency services provided under contract with adjacent St. Joseph Hospital	9,690
St. Jude Hospital	basic emergency; paramedic base station	25,932
Mercy General Hospital	basic emergency; paramedic receiving	19,354
Humana Westminister	basic emergency; paramedic receiving	16,984

Figure 2.1 Graphic Location Of Monitored Hospitals In Orange County



personnel would either not be informed about the questionnaire or would not be adequately instructed regarding the completion of the questionnaire. Third, for some of the monitored emergency rooms, pediatric motor vehicle accident cases were so infrequent that personnel would forget to distribute the questionnaire. Fourth, in many of the emergency rooms this study was not given the same priority as the numerous other activities which were more critical to the functioning of that department within the hospital. As a result of these problems and in order to assure that all pediatric motor vehicle accident cases were collected, the method of data collection was changed. In all nine hospitals, emergency room log books are audited by project staff -- the medical records of all children injured in motor vehicles are reviewed and information regarding the injuries and treatment are recorded. Physicians and nurses notes are also reviewed for additional information concerning the accident such as the child's seat location and restraint use. All cases identified in the log book which do not have a questionnaire completed by the parent or guardian are then contacted by a member of the project staff and the questionnaire is completed through a telephone interview.

In approximately 75% of the cases a telephone interview is necessary to complete the questionnaire. Generally, within one to two months following the accident, the parent or guardian is interviewed by telephone regarding the circumstances of the accident and the child who was injured. All questions are asked of the parents; however, in cases of differing information between the medical record report and the parent's report, the interviewer will attempt to reconcile the discrepancies.

A second monitoring system for data collection was installed in the Orange County Coroner's Office. In a majority of the fatal cases, because

the child died at the scene of the accident, transport to a hospital emergency room was not necessary. Consequently, without a coroner's office monitoring system, most fatal cases would have been missed. On a quarterly basis, the log book at the Coroner's Office is audited, and all motor vehicle fatality cases of under 15 year old children are noted. Using the documentation in the Coroner's Report which generally includes a police accident report, the hospital monitoring system questionnaire is completed by a member of the research team. All injuries listed in the autopsy report are noted. In those cases in which the fatality had been transported to one of the hospitals in the monitoring system, the medical record is also reviewed for information regarding both the injuries and the accident.

III. DATA CODING PROCEDURES

Several important procedures are done in preparing the data collected through the monitoring system prior to analysis and should be detailed. In this section, these procedures will be described.

A. Injury Coding

All injuries are coded utilizing a standardized injury severity coding scheme, the Abbreviated Injury Score (AIS-80), which was devised by a committee of the American Association for Automotive Medicine (AAAM, 1980). This particular scoring system is widely used and enables researchers in the field of automotive medicine to provide comparable injury severity measures. The scoring system is independent of whether or not the accident victim died from the injuries. The severity score is based only on the documented injuries which are medically confirmed. Consequently, it provides a measure of injury severity which is not dependent upon the quality of treatment. There are a total of seven levels of injury severity:

AIS-0: medically confirmed to be uninjured

AIS-1: minor

AIS-2: moderate

AIS-3: serious

AIS-4: severe

AIS-5: critical

AIS-6: maximum injury virtually unsurvivable at this time

Utilizing the AIS scoring method, all cases are assigned a Maximum Injury Severity Score (MAIS) which provides a numerical representation of overall injury severity. For a child with multiple injuries, the MAIS is the single highest AIS code which the child received; for a child with only one injury, the AIS is also the MAIS. A second summary measure of injury severity, the Injury Severity Score (ISS), is also calculated. This particular summary measure involves squaring the highest AIS score of three body areas (external, head, face, chest, abdomen, extremity) and then adding these three scores.

In addition to the AIS score, all specific injuries are coded. A specific injury coding manual was prepared based on the listing of injuries in the AIS-80 coding manual along with additional specific injuries found in the hospital records. This particular coding manual is continuously updated.

Finally, the combination of specific injuries sustained by each child is given a numerical code. This particular coding manual is specific to the sample of cases from the hospital monitoring system and affords a means of displaying the frequency of multiple injuries sustained by the sample of children.

B. Restraint Use

Information on restraint use is initially obtained through parental report. In the course of the interview, the parent is asked the following question: "At the time of the accident was your child: sitting alone, standing alone, in the arms or lap of another passenger, lying down, wearing a seat belt, in a child restraint seat, or other?" This particular question is embedded within a series of questions regarding the child in the accident. For those who indicate restraint use, additional questions are asked regarding what happened to both the child and the restraint system at the time of the accident. All cases in which restraint use is indicated are then reviewed by members of the research team using the hospital records, available newspaper reports and police accident reports when available.[2] Cases in which there is some doubt by the research team as to whether the child was restrained at the time of the accident are coded as "doubtful whether restrained." In the analyses contained in this report, these cases are analyzed as "unrestrained" cases.

IV. RESEARCH STRATEGY AND ANALYSIS TECHNIQUES

The major task in this report is that of ascertaining whether differences in various measures of injury exist between the two years prior to the enactment of the California Child Passenger Safety Law (1981-1982) and the two years since enactment of the law (1983-1984). This particular research focuses on a sample of children who were presumed to be injured following a

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[2] In an increasing number of cases, medical staff have questioned the family regarding the use or nonuse of restraint systems at the time of the accident and have included the information in the medical record.

motor vehicle accident and transported to a hospital emergency room for medical evaluation and treatment. Children involved in accidents who did not seek medical treatment are not available in this sample. Consequently, this sample precludes any statements regarding the overall effects of the California Child Passenger Safety Law on motor vehicle accident injury rates. Similarly, the extent of restraint usage in the general population is not known with this sample. The major thrust of the research is directed towards the impact of the California Child Passenger Safety Law on medical facility use as well as the impact of the law on trauma patterns and severity of injury for those children injured in motor vehicle accidents.

While the sample for this report consists of all children less than four years of age, the older children 4-14 years of age are used for comparison with the target population of under four year olds. The analytical strategy for much of this report consists essentially of the statistical testing of indicators of trauma as well as restraint use for the under four year old age group versus the 4-14 year old age group. Each age group is divided into those children evaluated in the medical facility during the pre-legislation period (1981-1982) and those evaluated during the post-legislation period (1983-1984). The Chi-Square test of association is the primary statistical tool that is utilized. This test enables us to answer the question whether the observed distributions between the pre-legislation period and the post-legislation period are higher than would have been expected given that all conditions remained equal.

CHAPTER 3

EFFECTS OF LEGISLATION ON MOTOR VEHICLE INJURIES TO CHILDREN

The major focus of this research was the investigation of the effects of the California Child Passenger Safety Law on changes in trauma and trauma patterns of those covered by the legislation (children less than four years of age). While other studies have focused on observed restraint use and changes in overall numbers of injuries and fatalities utilizing official police statistics, our approach was to investigate the impact of the legislation on trauma by analyzing patterns of injury, body area of injury, overall injury severity and mitigation of injury of children who were involved in motor vehicle accidents and subsequently evaluated in a hospital emergency room. As such, in some respects this sample of children might be considered as instances of the "failure" of restraint usage laws in that there was a presumption of injury from the motor vehicle accident along with transport to a medical facility for evaluation of the injury. Nonetheless, this sample should not be regarded only as "failure" rates, for such a sample also provides a means of obtaining further information about the "ultimate success" of the legislative method for child occupant injury prevention.

The importance of this sample is three-fold. First, medical determination of injury (available through a hospital monitoring system) provides more accurate, comprehensive and specific data on injuries than is generally possible at the scene of the accident. Police officers tend to grade injuries on only the visible signs and verbal complaints of injury; however, in the case of the under four years olds (the target population) who are less able to verbalize the exact nature of injuries and who may be crying

from pain or from the shock of the accident, such on-scene injury grading can be problematic. Second, this type of investigation allows an assessment of the direct effects of the legislation on the utilization of medical services. For example, tests of the extent to which there is a reduction in the numbers of children requiring medical attention can be done. If restraint use legislation is having an impact on injury reduction, this impact should be observable in hospital emergency room usage. Finally, investigation of emergency room patients, which includes complete medical information, provides a means of testing certain aspects of the impact of safety seat legislation which are not easily achievable through the use of observational data of restraint use or gross highway statistics. For example, studies such as the analysis of the injuries sustained by restrained children in crashes as well as the frequency of such injuries are well suited to a hospital-based sample.

In summary, the tests of the effects of mandatory restraint use legislation presented in this chapter provide information not currently available in the field of automotive medicine and traffic safety, rather than a validation of previous research findings. Four major topics will be investigated: 1) changes in various measures of injury among those less than four years of age evaluated in emergency rooms after involvement in a motor vehicle crash, 2) changes in rates of head injuries (the most common anatomic area of injury for children) among these children, 3) changes in the rates of noncrash injured children observed between the pre-legislative period and the post-legislative period, and 4) changes in overall rates of utilization of medical services after enactment of the law.

A. Method

The data used in the analysis consists of all children through the age of 14 who were involved in motor vehicle accidents and were subsequently evaluated in the monitored emergency rooms during the period 1981 - 1984. For most of the analyses, the sample will be divided into two groups: 1) children through the age of 3 years, namely those children covered by the law, and 2) children 4-14 years of age, the control group. In the analysis of the injury changes presented in Sections 1 and 2 of this chapter, the sample of cases will include only children involved in motor vehicle crashes. Those children injured in noncrash events will be analyzed separately in Section 3 of this chapter. In Section 4 both the crash and noncrash cases will be combined. Case data has been combined for the two years prior to the enactment of the California Child Passenger Safety Law (1981-1982) and for the two years after the enactment (1983-1984).

I. EFFECTS OF LEGISLATION ON HOSPITAL EMERGENCY ROOM CRASH CASES

The general characteristics of the children involved in motor vehicle crashes who were brought for evaluation and treatment at nine hospital emergency rooms in Orange County, California over a four-year period (1981 through 1984) are shown in Table 1.

Table 1 About Here

Both the number of children under the age of 4 and those 4-14 years of age who were evaluated in an emergency room following a motor vehicle crash increased in the post-legislation period. The percentage increase was similar in both age groups (11% for the under 4 year olds vs. 16% for the 4-14 year olds) so that at least at a gross level there was no apparent decrease in under four year old crash victim injury rates observed in the

TABLE 1. IMPACT OF CHILD PASSENGER SAFETY ACT ON HOSPITAL EMERGENCY ROOMS: GENERAL CHARACTERISTICS OF CHILDREN INVOLVED IN MOTOR VEHICLE CRASHES

	Under Four Years of Age			Four Years and Over		
	Two Years Pre-Law	Two Years Post-Law	sig.[a]	Two Years Pre-Law	Two Years Post-Law	sig.[a]
Number of children brought to emergency room	242	269		511	594	
Percent of children restrained	26%	50%	0.0000[b]	9%	18%	0.0000[b]
Percent medically determined to be uninjured	30%	43%	0.0031[b]	8%	9%	0.7800[b]
Number of fatalities	3	1	0.5426[b]	11	6	0.1959[b]

[a] sig. refers to the statistical significance level

[b] statistical significance level for the chi-square test; all tables are four-fold tables

emergency rooms following the enactment of the law. Similarly, there was no significant change observed in the number of fatalities before and after implementation of the legislation in either age group. Overall, the number of fatalities in the County is low; thus, relying solely on changes in the number of fatalities for measuring impact of the legislation is limiting. Three children under four years of age were fatally injured in the pre-law years; one was fatally injured in the post-law years. In the 4-14 year old age group, there were 11 fatalities in the pre-law period and 6 fatalities in the post-law period.

