able to the piece-meal approach of the common law.

We submit that if the common law continues to develop by itself, the seat belt defense will be increasingly recognized by the courts in the assessment of contributory negligence. If the seat belt defense is to be recognized by law, such statutes should be broad rather than restrictive to provide just penalty for unreasonable behavior on the part of an individual by which he or she contributes to injuries caused him or her by someone else's negligent act.

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Impact of Legislation and Public Information and Education on Child Passenger Safety

K.W. HEATHINGTON, JOHN W. PHILPOT, AND RANDY L. PERRY

The State of Tennessee passed legislation in 1977 (effective January 1, 1978) requiring that children under four years of age who are traveling in motor vehicles, with certain exceptions, be restrained in child-restraint devices (CRDs). A large-scale public information and education (PI&E) program was established that concluded with an analysis of the impact on child passenger safety of the legislation and PI&E program. The PI&E program involved two intensity levels of application: (a) a higher-intensity level, called the comprehensive plan (CP), and (b) a lower-intensity level, called the basic state plan (BSP). At the end of a two-year period, the CRD use rate was increased 103 percent over the baseline rate based on statewide estimates. The CP, when applied to target areas during the operational period of this research, was significantly more effective in increasing CRD use than the BSP. The expected number of deaths was reduced by 10 over a three-year period. There was a strong correlation between individuals using seat belts and individuals protecting their children by placing them in CRDs. Characteristics of nonusers of CRDs were identified through various statistical analyses. A nonuser is (a) less likely to be wearing a seat belt, (b) more likely to have a lower education-attainment level, (c) more likely to have more passengers in the vehicle, (d) more likely to be transporting older children (under four years of age), (e) less likely to be the parent of a child, (f) likely to be in a lower income bracket, and (g) less likely to own the vehicle.

The State of Tennessee passed legislation in 1977 requiring that children under four years of age who are traveling in a motor vehicle, with certain exceptions, be restrained in child-restraint devices (CRDs). The legislation became effective January 1, 1978. As a result of this legislation, a large-scale public information and education (PI&E) program was established in the state that concluded with an analysis of the impact on child passenger safety of the legislation and the PI&E program. The State of Tennessee, by passing an active child-restraint law, provided a unique research situation in the United States. Until Tennessee passed the restraint law in 1977, which required that children under four be protected in most moving vehicles, no state had any type of passenger-restraint law for any age group.

The research reported on in this paper was designed to investigate the effect of the Child Passenger Safety Program on the reduction of fatalities and injuries to children under four years of age in Tennessee for a two- to three-year period after the law and PI&E programs were implemented. [This paper is one portion of the larger research effort of the Child Passenger Safety Program (1-12).] Study areas were selected and procedures were developed to collect data on CRD use. The data-collection instruments were designed to record information from both observations of CRD use and interviews with parents. The information collected included characteristics of children under four years of age as well as characteristics of their parents.

BACKGROUND

Target Areas

The target areas chosen for this research were representative of both urban and nonurban areas in Tennessee. The five major metropolitan areas of the state were selected for the urban sampling; i.e., Memphis, Nashville, Knoxville, Chattanooga, and the Tri-Cities area of Johnson City, Kingsport, and Bristol. Three nonurban areas, one in each of the geographical divisions of the state, were chosen to represent the more rural population. The nonurban target area was made up of merged data from Dyersburg, Columbia, and Morristown. The term more rural is used because the three areas in which the sampling occurred may not be considered rural by most standards, although the population that surrounds each town within an approximate 30-mile radius is largely rural. Each of the nonurban areas chosen, however, has towns within the 30-mile radius that have more than 5000 persons in population. The east Tennessee area has three towns within 30 miles that have more than 5000 residents, the middle Tennessee area has two, and the west Tennessee area has one.

An average of five sites was chosen within each urban area to collect data. The nonurban areas had one or two sites each. Shopping areas, regional and local, were selected as the sites to collect a large percentage of the data because of the large volume of traffic composed of parents who stopped with small children. The selected sites represented a variety of types of shopping areas that attracted a broad range of shoppers from low to high socioeconomic and educational levels. The locations of the urban and nonurban areas chosen as study areas for this research are illustrated in Figure 1.

Tennessee Characteristics

The State of Tennessee is divided naturally into three geographical divisions--the mountains and valleys of east Tennessee, the basins and rolling hills of middle Tennessee, and the flat lowlands of west Tennessee. In 1970, the population was 3 923 687, with approximately 59 percent of the people residing in nonrural settings. Nonrural is defined as any place of 2500 or more inhabitants. The population estimate in 1977, just before the beginning of the research, was 4 299 000. The urban populations of the areas under study are shown in Table 1 (13), and the populations of the nonurban areas used in the study are shown in Table 2 (13). In 1975 Tennessee had 81 272 miles of highways and streets, 12 308 miles of which were classified as urban. There were 2 725 569 registered motor vehicles in 1975, which included more than 2 000 000 automobiles. A total of 2 434 206 persons had valid driver's licenses in Tennessee in 1975. There were 32 926 million vehicle miles driven in Tennessee in 1975. The estimation for 1978 by the Tennessee Department of Transportation was 37 500 million vehicle miles. The estimate of the total number of children under four years of age, as of January 1, 1978, was 251 132.