While the gross numbers of emergency room treated children as well as fatalities did not differ substantially in either age group, there were observable differences between the two age groups. First, the percentage of children under four years of age who were reported restrained at the time of the accident significantly increased from 26% before the law to 50% after enactment of the law.[1] The 4-14 year olds also showed a significant restraint usage increase from 9% to 18%. However, it should be emphasized that the extent of restraint use for this age group was well below that of the under four year old age group in both time periods.

Second, those children under four years of age who were medically determined to be uninjured increased from 30% in the two years prior to the law to 43% in the two years after the law. In contrast, the 4-14 year olds

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[1] We have combined child safety seats and seat belts in this measure of restraint use; unrestrained consists of both traveling alone and on the lap of another passenger. See Chapter 4 for the comparison of percentage use of child safety seat, seat belts, on-lap travel and traveling alone of the under four year olds between the pre-legislative and post-legislative period.

demonstrated remarkable stability in the percentage of children diagnosed as uninjured: 8% pre-law and 9% post-law. Even though there is a greater propensity for parents to bring very young children to the emergency room to be checked following involvement in a motor vehicle crash and, as Table 1 indicates, there were observable differences between the two age groups in the percent uninjured even prior to the law, the additional 13% increase for the under four year olds is significant. There is no evidence which would indicate that compliance with a safety seat law would affect the propensity of parents to bring their uninjured children in for medical evaluation after involvement in a motor vehicle accident. Indeed, in Table 2 which displays the distribution of the under four year old crash cases in terms of injury and restraint use, the proportion of children who were restrained and uninjured was essentially the same as the proportion of children who were restrained and injured. In general, this analysis indicates that while the actual numbers of children brought to the emergency room did not substantially change, there was evidence to indicate that some overall changes in injuries and restraint use were taking place between the pre-legislative and the post-legislative periods for the under four year olds. This was not observable in the four years and older age cohort.

Table 2 About Here

In Table 3 is a comparison of the distribution of severity of injury as measured by the Maximum Abbreviated Injury Score (MAIS) for those less than 4 and those 4-14 years of age in the pre- and post-legislation periods. Overall, the distribution of MAIS scores was significantly different between the two periods of time for those less than four years of age. No significant difference was seen for the 4-14 year old age group.

Table 3 About Here

TABLE 2. COMPARISON OF INJURY AND RESTRAINT USE FOR UNDER FOUR YEAR OLDS INVOLVED IN MOTOR VEHICLE CRASHES BEFORE AND AFTER ENACTMENT OF THE LAW

	Under Four Years of Age	
Restraint Use and Injury	Two Years Pre-Law (N=242)	Two Years Post-Law (N=269)
Restrained/uninjured	10%	26%
Restrained/injured	16%	24%
Unrestrained/uninjured	19%	17%
Unrestrained/injured	55%	33%

$X^2(p) = 0.00$[a]

[a] statistical significance level for chi-square test

TABLE 3. COMPARISON OF SEVERITY OF INJURY (MAIS) BEFORE AND AFTER ENACTMENT OF THE LAW OF CHILDREN INVOLVED IN MOTOR VEHICLE CRASHES

	Under Four Years of Age		Four Years and Over	
Injury Severity (MAIS)[a]	Two Years Pre-Law (N=242)	Two Years Post-Law (N=269)	Two Years Pre-Law (N=510)	Two Years Post-Law (594)
Uninjured (MAIS 0)	30%	43%	8%	9%
Minor (MAIS 1)	57%	49%	72%	73%
Moderate (MAIS 2)	9%	5%	14%	13%
Severe (MAIS 3)	2%	2%	2%	3%
Serious (MAIS 4)	0.4%	1%	1%	1%
Critical (MAIS 5)	1%	0.4%	2%	1%
Untreatable (MAIS 6)	0.4%		0.4%	0.2%
	$X^2(p) = 0.045$[b]		$X^2(p) = .588$[b]	

[a] MAIS is the Maximum Abbreviated Injury Score which is derived from the Abbreviated Injury Score, a standardized scoring method developed by the American Association For Automotive Medicine.

[b] statistical significance level for chi-square test; all tables are four-fold tables with degrees of freedom equal to 2

Although the full distribution of MAIS did show a significant difference in the post legislation period, it is important to examine more closely the specific changes in injury severity which occurred between these two time periods. One approach, which is displayed in Table 4, is to construct an expected injury distribution based on the assumption that if all travel conditions remained constant in these two time periods, then injury distributions would in turn remain constant. The expected distribution is then compared with the observed distribution following the enactment of the child safety law. This type of analysis provides one means of assessing the relative gains and losses of the numbers of children in each injury severity category after enactment of the California Child Passenger Safety Law.

Table 4 About Here

The following approach was taken in constructing Table 4. Given the non-significant differences seen in Table 3 among those 4-14 years of age, the percentage distribution of levels of injury severity for the under 4 years olds would have been expected to remain constant if there had been no intervention. It also would have been expected that the same percentage increase in the numbers of children in the under 4 year old category would have occurred as was seen in the 4-14 year old category. With a 16% increase in the 4-14 year olds, we would have expected a similar 16% increase in the 0-3 year olds and would have expected 280 children to have been seen in the emergency rooms in the post-legislation period. Using the percentage distribution of levels of injury severity for the pre-law period (column 2, Table 3), the expected numbers of children at each injury severity level was calculated.

The results of the analysis indicate that changes in the level of injury severity were not uniform at all levels. The difference between the

TABLE 4. COMPARISON OF EXPECTED VERSUS OBSERVED DISTRIBUTION OF INJURY SEVERITY FOR UNDER FOUR YEAR OLDS INVOLVED IN MOTOR VEHICLE CRASHES

	PRE-LEGISLATION	POST-LEGISLATION		
	Percentage Baseline Distribution	Expected Distribution of Injury	Actual Distribution of Injury	Difference between observed and expected number
No Injury (MAIS 0)	30%	84	115	+31
Minor (MAIS 1)	57%	160	131	-29
Moderate (MAIS 2)	9%	25	14	-11
Severe (MAIS 3)	2%	6	6	0
Serious (MAIS 4)	0.4%	1	2	+ 1
Critical (MAIS 5)	1%	3	1	- 2
Untreatable (MAIS 6)	0.4%	1	0	- 1
TOTAL	100%	280	269	-11

expected and the actual distribution indicates that there was an increase in the number of uninjured children accompanied by a decrease in the number of children with minor and moderate injuries. However, virtually no change in the number of children in the severe or more seriously injured categories was observed.

This leads us to the second issue covered in this section: once we factor out all uninjured children in the sample, are there differences between the pre- and post-legislation periods of time for the two age groups in general measures of severity of injury, numbers of injuries and level of care required for diagnosis and treatment of injuries.

In Table 5 are presented various characteristics of injury and disposition of the medically documented injured children for the target age group (under 4 years of age) and the 4-14 year old age group. When we focus solely on injured children, major injury severity changes were not observed in the sample. All measures of injury severity for the pre-law period and the post-law period were not significantly different for either age group.

Table 5 About Here

The data in Table 5, however, points to an important reason why gross changes in injury severity for this population would not be observed. Even in the pre-legislative period, most children injured in motor vehicle crashes received minor injuries. In general, severe injuries were few and episodic and consequently, dramatic shifts in measures of injury severity would be difficult to attain. Eighty-three percent of those under four years of age who were injured sustained minor injuries in the pre-law years compared to 86% in the post-law years. Children in the 4-14 year old age group were similarly overly clustered into the minor injury category (81% in the pre-law and 81% in the post-law). With the high percentage of minor

TABLE 5. IMPACT OF CHILD PASSENGER SAFETY ACT ON HOSPITAL EMERGENCY ROOMS: NON-FATALLY INJURED CHILDREN INVOLVED IN MOTOR VEHICLE CRASHES

	Under Four Years of Age			Four Years and Over		
	Two Years Pre-Law	Two Years Post-Law	sig.[a]	Two Years Pre-Law	Two Years Post-Law	sig.[a]
Total number of injured children	167	153	n.a.	457	534	n.a.
Percent of injured children with minor injuries (MAIS-1) only[d]	83%	86%	0.5645[b]	81%	81%	0.9459[b]
Average Injury Severity Score (ISS) for treatable injuries[e]	2.258	2.157	0.8220[c]	2.348	2.214	0.5680[c]
Average number of injuries sustained	1.425	1.536	0.3170[c]	1.536	1.581	0.4470[c]
Average number of body areas injured	1.144	1.170	0.6320[c]	1.204	1.229	0.4330[c]
Percent of injured children hospitalized	13%	13%	1.0000[b]	8%	11%	0.0963[b]

[a] sig. refers to the statistical significance level

[b] statistical significance level for chi-square test; all tables are four-fold tables with degrees of freedom equal to 2

[c] statistical significance level for t-test

[d] MAIS is the Maximum Abbreviated Injury Score which is derived from the Abbreviated Injury Score, a standardized scoring method developed by the American Association For Automotive Medicine.

[e] ISS is the Injury Severity Score which is derived from the Abbreviated Injury Score developed by the American Association For Automotive Medicine; it is calculated by squaring the maximum Abbreviated Injury Score for three out of six designated anatomic areas.

injuries and, even more importantly, the high incidence of single injuries and single body area injuries, differences in averages before the law and after the law for such characteristics as the number of injuries sustained, the number of body areas injured as well as the overall average injury severity were remarkably similar not only within age groups but also between age groups. Rates of hospitalization were similarly stable in both time periods.

Summary

The data from Tables 1 through 5 indicate that the major change between the pre-legislative and post-legislative period observed in the monitored hospital sites was in the number of children medically determined to be injured, rather than in the number of children served by the medical delivery system. Utilization rates of the hospital emergency rooms did not appear to decrease after enactment of the law, even though a higher percentage of the under four year olds were restrained at the time of the crash. Instead, a significant decrease was observed in the number of under four year olds who were medically determined to be injured. Given that the percentage of uninjured under four year olds was remarkably similar for 1981 and 1982 (approximately 30%), it would appear that the increased percent in 1983 and 1984 was more likely a function of reduced injury rather than an increase in parental concern.

II. EFFECT OF LEGISLATION ON HEAD INJURIES

The measures of severity of injury in Section I indicate that very little difference in injury was observed between the pre-legislation and post-legislative period. However, the analysis up to this point has focused solely on summary measures of injury severity and the numbers of injuries

sustained. While most of the injuries to children were minor, the specification of the level of severity of injury provides no information regarding the anatomic area of injury. Are any changes observed in the types of injuries sustained by children before and after enactment of the law?

In Table 6 is a comparison of body area of injury before and after enactment of the law for those less than 4 years of age and for those 4-14 years of age. As is readily apparent, no significant changes (pre vs. post law) occurred in the percent of children sustaining injuries to the torso, extremity, or spine. In contrast, a significant decrease in those sustaining head injuries was observed in those less than 4 years of age in the two years following implementation of the law. This was not observed in the 4-14 year olds, and, in fact, no significant changes were seen among these children with respect to any body area of injury.

Table 6 About Here

Furthermore, as Table 6 indicates, the most frequent anatomic area injured for children of all ages in motor vehicle crashes was the head and face area. In Table 7 are listed the specific head injuries incurred by the under four year olds in the pre- and post-legislation time periods. These head injuries ranged from minor lacerations and contusions to the face and head to the more serious internal head and facial injuries such as fractures, brain contusions and hemorrhage.

Table 7 About Here

All injuries to the head are significant in terms of survival and in terms of future physical and cognitive development. The child who sustains a severe abdominal injury, for example, a liver laceration or pulmonary contusion and hemorrhage, and who receives appropriate and timely emergency medical intervention will generally survive the injury with little or no

TABLE 6. COMPARISON OF DISTRIBUTION OF BODY AREAS INJURED BEFORE AND AFTER ENACTMENT OF THE LAW OF CHILDREN INVOLVED IN MOTOR VEHICLE CRASHES

	Under Four Years of Age			Four Years and Over		
Body Area of Injury[a]	Two Years Pre-Law (N=242)	Two Years Post-Law (N=268)[b]	sig.[c]	Two Years Pre-Law (N=509)[b]	Two Years Post-Law (N=589)[b]	sig.[c]
Head area (includes head and face)	64%	48%	0.0003	64%	64%	0.9061
Torso (includes chest, abdomen and hip)	5%	6%	0.7898	11%	13%	0.3534
Extremity (includes arm, leg and shoulder)	9%	12%	0.3106	33%	30%	0.2927
Spinal strains	2%	1%	0.8879	11%	14%	0.1504

[a] Percentage can sum to more than 100% since in some of the cases, more than one body area was injured.

[b] Several cases could not be classified regarding body area of injury: 1 under four year old and 5 of the 4-14 year old cases were not classified for the post-law period; 2 4-14 year old cases were not classified for the pre-law period. In all cases, the children sustained minor injury. However, the medical record indicated only 'minor contusions and abrasions' without reference to the body area(s) injured.

[c] sig. refers to the statistical significance level for the chi-square test

TABLE 7. DISTRIBUTION OF SPECIFIC HEAD INJURIES SUSTAINED BY UNDER FOUR YEAR OLDS INVOLVED IN MOTOR VEHICLE CRASHES

PRE-LEGISLATION PERIOD (1981-1982)	
Head contusions, abrasions or lacerations	126
Head contusions, abrasions or lacerations and extremity contusions, abrasions or lacerations	4
Head contusions, abrasions or lacerations and torso contusions, abrasions or lacerations	6
Head contusions, abrasions or lacerations and extremity and torso contusions, abrasions or lacerations	2
Head abrasions, humerus fracture, arm and leg abrasions	1
Head lacerations, pelvic fracture, arm abrasion	1
Cerebral concussion	4
Cerebral concussion, mandible fracture, tibia fracture	1
Simple skull fracture	3
Eye avulsion, femur fracture	1
Compound skull fracture	1
Cerebral contusion	1
Cerebral contusion, radius fracture	1
Cerebral contusion, simple skull fracture	1
Brain stem contusion, depressed skull fracture, cerebral contusion	1
Diffuse brain injury	1
Diffuse brain injury, skull fracture	1
Skull crush, arm amputation, muscle avulsion leg	1
POST-LEGISLATION PERIOD (1983-1984)	
Head contusions, abrasions or lacerations	101
Head contusion, abrasions or lacerations and extremity contusions, abrasion or lacerations	12
Head contusions, abrasions or lacerations and torso contusions, abrasions or lacerations	3
Head contusions, abrasions or lacerations and extremity and torso contusions, abrasions or lacerations	3
Head contusions and fibula/tibia fracture	1
Cerebral concussion	1
Zygoma fracture and head laceration	1
Simple skull fracture	1
Simple skull fracture and cerebral concussion	1
Compound skull fracture	2
Cerebral injury involving subarachnoid hemorrhage	2
Basilar fracture, mandible fracture, nose fracture, maxilla fracture, spleen rupture and femur fracture	1
Basilar fracture, skull fracture, maxilla fracture, orbit fracture, spleen rupture and ankle fracture	1

long term residual impairment. However, the child who sustains a head injury of similar severity has a greater probability of a fatal outcome, or of sustaining residual disability and/or permanent damage. Even minor head injuries have a greater potential for harm in the young child than an injury of similar severity to another area of the body. Boll (1983), in a thorough review of the effects of minor head trauma on children has concluded that seemingly minor head injuries may have serious neuropsychological sequelae. Specifically, personality changes, school learning difficulties, including memory and attention deficits have been reported. These disorders may not be apparent in the immediate post trauma period and may surface years later, i.e., in the case of an infant or toddler, not until he/she is of school age. Interestingly, Boll further concludes that prevention of even minor head injuries is critical and this could best be accomplished by restraint use.

Because of the preponderance of head injuries among children as well as the serious nature of head injuries to children, intensive investigation of the impact of legislation in terms of head injuries is important. Three analyses will be done: 1) a comparison of the level of severity of head injuries before and after enactment of the law, 2) an analysis of the changes in the numbers of head injured children between the two age cohorts before and after enactment of the law, and 3) an analysis of the changes in the numbers of head injured children by specific age in order to consider the issue of whether some ages may be more affected than other ages.

In Table 8 is shown a comparison of severity of head injury before and after enactment of the law for those under 4 years of age and for those 4-14 years of age. The distribution of MAIS scores for those receiving a head injury was significantly different between the pre- and post-legislation

periods for those less than 4 years of age. No significant difference between the two time periods was seen among those not covered by the law. While in the pre-law period, 36% of the under four year olds did not receive a head injury, this increased to 52% with no head injury in the post-law period. The drop seen in the number of minor head injuries in the post-law period relates to the increase in uninjured with respect to the head and face areas. The percent of children receiving more than a minor head injury decreased by 50% in the post-law period (from 10% pre-law to 5% post-law).

Table 8 About Here

While changes in severity of head injury (particularly at the minor and uninjured level) are observable, this provides no information regarding changes in the actual numbers of children sustaining a head injury. In Table 8 is presented an analysis of the distribution of the number of head injured children between the pre-legislative and the post-legislative period for the under four year olds; a similar analysis is presented for the 4-14 year olds. The primary aim of this analysis was to ascertain whether there were any changes in the number of under four year olds who sustained head injuries after the enactment of the child passenger safety legislation. Briefly, the method used was to calculate the number of head injuries expected in the post-legislative period based on the percentage distributions in the pre-legislative period and then to statistically test whether the observed numbers of head injuries in the under four year old age group and the 4-14 year old age group deviated significantly from what would have been the expected numbers of head injuries given no change in distribution of head injuries from the previous two years. In this analysis it is assumed that if there was no intervention, such as a Child Passenger Safety Act, it would be reasonable to expect that the distribution of head injury

TABLE 8. COMPARISON OF SEVERITY OF HEAD INJURY BEFORE AND AFTER ENACTMENT OF THE LAW OF CHILDREN INVOLVED IN MOTOR VEHICLE CRASHES

	Under Four Years of Age		Four Years and Over	
Injury Severity (MAIS)[a]	Two Years Pre-Law (N=242)	Two Years Post-Law (N=268)[b]	Two Years Pre-Law (N=509)[b]	Two Years Post-Law (N=589)[b]
Uninjured (MAIS 0)	36%	52%	36%	36%
Minor (MAIS 1)	55%	43%	52%	52%
Moderate (MAIS 2)	6%	3%	9%	9%
Severe (MAIS 3)	2%	2%	1%	1%
Serious (MAIS 4)	0.4%		1%	1%
Critical (MAIS 5)	1%		1%	1%
Untreatable (MAIS 6)	0.4%		0.2%	
	$X^2(p) = 0.003$[c]		$X^2(p) = .55$[c]	

[a] MAIS is the Maximum Abbreviated Injury Score which is derived from the Abbreviated Injury Score, a standardized scoring method developed by the American Association For Automotive Medicine.

[b] Several cases could not be classified regarding body area of injury: 1 under four year old and 5 of the 4-14 year old cases were not classified for the post-law period; 2 4-14 year old cases were not classified for the pre-law period. In all cases, the children sustained minor injury. However, the medical record indicated only 'minor contusions and abrasions' without reference to the body area(s) injured.

[c] statistical significance level for chi-square test; all tables are four-fold tables with degrees of freedom equal to 2

for 1981-1982 should remain fairly constant during the subsequent two years (1983-1984). Consequently, given the actual number of children brought to the emergency room in 1983 and 1984, we should be able to predict how many of the children in 1983 and 1984 would sustain a head injury. The results of this analysis are contained in Table 9.

Table 9 About Here

In 1983 and 1984, a total of 268 children under the age of 4 were brought to emergency rooms for assessment and treatment following a motor vehicle crash. Using the previous two years' distribution of head injuries (64% head injury) we would expect that approximately 172 of these children should have sustained a head injury. In fact, only 129 of the children under the age of 4 sustained a head injury. A similar test with the children 4-14 years of age indicated that of the 591 children brought to the emergency room, given a baseline proportion of 64% head injury, we would expect 378 to have sustained a head injury. In fact, 377 of the children sustained a head injury.

The test of the changes in observed numbers of head injuries contained in Table 9 is conservative in that we are looking only at those children who were brought to the medical facility after a motor vehicle crash. We are not able to take into account the number of children under the age of 4 who were involved in a crash, but who were not taken to a hospital emergency room. Our interest is solely on the emergency room distribution of injury and even within this narrow population, we observed a 16% decrease in head injuries in the under four year olds and no change in the 4-14 year olds. In actual numbers, a total of 43 fewer than expected head injured children under the age of 4 was observed in the post-legislation period.

TABLE 9. SUMMARY TABLE OF CHANGE IN HEAD INJURY IN PRE- AND POST-LEGISLATION PERIOD OF CHILDREN INVOLVED IN MOTOR VEHICLE CRASHES

	PRE-LEGISLATION	POST-LEGISLATION			
	Percentage Baseline Distribution	Expected Distribution of Injury	Actual Distribution of Injury	Number of head injuries prevented	Percent
UNDER FOUR YEAR OLDS					
Uninjured	30%	80	115		
No head injury	6%	16	24		
Head injury	64%	172	129	43	16%
FOUR TO FOURTEEN YEAR OLDS					
Uninjured	9%	53	54		
No head injury	27%	160	160		
Head injury	64%	378	377	1	0%

In Table 10 are shown the baseline percentages along with the expected and actual numbers of children in the post-legislative period for each age.[2] Our major interest in performing this analysis was to test the extent to which the reduction in head injuries observed in the post-legislation period was observed for each year of age under four.

Table 10 About Here

The discrete age analysis in Table 10 indicates that the major head injury reduction was clearly confined to the under four year olds and was apparent for each age category. Up through the age of 3, the percent of head injuries prevented was from a low of 9% for the one year olds to a high of 24% for the two year olds. The significant change in the numbers of head injured children abruptly stopped at the age of 4. From the age of 4 onwards, except for the nine year olds, no other age group evidenced a statistically significant reduction in head injuries and indeed many of the age groups evidenced an increase in head injuries for 1983 and 1984.

Summary

The analysis of the hospital monitoring system sample indicates that after enactment of the Child Passenger Safety Act, a reduction in head injuries and in severity of head injuries was documented among those under

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[2] In this table we have combined the categories of 'no head injury' and 'uninjured' in a single category in order that we may perform statistical testing between the expected and actual distributions of injury. Since children disproportionately sustain head injuries in comparison to other body area injuries, the expected frequency for some age levels is less than 5 (an expected frequency of at least 5 is required for the chi-square one-sample test). Given that the main interest is on the distribution of children sustaining a head injury versus non head injury, the collapsing of the 'uninjured' and 'no head injury' into a single category is possible and does not bias the results.

TABLE 10. CHANGES IN HEAD INJURY BETWEEN PRE- AND POST-LEGISLATION PERIOD

	PRE-LEGISLATION	POST-LEGISLATION			
	Percentage Baseline Distribution	Expected Distribution of Injury	Actual Distribution of Injury	Number of head injuries prevented	Percent
UNDER ONE YEAR OLDS					
No head injury	48%	33	44		
Head injury	52%	36	25	11	16%[a]
ONE YEAR OLDS					
No head injury	42%	27	33		
Head injury	58%	37	31	6	9%
TWO YEAR OLDS					
No head injury	23%	14	29		
Head injury	77%	48	34	15	24%[a]
THREE YEAR OLDS					
No head injury	26%	19	33		
Head injury	74%	53	39	14	19%[a]
FOUR YEAR OLDS					
No head injury	33%	16	17		
Head injury	67%	32	31	1	2%
FIVE YEAR OLDS					
No head injury	38%	24	21		
Head injury	62%	38	41	-3	-5%
SIX YEAR OLDS					
No head injury	36%	22	25		
Head injury	64%	40	37	3	5%
SEVEN YEAR OLDS					
No head injury	40%	16	10		
Head injury	60%	23	29	-6	-15%
EIGHT YEAR OLDS					
No head injury	37%	19	14		
Head injury	63%	32	37	-5	-10%
NINE YEAR OLDS					
No head injury	19%	10	19		
Head injury	81%	43	34	9	17%[a]
TEN YEAR OLDS					
No head injury	41%	21	18		
Head injury	59%	31	34	-3	-6%

(continued)

(Table 10 continued)

	PRE-LEGISLATION Percentage Baseline Distribution	POST-LEGISLATION Expected Distribution of Injury	Actual Distribution of Injury	Number of head injuries prevented	Percent
ELEVEN YEAR OLDS					
No head injury	46%	18	16		
Head injury	54%	22	24	-2	-5%
TWELVE YEAR OLDS					
No head injury	35%	17	22		
Head injury	65%	33	28	5	10%
THIRTEEN YEAR OLDS					
No head injury	36%	23	25		
Head injury	64%	40	38	2	3%
FOURTEEN YEAR OLDS					
No head injury	31%	22	27		
Head injury	69%	49	44	5	7%

[a] Statistically significant at the .05 level or below based on the chi-square one-sample test

four years of age in contrast to those older children not covered by the legislation. With the small child's top-heavy anatomic structure which predisposes the child in a crash situation to propel head first towards an interior portion of the vehicle, the child safety seat and the adult seat belt can prevent many injuries to the head by holding the child in place. In this sample, as Table 1 indicates, nearly 50% of the under four year olds were restrained at the time of the accident and it appears that this level of restraint usage has had an impact on reducing the rate of head injuries.

III. EFFECTS OF LEGISLATION ON NONCRASH INJURIES

Approximately 10% of pediatric patients with motor vehicle occupant injuries seen in a hospital emergency room were injured in noncrash events. In these cases, the child was injured while traveling in a motor vehicle; however, there was no impact of the vehicle with another vehicle or object. Due to sudden stops, sudden swerves of the vehicle, loss of balance by the child or, in many cases, falls out of the vehicle either because of an improperly latched door or through accidental opening of the vehicle door, a child sustained injury. The significance of the noncrash injured child relates to the high probability of ejection in a noncrash event compared to a crash event. In a previous study, Agran and Dunkle (1982) reported that 50% of noncrash injured children were ejected from the vehicle compared to 4% of those injured in a crash. In terms of trauma, ejection resulted in more severe injury compared to injury incurred by the child impacting with an interior portion of the vehicle. Evaluation of the cases of noncrash injury indicated that if restraints had been properly used, most of the noncrash injuries could have been prevented. With increased restraint use

due to the law, a major expected effect of the legislation is a decrease in the total number of noncrash cases.

In Table 11 are displayed the statistical tests of the impact of the Child Passenger Safety Act on the incidence of noncrash cases treated in emergency rooms. With the under four year olds, there was a dramatic decrease in the number of children brought to the emergency room for treatment of noncrash injuries after the legislation was enacted. Thirty fewer cases of noncrash injury were found in the post-law period, representing a decrease of 59%. In contrast, among the 4-14 year olds, the reverse was demonstrated. An additional 15 cases of noncrash injury were seen in the post-law period, representing an increase of 56%.

Table 11 About Here

To further illustrate the dramatic change in the incidence of noncrash cases, Table 11 also shows the percentage of all pediatric motor vehicle passenger cases which were noncrash cases. In the pre-legislation period, 18% of the under four year olds seen in the emergency room following a motor vehicle accident were involved in noncrash incidents. In the post-legislation period, 7% of under four year olds were involved in noncrash incidents. The 4-14 year old cohort showed no major change in the percentage of noncrash injury cases. In fact, the difference between the percentage of under 4 year olds and 4-14 year olds involved in noncrash incidents observed in the pre-legislation period (17% vs. 5%) was eliminated in the post-legislation period.

Overall, restraint use was markedly lower for the noncrash cases than for the crash cases (8% vs. 26% in the pre-law period of time among those less than 4 years). (See Table 10.) Although restraint use doubled in the post-law period among the noncrash injured children, the overall figure of

TABLE 11. IMPACT OF CHILD PASSENGER SAFETY ACT ON HOSPITAL EMERGENCY ROOMS: CHILDREN INVOLVED IN MOTOR VEHICLE NONCRASHES

	Under Four Years of Age			Four Years and Over		
	Two Years Pre-Law	Two Years Post-Law	sig.[a]	Two Years Pre-Law	Two Years Post-Law	sig.[a]
Number of children brought to emergency room	51	21	n.a.	27	42	n.a.
Percent of motor vehicle accident cases that were noncrash cases[e]	17%	7%		5%	7%	
Percent of children restrained	8%	14%	0.6883[b]	4%	5%	1.000[b]
Percent of children injured through ejection from the vehicle	37%	62%	0.0985[b]	59%	69%	0.5658[b]
Percent of injured children with more than minor injuries (MAIS 2-6)	20%	33%	0.3466[b]	44%	31%	0.3781[b]
Average Injury Severity Score (ISS) for treatable injuries[d]	2.020	2.143	0.802[c]	3.074	2.732	0.658[c]
Number of fatalities	1	0	1.0000[b]	0	1	1.0000[b]

[a] sig. refers to statistical significance level

[b] statistical significance level for chi-square test; table is a four-fold table, degrees of freedom is equal to 2

[c] statistical significance level for t-test.

[d] ISS is calculated excluding the fatalities in order not to bias the average scores. "Untreatable" fatalities are assigned the highest ISS score.

[e] Percent noncrash calculated by dividing the sum of crash and noncrash cases into the number of noncrash cases. Total motor vehicle accidents cases for the under 4 year olds were the following: pre-law=293, post-law=290. Total cases for the 4-14 year olds were: pre-law=538, post-law=636.

14% restraint use is small compared to the post-law figure of 50% among the crash involved children. Restraint use among those 4-14 years of age injured in noncrash events likewise was minimal in either the pre-law period (4%) or the post-law period (5%).

In examining the 8 cases of restrained under 4 year olds who were injured in a noncrash event, we find that none were properly restrained in a CSS at the time of the incident. Two children were not actually restrained when they were injured as they had unbuckled themselves from the CSS prior to the event. Two children restrained by vehicle seat belts struck against the vehicle interior in sudden stops. One infant in an infant feeding seat, rather than a CSS, hit against an interior portion of the vehicle in a swerve. Three additional children in CSS's which were not properly secured in the vehicle hit against the vehicle interior in sudden stops.

The most frequent cause of noncrash injuries to children is ejection from the vehicle. Even though there was a significant decrease in the number of less than 4 year olds injured in noncrash events after the legislation was enacted, there was no difference in the distribution (percentage) of ejection among the noncrash cases between the pre- and post-legislation periods of time. Likewise, the percentage of children 4-14 years of age who were ejected remained essentially unchanged. Because of the nature of the noncrash event, it is not expected that the percent injured by ejection would significantly change after a child passenger restraint law. Noncrash injuries primarily occur among unrestrained children; and, indeed, in this sample, all cases of noncrash ejections were unrestrained.

As demonstrated in Table 11, no significant difference in the percent of children sustaining moderate to severe injuries was apparent for noncrash injured children between the pre- and post-law periods. Likewise, average

injury severity score (ISS) did not significantly change in the two monitored time frames. The average ISS in the pre-law period was 2.02; the post-law average ISS was 2.14 for children under 4 years of age. Similar to the younger age group, no significant differences in these two injury severity measures was found among those 4 to 14 years of age.

Summary

The risk of injury in a noncrash event is primarily a function of the failure of a child occupant to be restrained. In this sample of cases, noncrash injuries did not occur among properly CSS restrained children. Some children in seat belts did sustain minor injuries. The primary concern with noncrash events is the high probability of ejection from the vehicle with the subsequent risk of serious injury. With the passage of a restraint use law and subsequent high levels of restraint use among this population of children, the expectation would be a substantial reduction in the number of children seen in the emergency rooms with this history. And, in fact, as demonstrated by this study, a major impact of the Child Passenger Safety law has been a significant decrease in the number of children treated in the emergency rooms for noncrash related injuries.

IV. OVERALL EFFECTS OF LEGISLATION ON EMERGENCY ROOM USE

In the foregoing analyses, crash and noncrash cases were kept separate in order not to introduce misinterpretations of the data. Yet the combination of crash and noncrash cases represents the total number of children treated in the emergency rooms following motor vehicle accidents. In this final section, we will re-address the issue of changes in utilization rates of emergency room services.

Table 12 shows the combined crash and noncrash case distributions for the pre- and post-legislation periods. Once crash and noncrash cases are combined, we observe a 1% decrease in the post-legislation period in the use of emergency room services for the under 4 year olds and an 18% increase in the number of 4-14 year olds for the same time period. This translates into 56 fewer under 4 year olds than would have been expected.

Table 12 About Here

While at first glance, this may appear a fairly small number of under 4 year olds, it should be emphasized that this total represents only a single County. This County represents approximately 8% of the State of California's population. Over the entire State, we could grossly estimate a decrease in 700 cases of children less than 4 years of age seen in the emergency rooms and a rough estimate of 7,000 cases nation-wide. This decrease was seen during a period of time when the population of under 4 year olds in the County actually increased. Hence, these estimates would be on the low side in terms of a decrease in the number of children seen in the emergency rooms.

TABLE 12. TOTAL NUMBER OF MOTOR VEHICLE ACCIDENT CASES BEFORE AND AFTER ENACTMENT OF THE LAW

	Under Four Years of Age			Four Years and Over		
	Two Years Pre-Law	Two Years Post-Law	Percent change	Two Years Pre-Law	Two Years Post-Law	Percent Change
Total crash cases	242	269	+11%	511	594	+16%
Total noncrash cases	51	21	-59%	27	42	+56%
Total motor vehicle accident cases	293	290	- 1%	538	636	+18%

CHAPTER 4

TRAUMA PATTERNS OF RESTRAINED CHILDREN LESS THAN FOUR YEARS OF AGE

While a sample of cases from a hospital monitoring system is inappropriate for the calculation of restraint utilization rates, such a sample can provide insight into the types of trauma sustained by children injured in motor vehicle crashes who were restrained at the time of the accident. How or why restrained children sustain injury and what kinds of injuries are sustained are important questions well suited to data obtained from a hospital emergency room monitoring system. In this chapter, attention will be directed towards the analysis of the injuries of the restrained pediatric trauma victim.

The major portion of this chapter will be devoted to the analysis of a sample of restrained under 4 year old children collected over a four year period (1981-1984). The chapter is divided into three sections. In order to provide the context of restraint usage patterns during this period of time, Section 1 will present the distribution of restraint use pre- and post-legislation. While it is interesting to note what changes have occurred in restraint usage and while the data from the hospital monitoring system is most likely reflective of the larger community restraint use patterns, it must be emphasized that this sample does not represent under four year old travel patterns in Orange County. Section 2 will focus on the injuries to children who were in child safety seats (CSS), with particular attention directed towards the role of improper use of child safety seats in sustaining injuries. In Section 3, injuries to seat-belted under 4 year olds will be described. It should be noted at the outset that no attempt will be made to compare or contrast the degree of severity or the types of

injuries of variously restrained under 4 year olds. The intention of this chapter is mainly to identify patterns and severity of injury of restrained children and factors associated with the restraint systems which may have contributed to the injuries. The total number of cases precludes statistical testing for various features of the accident or for each type of restraint use identified.

I. CHANGES IN TRAVEL PATTERNS (1981-1984)

Five hundred and eleven child passengers under the age of 4 years were seen in the 9 hospital emergency rooms during the study period, 1981-1984. A total of 38% were traveling restrained in the motor vehicle at the time of the accident; 29% were using a CSS, while 9% were restrained with a vehicle seat belt. The remaining 62% were unrestrained, either sitting on the lap of another passenger or sitting alone without any type of restraint. (Table 1) The distribution pre- and post-legislation indicates that restraint use increased dramatically after enactment of the law. At an aggregate level, the increased restraint use resulted in a drop both in on-lap travel as well as the totally unrestrained mode of travel.

Table 1 About Here

The distribution of restraint use by age of child, presented in Table 2, describes the types of restraint use for infants, toddlers, and preschool children as well as the changes that occurred. Overall, child safety seat utilization was highest among those less than two years of age while seat belt use was more common with the 2 and 3 year olds. Only in the post-legislation period did the percent of restraint use exceed 50% and it was only apparent among those children under two years of age. On-lap travel, overall, predominated in the under two year old age groups. In the case of

TABLE 1. COMPARISON OF MODES OF TRAVEL TWO YEARS BEFORE THE LAW AND TWO YEARS AFTER ENACTMENT OF THE LAW

	Under Four Years of Age		
Mode of Travel	Two Years Pre-Law (N=242)	Two Years Post-Law (N=269)	Total (N=511)
Child Safety Seat	19%	39%	29%
Seat Belt	7%	11%	9%
On-lap of another passenger	24%	14%	19%
Alone	50%	35%	42%

$X^2(p) = 0.0000$[a]

[a] statistical significance level for chi-square test

the under one year olds, a dramatic decrease in on-lap travel was observed in the post-legislation period.

Table 2 About Here

II. CHILD SAFETY SEATS

Over the 4 year monitoring period, there were a total of 150 cases of under 4 year olds who were reported to be in child safety seats at the time of the motor vehicle accident and who were subsequently brought to the emergency room for medical evaluation. Of particular importance in this sample of restrained children is the issue of whether or not the child safety seat was properly used and the effect this may have had on the injuries sustained by the child. A body of research has indicated that improper use of the child safety seat is not a trivial matter and may not provide adequate protection to the child in a vehicle accident, or may in fact contribute to the injury of the child (Weber and Melvin, 1984; Kelleher et al., 1983).

During the period of this study there were approximately 30 different kinds of CSS's available to parents in Southern California, many of which required different instructions for proper installation and use. In a monitoring system utilizing a questionnaire design, it is not possible to obtain specific information regarding all potential types of improper use of the CSS's. However, there are some modes of improper use which are consistent across the different models. The questionnaire was designed to elicit information regarding these dominant improper uses. Consequently, improper use criteria utilized in this monitoring system involved the following criteria:

1. Proper positioning of the CSS, namely, up to the age of 10 mos.,

TABLE 2. COMPARISON OF MODES OF TRAVEL TWO YEARS BEFORE THE LAW AND TWO YEARS AFTER ENACTMENT OF THE LAW: BY AGE CATEGORY

Mode of Travel	Two Years Pre-Law	Two Years Post-Law	Total (N=140)
UNDER ONE YEAR OF AGE	(N=71)	(N=69)	(N=140)
Child Safety Seat	30%	59%	44%
Seat Belt	-	-	-
On-lap of another passenger	45%	26%	36%
Alone	25%	14%	20%
	$X^2(p) = 0.0018$[a]		
ONE YEAR OF AGE	(N=60)	(N=64)	(N=124)
Child Safety Seat	27%	52%	40%
Seat Belt	7%	6%	6%
On-lap of another passenger	27%	17%	22%
Alone	40%	25%	32%
	$X^2(p) = 0.0401$[a]		
TWO YEARS OF AGE	(N=57)	(N=64)	(N=121)
Child Safety Seat	12%	30%	22%
Seat Belt	10%	16%	13%
On-lap of another passenger	14%	3%	8%
Alone	63%	52%	57%
	$X^2(p) = 0.0195$[a]		
THREE YEARS OF AGE	(N=54)	(N=72)	(N=126)
Child Safety Seat	2%	17%	10%
Seat Belt	15%	22%	19%
On-lap of another passenger	6%	11%	9%
Alone	78%	50%	62%
	$X^2(p) = 0.0062$[a]		

[a] statistical significance level for chi-square test

the CSS should be placed in a rearward facing position, while after 10 mos. of age, it should be placed in a forward position.

2. Securement of the CSS with the vehicle seat belt.
3. Securement of the child in the restraint harness.
4. Use of a top anchor strap when required by the CSS.

In addition to the above information, we also elicited information from the parents regarding what had happened to the child and the CSS at the time of the accident (e.g., did the CSS tip over, did the child fall out?). All CSS cases were reviewed by members of the research team and were assigned to one of three categories of use: proper, improper, or indeterminate, i.e., not enough information to categorize. Specific types of improper use were also categorized based on the review of all of the criteria.

In Table 3 is the distribution of modes of CSS use. Based on the criteria for improper use, 49% were classified as properly used, 31% were classified as improperly used, and 20% of the cases had insufficient information to be classified. With respect to the 46 cases of improper use, the most common modes of improper use were failure to secure the CSS into the vehicle seat belt (19 instances) and failure to secure the top anchor when required (18 instances).

Table 3 About Here

With most types of improper use the CSS simply did not adequately protect the child and allowed the child to strike against an interior portion of the vehicle. In Table 4, the mechanism of injury for those children improperly secured in a child safety seat is displayed by the type of improper use. It is particularly apparent that the failure to secure the CSS with the vehicle seat belt affords at best only minimal protection to the child. Even though the child is secured in the CSS, the child and CSS

TABLE 3. MODES OF RESTRAINT USE OF RESTRAINED UNDER FOUR YEAR OLDS
N = 150

Properly Used Child Safety Seat		49% (73)
Improperly Used Child Safety Seat		31% (46)
Top anchor not secured	12	
Seat belt not secured	7	
Improper position	4	
Harness loose	6	
Top anchor and seat belt not secured	3	
Harness and seat belt not secured	3	
Top anchor secured but no seat belt	3	
Seat belt loose	3	
Seat positioned too low	1	
Nonapproved carrier	2	
No harness and improper position	1	
Indeterminate	1	
Subtotal	46	
Unknown How Child Safety Seat Used		20% (31)
TOTAL		100% (150)

are free to move in the direction dictated by the force of the impact in the crash even to the extent of being propelled from a back seat location to a front seat location. On the other hand, the failure to secure a top anchor strap did not appear to contribute to the child's injury in this sample of cases. In only 2 of the 12 cases in which a top anchor strap was not used was the child injured through contact with the vehicle interior. In contrast, in 6 of the 10 cases in which a seat belt was not used, the child was injured through contact with the vehicle interior. Loose securement of the CSS into the vehicle with the seat belt or loosely harnassing the child into the CSS also provided little protection from interior impact. In 6 of the 12 cases of inadequate use of the restraint, the child struck against some portion of the vehicle.

Table 4 About Here

In the case of properly used child safety seats, the mechanism of injury for those children who were medically determined to be injured was primarily confined to straining against the harness of the child safety seat or being hit by flying glass. Table 5 provides a list of the mechanisms of injury for the properly restrained children.

Table 5 About Here

While mechanism of injury indicates that there are differences between those children in properly used CSS's as compared with children in improperly used CSS's, of more importance, is the question of whether these differences translate into trauma differences. Injury severity by proper versus improper use of a CSS is presented in Table 6. Approximately two-thirds of those properly restrained escaped injury and only one-third sustained any type of injury. Only 2 children received more than a minor injury. In contrast, among those improperly restrained within a CSS, less than one-

TABLE 4. MECHANISM OF INJURY FOR UNDER FOUR YEAR OLDS IN IMPROPERLY USED CHILD SAFETY SEATS N=46.

IMPROPERLY USED CHILD SAFETY SEAT	
No seat belt:	
No injury sustained	3
Flew from back seat to front seat and hit the dashboard	1
Struck against the back of the front seat	1
Fell to the floor of the vehicle	1
Struck against the door of the vehicle	1
Struck by flying glass	1
Miscellaneous (hit table in van)	1
Not ascertained-interior impact	1
Restraint inadequate, e.g., loose harness, seat belt, etc.	
No injury sustained	2
Hit against the front of the vehicle	3
Struck against the back of the front seat	1
Fell to the floor of the vehicle	1
Strained against the CSS	4
Not ascertained-interior impact	1
Improper positioning of CSS	
No injury sustained	2
Hit against the front of the vehicle	1
Struck against the back of the front seat	1
Strained against the CSS	1
No top anchor	
No injury sustained	6
Loose object in vehicle; child's toy hit against the child	2
Strained against the CSS	2
Not ascertained-interior impact	2
Multiple modes of improper use, e.g., no harness and improper positioning	
No injury sustained	1
Hit against the front of the vehicle	2
Struck against the back of the front seat	2
Non-approved carrier	
No injury sustained	1
Strained against restraint	1

TABLE 5. MECHANISM OF INJURY FOR UNDER FOUR YEAR OLDS IN PROPERLY USED CHILD SAFETY SEATS N=73.

PROPERLY USED CHILD SAFETY SEAT

No injury sustained	47
"Whiplash"	1
Hit against front of the vehicle	1
Hit by another passenger	2
Hit by flying glass in the vehicle	9
Hit by portion of vehicle intruding inwards (vehicle deformation)	2
Strained against the CSS	11

third were uninjured; approximately two-thirds sustained a minor injury. This is almost the reverse of what was seen among the properly restrained children. The potential for injury if improperly restrained is greater than that observed among the properly restrained children. To provide further elaboration of these differences, Table 7 provides a listing of the specific injuries sustained by the children with respect to the mode of child safety seat use. The primary type of injury sustained by all CSS children is that of contusions and lacerations, primarily to the head and face. More of the serious head injuries were found in the classifications of improper use and indeterminate use.

Tables 6 and 7 About Here

In summary, this highly descriptive view of the child safety seat cases provides some evidence that improper use diminishes the protectiveness of this type of restraint for the under four year old. As a final means of underscoring the effects of improper use of a CSS, Table 8 provides short case descriptions of all CSS restrained children who received MAIS 2 or greater injuries. The serious injuries sustained by the two children who were properly restrained in a CSS were the result of other factors in the crash situation, e.g., flying glass and intrusion of the roof onto the child in the safety seat. The more seriously injured children who were improperly restrained in the child safety seats predominantly sustained their injuries through contact with the vehicle interior.

Table 8 About Here

III. SEAT-BELTED

Seat belt use by specific age among under four year olds was previously presented in Table 2. Seat belt use increased with increasing age. No

TABLE 6. SEVERITY OF INJURY BY MODE OF CSS USE

	Restraint Use of Child		
Severity of Injury	CSS proper use	CSS improper use	CSS unknown use
Uninjured	65% (47)	33% (15)	58% (18)
Minor (MAIS-1)	33% (24)	61% (28)	32% (10)
Moderate (MAIS-2,3)	1% (1)	6% (3)	7% (2)
Severe (MAIS-4,5,6)	1% (1)		3% (1)
Total	100% (73)	100% (46)	100% (31)

TABLE 7. SPECIFIC INJURIES FOR MODES OF CHILD SAFETY SEAT USE

PROPERLY USED CHILD SAFETY SEAT		(N=73)
Uninjured	47	
Head, contusions/abrasions	13	
Head, lacerations	6	
Leg, contusions/abrasions	2	
Head and arm, contusions/abrasions	2	
Head and arm, lacerations	1	
Cervical strain	1	
Diffuse brain injury	1	
IMPROPERLY USED CHILD SAFETY SEAT		(N=46)
Uninjured	15	
Head, contusions/abrasions	23	
Head, lacerations	3	
Arm, contusions/abrasions	2	
Head lacerations and leg abrasion	1	
Compound skull fracture	1	
Cerebral injury involving sub-arachnoid hemorrhage, leg abrasions	1	
INDETERMINATE USE OF CHILD SAFETY SEAT		(N=31)
Uninjured	18	
Head, contusions/abrasions	9	
Head, lacerations	1	
Clavicle fracture	1	
Cerebral contusion and head laceration	1	
Basilar fracture, skull fracture, maxilla fracture, orbit fracture, spleen rupture, ankle fracture	1	

TABLE 8. CASE DATA FOR CSS RESTRAINED CHILDREN WITH MAXIMUM ABBREVIATED INJURY (MAIS) SCORE OF 2 OR GREATER

AGE	RESTRAINT	SEAT LOCATION	IMPACT	MECHANISM	INJURIES	MAIS
14 mos	CSS/proper	Front passenger	Passenger side	Flying glass	Multiple deep facial lacerations	2
17 mos	CSS/proper	Rear driver	Rollover	Intrusion of roof	Diffuse brain injury	5[a]
2 yr	CSS/improper	Front passenger	Front	Hit table in van	3-in forehead laceration	2
6 mo	CSS/improper	Rear passenger	Passenger side	Hit by loose stereo speaker	Depressed skull fracture	3
2 yr	CSS/improper	Rear driver	Front	Hit back of seat and another passenger	Subarachnoid hemorrhage, occipital skull fracture, hematoma to forehead and legs	3
3 yr	CSS/unknown	Back seat	Driver side	Fell to floor	Fractured clavicle	2
6 mo[b]	CSS/unknown	Front passenger	Driver side	Unknown	Cerebrum contusion and deep laceration to head	3
2 yr[c]	CSS/unknown	Unknown	Front	Unknown	Basilar skull fracture, right parietal skull fracture, bilateral orbit fracture, maxillary fracture, ruptured spleen, ankle fracture	4

[a] fatality

[b] Details regarding restraint use and mechanism of injury unknown since driver (only adult in vehicle) was killed

[c] Details regarding restraint use, mechanism of injury, seat location unknown since driver (only adult in vehicle) and 3 older children were killed.

child less than one year of age was using a seat belt at the time of the accident. Six percent of the one years olds, 13% of the two year olds, and 19% of those three years of age were using seat belts. With the increased use of seat belts by children under the age of 4 in the post-legislation period, the issue regarding the protectiveness of this type of restraint for young children becomes important.

As can be seen in Table 9, the primary mechanism of injury among the under four year olds restrained by a vehicle seat belt was impact with an interior portion of the vehicle. Of the 39 cases of seat belted children, 18 were injured by hitting against a portion of the vehicle interior. Compared to proper restraint in a CSS, there is increased mobility of all body parts, and in particular, the upper torso and head when an infant or toddler is restrained by a seat belt. This increased mobility most likely predisposes the child to striking an interior area of the vehicle.

Table 9 About Here

Almost one-third of the seat belted under 4 year olds were medically confirmed to be uninjured. Sixty percent sustained a minor injury, similar to the percent seen among those improperly restrained in a CSS. Ten percent sustained moderate to severe injuries. (See Table 10.) In Table 11 are detailed the specific injuries sustained by the seat-belted children. Head contusions/abrasions predominated; however, some children did sustain serious head injuries. It is also noteworthy that in contrast to the specific injuries sustained by the CSS children, several of the seat belted children sustained abdominal contusions and abrasions which indicate that the seat belt most likely was improperly lying over the child's abdomen at the time of the accident.

Tables 10 and 11 About Here

TABLE 9. MECHANISM OF INJURY FOR SEAT-BELTED UNDER FOUR YEAR OLDS
N=48

Mechanisms of Injury	
No injury sustained	14
"Whiplash"	3
Hit against front of the vehicle	11
Struck against back of the front seat	2
Fell to the floor	2
Hit against the door of the vehicle	2
Hit the roof of the vehicle	1
Struck by flying glass	2
Hit by portion of vehicle intruding inwards (vehicle deformation)	1
Strained against the seat belt	2
Strained against the seat belt and and hit interior portion of vehicle	1
Miscellaneous interior impacts	3
Not ascertained	4

TABLE 10. SEVERITY OF INJURY FOR SEAT-BELTED UNDER FOUR YEAR OLDS

Severity of Injury	
Uninjured	29% (14)
Minor (MAIS-1)	61% (29)
Moderate (MAIS-2,3)	8% (4)
Severe (MAIS-4,5,6)	2% (1)
Total	100% (48)

TABLE 11. SPECIFIC INJURIES OF SEAT-BELTED UNDER FOUR YEAR OLDS
N=48

Specific Injuries	
Uninjured	14
Head, contusions/abrasions	16
Head, lacerations	1
Abdomen, contusions/abrasions	3
Arm, contusions/abrasions	1
Leg, contusions/abrasions	1
Head and hip, contusions/abrasions	1
Head and leg, contusions/abrasions	4
Head and arm, lacerations	1
Cervical strain	3
Cerebral concussion, head laceration	1
Compound skull fracture	1
Brain stem contusion, depressed skull fracture, brain contusion	1

The seat-belted children who sustained serious injuries are listed in Table 12. A side impact collision which resulted in intrusion of the vehicle into the child caused a serious brain stem contusion in one child. Increased mobility allowing impact with the vehicle door resulted in another serious head injury. There were two cases in which an under 4 year old shared a seat belt with an older child; serious injuries were sustained in both cases. However, the extremely small overall number of cases of children sharing seat belts or injured in lateral impacts precludes making any generalized conclusions regarding the protectiveness of seat belts in either of these situations.

Table 12 About Here

IV. SUMMARY

In summary, proper use of a child restraint system was not the norm in this sample of children evaluated and treated in an emergency room following involvement in a motor vehicle accident. However, if properly restrained, there was a high probability that the child did not sustain any injuries. And if injured, the child generally sustained only a minor injury. Among those children improperly restrained in a CSS, there was a greater likelihood of the child being injured; however, most still received only minor injuries. This pattern also was found among those children using a seat belt. Use of a seat belt or even, in some cases, an improperly used CSS did in many situations provide a degree of protection. However, some restrained children did sustain serious injuries. Some of these were caused by what could be categorized as unavoidable circumstances. Other children, however, were injured because the child restraint was improperly used. And with the seat belted children, some were injured because the vehicle seat belt was

TABLE 12. CASE DATA FOR SEAT BELTED CHILDREN WITH MAXIMUM ABBREVIATED INJURY (MAIS) SCORE OF 2 OR GREATER

AGE	RESTRAINT	SEAT LOCATION	IMPACT	MECHANISM	INJURIES	MAIS
17 mo	Seat belt	Rear passenger	Front	Hit door	Large frontal hematoma	2
3 yr[a]	Lap belt	Back seat	Front and driver's side	Unknown	Concussion, deep head laceration	2
2½ yr	Seat belt	Front passenger	Passenger side	Intrusion	Brainstem contusion, depressed skull fracture	5
3 yr	Shared seat belt	Front passenger	Front	Seat belt and unknown impact site	Large abdominal contusion, minor head contusion	2
2½ yr	Shared seat belt	Front passenger	Passenger	Hit dash-board	Depressed skull fracture	3

[a] Details regarding restraint use and mechanism of injury unknown since driver (only adult in vehicle) was killed

not able to adequately hold the young child in place. Attention needs to be directed towards increasing proper use of CSS's among those children less than 4 years of age since this means of protection is the most effective currently available.

CHAPTER 5

SUMMARY AND CONCLUSIONS

A number of studies have found that mandatory child passenger safety laws, when enforced, are effective in reducing the overall number of injuries and fatalities for the legislated population (Hall and Daniel, 1983; Decker et al., 1984; Montague, 1984; Wagenaar and Webster, 1985; Guerin and MacKinnon, 1985). However, the effects of mandatory restraint use legislation on injury patterns and severity of injury or on the health care delivery system in terms of utilization rates have not been addressed.

This study was designed to examine the effects of a mandatory restraint use law on trauma patterns and severity of injury of pediatric motor vehicle accident victims who were evaluated and treated in hospital emergency rooms in Orange County, California. The impact of the California Child Passenger Safety Act was analyzed in terms of 1) changes in injury patterns and injury severity measures; 2) changes in frequency and severity of head injuries, (the most common anatomic area of injury for children); 3) changes in the number of noncrash injured children; and 4) changes in utilization of emergency rooms by young children. Descriptive analyses of the mechanisms of injury and trauma patterns of restrained under four year olds who were injured were also done.

In this chapter, the major findings from this study will be presented. It should be re-emphasized that the conclusions noted below focus solely on children evaluated in a hospital emergency room setting. All children were passengers involved in motor vehicle accidents and were presumed to be injured in the accident.

I. FINDINGS

Restraint use significantly increased in the sample of under four year olds in the hospital monitoring system following enactment of the law. In the context of the emergency room setting, a major change in restraint use among children less than 4 years coming for evaluation of injuries secondary to involvement in a motor vehicle crash was observed. The percent of restrained under four year olds significantly increased from 26% in the two years before the law to 50% in the two year period following enactment of the law. With this sample of under four year olds, this 50% restraint usage rate did appear to have a measurable impact on trauma.

A significantly higher proportion of under four year olds were medically determined to be uninjured after enactment of the mandatory restraint legislation. The percent of uninjured under 4 year olds significantly increased from a pre-legislation baseline of 30% to 42% uninjured in the post-law period. While the phenomenon of the uninjured young child coming to an emergency room for evaluation following a motor vehicle crash was apparent even in the pre-legislation period, the analysis indicated that restraint use rather than a rise in parental concern was a factor in the increase in uninjured in the post-legislative period.

While there was an increase in uninjured under four year olds evaluated in hospital emergency rooms, no significant change was seen in the frequency of those sustaining serious or critical injuries. The majority of injuries among children in both the pre- and post-legislation periods were in the minor and moderate injury severity categories. Few serious injuries were observed in the under four year olds in either the pre- or post-legislation period of time. In general, the major change observed in the hospital emergency rooms was a decrease in the number of children medically

determined to have sustained minor and moderate injuries and an increase in the number of children medically determined to be uninjured. The increase in restraint use appears to have had its major effect in shifting injuries from minor and moderate severity categories to the category of 'no injury'. There appeared to be little effect on the reduction of the more serious injuries.

In the two years following implementation of the child passenger safety law, a significant reduction in the number of head injuries was documented in the children less than 4 years of age. It has been well established that head trauma in motor vehicle accidents is a significant cause of mortality and a major cause of neurologic impairment both of a permanent and, in some cases, of a transient nature. In the case of children, even minor head trauma has been found to result in neuropsychological sequelae, including learning disorders and attention deficits. Therefore, it is important to consider the impact of the legislation on head injuries. In this sample, injuries to the head and face area predominated in all age groups. However, the analysis did indicate that there was a 16% reduction in the number of under four year olds who sustained head injuries in the post-legislation period. There was no change in the number of head injuries among those not covered by the law.

While head injuries decreased for the under four year olds in the post-legislation period, there was no accompanying increase in injuries to other body areas. In the pre- and post-legislation periods of time and among both restrained and unrestrained children, head injuries were the most common body area of injury. Although there was a reduction in head injuries in the post-legislation period, this reduction was not associated with an increase in injuries to other body areas. The major change in trauma

pattern for the under four year olds in the post-law period was from head injury to no injury rather than from head injury to injury to another body area.

Utilization rates of hospital emergency rooms for under four year olds involved in motor vehicle crashes did not decrease significantly after enactment of the law. While there was a significant increase in those who were not injured, emergency room use did not substantially decrease. For the young child it appears to be the norm for the parent/guardian to bring the child in to the emergency room to be checked following involvement in a motor vehicle accident, even in the absence of a visible injury. Children in this age cohort are less verbal regarding their injuries and parents are more likely to take a conservative approach and have the child medically examined. Restraint use does not appear to have altered this behavior. This finding indicates that mandatory restraint legislation is unlikely to dramatically reduce emergency room use among very young children involved in motor vehicle crashes.

Utilization rates of hospital emergency rooms for under four year olds involved in motor vehicle noncrashes, however, did decrease significantly after enactment of the law. In a noncrash accident, the child is injured as a result of sudden stops, swerves, loss of balance or falling out of the vehicle in the absence of vehicle impact with another vehicle or object. Unrestrained under 4 year olds are particularly prone to noncrash accidents because they can easily lose their balance in the vehicle or, because of their level of cognitive development, they may be more likely to open a door in a moving vehicle or lean against an improperly latched vehicle door. A dramatic decrease in noncrash cases was seen in the post-law period. In the two years prior to the enactment of the law, 17% of under four year olds

involved in motor vehicle accidents and evaluated in the emergency rooms had been involved in noncrash accidents. In the two years after the enactment of the law, only 7% were involved in noncrash accidents. In addition, no child who sustained a noncrash injury was properly restrained in a CSS at the time of the accident. With increased restraint use as a result of legislation, the expectation is the eventual near elimination of noncrash injuries.

Mortality data is not especially helpful when examining the impact of a restraint use law for children. The number of fatally injured children according to overall injury statistics is quite small. The overwhelming majority of children who are involved in car crashes are not fatally injured. Among those who do receive fatal injuries, the circumstances are generally complex: 1) the crashes are generally quite severe, 2) the injuries can often be regarded as unavoidable irrespective of restraint use, 3) the fatal outcome may be related to the type of emergency care rendered at the scene, transport to the hospital, and the emergency treatment provided. In this sample of emergency room treated children, there was no significant change in the number of fatalities.

II. EXPECTATIONS

With increased restraint use mandated by law, the expectation is that emergency room utilization for motor vehicle related trauma will decrease. As more individuals travel restrained, injuries will decrease and emergency medical care will not be required. However, analysis of the data for children covered by this type of law in a single urban county, indicate that this expectation will probably never be met to the extent anticipated, especially with young children. Even with a decrease in the total number of

children injured, a decrease in serious head injuries, and a dramatic decrease in the number of noncrash injured children, a marked reduction in hospital emergency room utilization for the under four year olds was not realized. A major countervailing force is that of parental concern for this age group who cannot verbalize the extent of their injury or non-injury. And, the 'well baby check' is a positively encouraged normative behavior for parents of very young children. Even if the child is properly restrained, a parent may take the infant or toddler in 'just to be checked'. Consequently, the sheer number of medically evaluated under four year olds will not dramatically change with the advent of increased restraint use nor will the medical costs associated with treatment be reduced to the extent expected.

On the other hand, noncrash cases in the under four year old age group dramatically decreased and we would expect this trend to continue as restraint use increases. The reason for dramatic reductions in noncrash cases relates directly to the increased restraint use. The risk of injury in a noncrash event is primarily a function of the failure of the child occupant to be restrained. A restrained child has little likelihood of being injured in a noncrash situation by virtue of the fact that the restraint actually prevents certain behaviors. For example, a restrained child cannot fall out of the vehicle nor can a restrained child fly from the back to the front seat in a sudden stop. The effects of restraint use on noncrash injuries were apparent and we would expect that there will be fewer noncrash injuries as restraint use increases.

Based on the analyses performed in this study we also conclude that injury reduction in motor vehicle crashes can be maximized by increased proper use of age appropriate restraints. However, the currently available restraint use technology, even in the face of 100% use, will not totally

eliminate injuries in motor vehicle crashes. As has been documented in this study, trauma can occur even in the face of proper restraint use. A certain degree of mobility is allowed even with proper use of the CSS. This is particularly noted with respect to the head of the child which can hit against the side of the restraint itself. Seat belts also allow some lateral movement of the body and, in the case of lap only belts, jackknifing over the belt. Such movements can cause head injuries if there is impact with the vehicle interior or abdominal injuries from loading against the belt. In the case of severe crashes, injuries can occur which are unavoidable and unrelated to the use of a restraint, e.g., intrusion into the passenger compartment from lateral impacts, or flying glass in the vehicle. Additional technologies in the areas of restraint systems and vehicle designs will have to be instituted in order to further reduce death and injury.

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INJURIES TO CHILDREN IN MOTOR VEHICLES
PUBLIC POLICY RESEARCH ORGANIZATION
UNIVERSITY OF CALIFORNIA, IRVINE

Name of Facility _____ Patient ID No._____

Child's Name _____ Parent's Name _____

Phone Number _____

WE ARE CONDUCTING A STUDY ON THE EFFECTS OF INJURIES TO CHILDREN IN MOTOR VEHICLES. WE UNDERSTAND THAT THIS IS A DIFFICULT TIME TO ASK FOR YOUR HELP BUT IT WOULD BE VERY USEFUL IF YOU COULD TAKE SOME TIME AND ANSWER THESE QUESTIONS. THIS IS PART OF A COUNTY-WIDE SURVEY OF MOTOR VEHICLE INJURIES TO CHILDREN CONDUCTED BY THE UCIMC DEPARTMENT OF PEDIATRICS AND THE PUBLIC POLICY RESEARCH ORGANIZATION OF THE UNIVERSITY OF CALIFORNIA, IRVINE. THE STUDY IS SUPPORTED BY A FEDERAL GRANT FROM THE DEPARTMENT OF TRANSPORTATION [DOT]. ALL INFORMATION IS CONFIDENTIAL. PLEASE SIGN THE CONSENT FORM BELOW BECAUSE IT WILL BE NECESSARY FOR OUR STUDY TO LOOK AT YOUR CHILD'S MEDICAL RECORD REGARDING THE TREATMENT OF THE INJURIES FROM THE ACCIDENT.

UNIVERSITY OF CALIFORNIA IRVINE COLLEGE OF MEDICINE HSM 79-191

CONSENT TO ACT AS A HUMAN RESEARCH SUBJECT
'INJURIES TO CHILDREN IN MOTOR VEHICLE INCIDENTS'

Phyllis F. Agran, M D., M.P.H and Debora E. Dunkle, Ph.D.
714/856-5371

I, _____ ,have been asked to participate in a research study conducted by Dr P Agran, which is designed to identify children involved in motor vehicle accidents and to learn about the injuries they sustain as a result of these accidents.

I understand that the results of this study will assist in the development of public policies aimed at preventing injuries to children in motor vehicle accidents. I understand that my participation in this study will require approximately ten minutes of my time. I shall be asked questions relating to the motor vehicle accident in which my child was involved I may be called by telephone at a later time for additional information. The injuries incurred by my child and the treament rendered will be obtained from the medical record

I understand that there is no health or medical risk involved in answering these questions. My participation will in no way interfere with the physician in the proper evaluation of my child; in fact, the information will assist the physician I understand I can refuse to answer any question(s) and/or withdraw from this study at any time without jeopardy to my/our child's future medical care or entitlements.

If I have questions or comments regarding the research study, I may ask Dr. P. Agran or her assistants to answer them [714/856-5371].

With the understanding that my identity and the information I provide will remain confidential to the extent provided by law, I give permission for the investigators to use information obtained from this study to advance medical knowledge.

Signature of Parent(s) _____ *Date*_____

Signature of Witness _____ *Date*_____

TO BE COMPLETED FOR ANY CHILD UP TO 15 YEARS OLD INJURED IN A MOTOR VEHICLE

For Office Use Record 1

Patient Birthdate ___/___/___ (mo day yr) Patient Sex [circle one]: male female _____[13-18] _____[19]

Date of visit ___/___/___ (mo day yr) Time of visit _____(circle) A.M. or P.M. _____[20-25] _____[26-27]

Date of accident ___/___/___ (mo day yr) Time of Accident _____(circle) A.M. or P.M. _____[28-33]

_____[34-35]

1. TYPE OF MOTOR VEHICLE IN WHICH THE CHILD WAS INJURED: [CIRCLE ONE ITEM]

01.	*Two door car*	*04.*	*Stationwagon*	*07.*	*Camper*
02.	*Four door car*	*05.*	*Van*	*08.*	*Jeep*
03.	*Car [unspecified]*	*06.*	*Truck*	*09.*	*Other [specify]*

_____[36-37] _____[38-41] _____[42-43]

Indicate: Make:_____ Model: _____ Year:____ _____[44-45]

2. LOCATION OF ACCIDENT [Circle One Item]

1.	*Surface street*	*5.*	*Parking lot*
2.	*Rural highway*	*6.*	*Driveway*
3.	*Freeway*	*7.*	*Other [please describe]*
4.	On/off ramp of freeway		_____

_____[46]

Accident occurred at [streets,city]_____

3. SPEED OF YOUR VEHICLE PRIOR TO ACCIDENT [Enter Estimated MPH] ___/___ _____[47-48]

4. CAUSE OF ACCIDENT: [Circle One Item From Either Crash Or Noncrash List]

CRASH [Your vehicle was damaged]

01. Your vehicle hit another vehicle
02. Your vehicle was hit by another vehicle
03. Your vehicle hit an object, such as a stop sign, pole, tree, etc.
04. Your vehicle rolled over
05. Your vehicle tipped over
06. Crash [unspecified]

NONCRASH [Vehicle not damaged]

07. Sudden acceleration
08. Sudden stop
09. Turn
10. Swerve
11. Door opened
12. Door opened during a turn
13. Child opened the door
14. Child lost balance
15. Noncrash [unspecified]

16. Other [specify] _____ _____[49-50] _____[51]

5. WHERE WAS YOUR CAR HIT? [Circle All That Apply]

1.	*In the front*	*5.*	*In the back*
2.	*On passenger's side*	*6.*	*Rollover*
3.	*On driver's side*	*7.*	*Not hit*
4.	*On the side [unspecified]*	*8.*	*Other [specify]* _____

_____ _____ _____ _____ _____ _____ _____[58]

6. WHERE WAS YOUR CHILD LOCATED IN THE VEHICLE? [Circle one item]

FRONT SEAT

01. Driver's side
02. In the middle
03. Passenger's side
04. Unspecified

BACK SEAT

05. Driver's side
06. In the middle
07. Passenger's side
05. Unspecified

OTHER AREAS

09. Luggage area
10. Shell of camper
11. Back of van
12. Back of truck
13. On hood, trunk, bumper, etc.

14. Other [specify] _____ _____[59-60]

For Office Use Record 2

7. WHAT HAPPENED TO THE CHILD TO CAUSE THE INJURIES?

A. WAS YOUR CHILD EJECTED FROM THE VEHICLE — *Yes* *No*

B. IF CHILD EJECTED; DID THE CHILD FALL OUT OF VEHICLE OR WAS THE CHILD THROWN OUT? — *Fall* *Thrown* [8]

C. WAS YOUR CHILD THROWN FROM BACK SEAT INTO THE FRONT SEAT? — *Yes* *No*

D. DID YOUR CHILD HIT ANOTHER PASSENGER? — *Yes* *No* [13]

E. DID YOUR CHILD RECEIVE A WHIPLASH INJURY? — *Yes* *No*

F. DID YOUR CHILD HIT ANY OF THE FOLLOWING PORTIONS OF THE VEHICLE? [Circle all that apply]

01.	*Dashboard*	*05.*	*Windshield*	*09.*	*Roof*
02.	*Gear shift*	*06.*	*Rear view mirror*	*10.*	*Back of the truck bed*
03.	*Door/side window*	*07.*	*Steering wheel*	*11.*	*Back of van/camper*
04.	*Back of front seat*	*08.*	*Floor*	*12.*	*Other [specify]*_____

G. WAS YOUR CHILD HIT BY ANY OF THE FOLLOWING? [Circle all that apply]

1. Object such as a pole or another car intruding into the car? — *Yes* *No* [25]
2. Flying glass? — *Yes* *No*
3. Loose objects in the car? [specify] _____ — *Yes* *No*

8. WAS YOUR CHILD TRANSPORTED TO THE HOSPITAL BY AMBULANCE OR PARAMEDIC? — *Yes* *No*

9. WERE POLICE AT THE SCENE OF THE ACCIDENT? — *Yes* *No*

10. HOW MANY OTHER PASSENGERS WERE IN VEHICLE WHEN THE ACCIDENT OCCURRED? [Enter Number For Each Category] [30-31]

Total number of people in the car = ___ [32-33]
Total number of people under 15 yrs = ___ [34-35]
Total people injured = ___
Total people injured under 15 years = ___ [36-37]

11. AT THE TIME OF THE ACCIDENT WAS YOUR CHILD; [Circle one item] [38-39]

01. Sitting alone [unrestrained]
02. Standing alone [unrestrained]
03. In the arms or lap of another passenger
04. Lying down
05. Wearing a lap seat belt
06. Wearing a lap-shoulder seat belt
07. In a child restraint seat
08. In a booster seat
09. Other [specify] _____

IF YOUR CHILD WAS RESTRAINED IN A CHILD RESTRAINT SEAT, PLEASE ANSWER THE FOLLOWING QUESTIONS:

12. CAN YOU TELL ME THE BRAND AND MODEL OF THE CHILD RESTRAINT? [40-41]

Brand _____ Model _____

			For Office Use Record 2
13. DOES THE CAR SEAT [CHILD RESTRAINT] HAVE A TOP ANCHOR STRAP THAT HAS TO BE INSTALLED IN THE CAR?	*Yes*	*No*	_____[42]
14. WAS THE ANCHOR STRAP INSTALLED AND USED AT THE TIME YOUR CHILD WAS INJURED?	*Yes*	*No*	_____[43]
15. WAS YOUR CHILD HARNESSED IN THE CAR SEAT AT THE TIME OF THE INJURY?	*Yes*	*No*	_____[44]
16. WAS THE CAR SEAT HELD IN PLACE BY THE SEAT BELT IN THE CAR AT THE TIME YOUR CHILD WAS INJURED?	*Yes*	*No*	_____[45]
17. WAS THE CAR SEAT FACING FORWARD OR BACKWARD?	*Forward*	*Backward*	_____[46]
18. WHAT HAPPENED TO THE CAR SEAT DURING THE ACCIDENT? [Circle yes or no for each item]			
A. Nothing happened; it stayed in place	*Yes*	*No*	_____[47]
B. It fell forward	*Yes*	*No*	_____
C. It tipped over	*Yes*	*No*	_____
D. It broke [specify] _____	*Yes*	*No*	_____
E. Other [specify] _____	*Yes*	*No*	_____[51]
19. WHAT HAPPENED TO YOUR CHILD? [Circle yes or no for each item]			
A. Nothing happened	*Yes*	*No*	_____[52]
B. Injured by the car seat [specify] _____	*Yes*	*No*	_____
C. Child fell out of the car seat.	*Yes*	*No*	_____
D. Child strained against the belt or harness	*Yes*	*No*	_____
20. WHY DID YOU USE A CHILD RESTRAINT? [Circle yes or no for each item]			
A. It was recommended by friends, relatives	*Yes*	*No*	_____[56]
B. It's the law now.	*Yes*	*No*	_____
C. I was told about it in my pre-natal classes.	*Yes*	*No*	_____
D. I was told about using a child restraint in the hospital when my child was born.	*Yes*	*No*	_____
E. I read about it in newspapers, magazines, etc.	*Yes*	*No*	_____
F. Other [specify] _____	*Yes*	*No*	_____[61]

THANK YOU FOR YOUR PARTICIPATION

Restrain _____ 62

Resapp _____ 63-

Mechnism _____ 65-

To Be Completed By Hospital Staff:

For Office Use Record 3

1. Did the child experience loss of consciousness?

no	yes, less than 15 minutes yes, 15 to 59 minutes yes, 1 to 24 hours yes, greater than 24 hours	_____[8]

2. On presentation for medical evaluation was the child

awake	**IF AWAKE**, was the child			_____[9]
	complaining of amnesia regarding the event?	yes	no	
	complaining of headaches or dizziness	yes	no	
	complaining of vomiting	yes	no	
lethargic or obtunded				
unconscious	**IF UNCONSCIOUS**, was the child			
	responsive to painful stimuli	yes	no	

3. Laboratory studies required: yes no _____[10]

4. Xray studies required:

Skull	yes	no	_____[11]
Face	yes	no	_____
Spine	yes	no	_____
Chest	yes	no	_____
Extremities	yes	no	_____
Other	yes	no	_____

5.

Sutures required	yes	no	_____
Cast required	yes	no	_____
Splint required	yes	no	_____

6. Disposition Emergency Room Hospital Admit Expired _____[20]

7. **IF CHILD HOSPITALIZED;**

Number of days in hospital	___	_____[21-23]
Number of days in intensive care unit	___	_____[24-25]
Number of surgeries	___	_____[26-27]

HOME FOLLOWUP:

1. Has the child suffered any permanent injuries or problems due to the motor vehicle accident? For example, a visual or hearing problem, a limp, a behavioral problem? yes no _____[28]

2. If permanent injuries: Could you please describe these injuries.
Notes: _____

_____

3. As part of our research on the overall impact of motor vehicle injuries on children, we are attempting to gather information not only about the physical and emotional injuries to the child, but also the total costs of the injury. Could you please tell us approximately how much the cost was for the total treatment of your child from the accident. This would include all bills for any medical treatment beginning with the initial treatment of the child and any follow-up treatment [for example, doctor's office visits, xrays, cast removal] that was necessary.

Dollar amount [rounded] _____ _____[29-35]

Body Region	Injury (Description)	AIS	SC
EXTERNAL (burns, lacerations, contusions, abrasions	1)		
	2)		
	3)		
	4)		
HEAD (bony skull & brain) **Neck** (including throat) **EARS, CERVICAL SPINE**	1)		
	2)		
	3)		
	4)		
FACE (eye, nose, facial bones, mouth)	1)		
	2)		
	3)		
	4)		
CHEST (heart,lungs & rib fractures, disaphragm, thoracic spine)	1)		
	2)		
	3)		
	4)		
ABDOMEN & PELVIC CONTENTS (including lumbar spine)	1)		
	2)		
	3)		
	4)		
EXTREMITIES (including bony pelvis, sprains, FX, dislocations, amputations)	1)		
	2)		
	3)		
	4)		

For Office Use Record 4

(8-12)

Record 5 (8-12)

(63-67)

Indicate the Maximum AIS [MAIS] score of the child for each body area:

Body Area	No Injury	Minor	Mod-erate	Serious	Severe	Critical	Maxi-mum	NA	For Office Use Record 6
Head Injury	0	1	2	3	4	5	6	9	[8]
Face Injury	0	1	2	3	4	5	6	9	
Neck Injury	0	1	2	3	4	5	6	9	
Chest Injury	0	1	2	3	4	5	6	9	
Abdomen/groin injury	0	1	2	3	4	5	6	9	
C-Spine Injury	0	1	2	3	4	5	6	9	
LS-Spine Injury	0	1	2	3	4	5	6	9	
T-Spine Injury	0	1	2	3	4	5	6	9	
Buttocks/ hip	0	1	2	3	4	5	6	9	
Upper extremity	0	1	2	3	4	5	6	9	
Lower Extremity	0	1	2	3	4	5	6	9	[18]

Final Case Notes:

REQUEST FOR FEEDBACK TO
The DOT Program Of University Research

Report No. DOT/OST/P-34/86-044 **Report Title:** The Effects of Safety Seat Legislation on Pediatric Trauma: FINAL REPORT

YES	NO	
☐	☐	**Did you find the report useful for your particular needs? If so, how?**
☐	☐	**Did you find the research to be of high quality?**
☐	☐	**Were the results of the research communicated effectively by this report?**
☐	☐	**Do you think this report will be valuable to workers in the field of transportation represented by the subject area of the research?**
☐	☐	**Are there one or more areas of the report which need strengthening? Which areas?**
☐	☐	**Would you be interested in receiving further reports in this area of research? If so, fill out form on other side.**

Please furnish in the space below any comments you may have concerning the report. We are particularly interested in further elaboration of the above questions.

COMMENTS (Continued on back)

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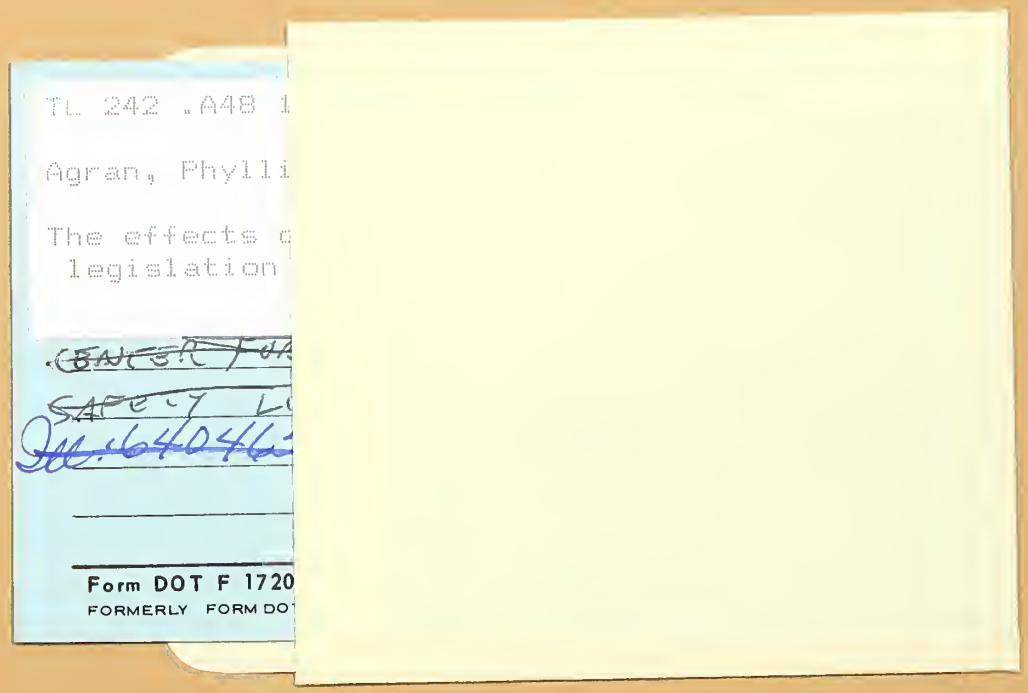
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