Figure 1. Location of target areas for data collection.

Table 1. Population, selected Tennessee urban areas.

Area	Population, 1970	Estimated Population, 1975
Memphis	623 530	661 319
Memphis (SMSA)	834 006	873 300
Memphis SMSA (TN)[a]	750 015	767 000
Nashville (metro)[b]	448 003	451 200
Nashville (SMSA)	669 144	753 100
Knoxville	174 586	183 383
Knoxville (SMSA)	409 409	436 100
Chattanooga	119 082	165 282
Chattanooga (SMSA)	370 016	393 000
Chattanooga SMSA (TN)[a]	260 567	294 000
Tri-Cities	85 772	99 365
Tri-Cities (SMSA)	312 876	339 000
Tri-Cities SMSA (TN)[a]	292 808	313 000

Note: SMSA = standard metropolitan statistical area.
[a]Includes only population inside Tennessee. [b]Includes all of Davidson County.

SAMPLING AND PI&E IMPLEMENTATION PLAN

The sampling and PI&E implementation plan for this research is shown in Figure 2. CRD use data were collected before the effective date of the law and every six months after the effective date of the law, for a two-year period. The data collected

Table 2. Population, selected Tennessee nonurban areas.

Area	Population, 1970		Estimated Population, 1975	
	City	County	City	County
Dyersburg	14 523		14 694	
Dyer County		30 427		31 727
Columbia	21 471		22 124	
Maury County		43 376		45 879
Morristown	20 318		20 655	
Hamblen County		38 696		43 405
Total	56 312	112 499	57 473	121 011

Figure 2. Data collection and PI&E implementation plan.

Target Area	Oct. 77 – Jan. 78	Jan. 78 – July 78	July 78 – Jan. 79	Jan. 79 – July 79	July 79 – Jan. 80	Jan. 80 – July 80	July 80 – Oct. 80
Memphis		BSP	CP + LP	CP + LP	CP + LP	CP + LP	Analysis and Report Preparation
	BLD	SAS	SAS	SAS	SAS		
Nashville		CP	CP	CP	CP	CP	
	BLD	SAS	SAS	SAS	SAS		
Knoxville		BSP	CP	CP	CP	CP	
	BLD	SAS	SAS	SAS	SAS		
Chattanooga		BSP	BSP	CP + LP	CP + LP	CP + LP	
	BLD	SAS	SAS	SAS	SAS		
Tri-Cities		BSP	BSP	CP	CP	CP	
	BLD	SAS	SAS	SAS	SAS		
Nonurban Dyersburg Columbia Morristown		BSP	BSP	CP	CP	CP	
	BLD	SAS	SAS	SAS	SAS		

Legend: BLD = Baseline Data; SAS = Semiannual Survey; BSP = Basic State Plan; CP = Comprehensive Plan (includes BSP); LP = Loaner Program prior to January 1, 1978, provided the baseline data for comparison purposes throughout the program. As can be seen from Figure 2, baseline data were collected in each of the target areas. In addition, a semiannual survey was conducted at each location.

A comprehensive plan (CP) and a basic state plan (BSP) for PI&E were initiated for six-month intervals at different target areas. The use of these two plans in different target areas was to provide analyses relative to the cost-effectiveness of comprehensive PI&E programs. Two target areas, Chattanooga and Memphis, were selected for implementation of loaner programs. The loaner programs provided a mechanism whereby low-income families could receive CRDs without having to purchase them at regular retail prices.

The BSP was designed to distribute brochures informing parents of children under the age of four of the law and how they could protect their children. Stand-up posters for offices were designed and distributed with the brochures. Distribution was made to hospitals, doctors' offices, clinics, and other strategic places where parents with small children visited frequently.

The CP included using a mass media approach to inform the general public about the law and the need for passenger protection. Public service announcements, news spots, and talk shows on television and radio were used. Newspapers were encouraged to run feature stories and to cover events such as press conferences. Newspaper editorials were also effective public information sources. Billboards were also used as part of the CP. As can be seen from Figure 2, the CP was initially implemented in Nashville on January 1, 1978. The overall master plan shown in Figure 2 called for the number of target areas receiving the CP treatment to be increased during each six-month interval until all target areas were included.

A loaner program, designed to provide CRDs to selected citizens who could not afford them, was implemented at one target area beginning six months after the effective date of the law and PI&E program. A second target area received the loaner program six months after the first loaner program was initiated.

Evaluation Limitations

This study was designed to evaluate the impact of legislation and a PI&E program promoting child passenger safety. Measures used for evaluation were CRD use and the change in the number of fatalities and serious injuries among children under four years of age. One limitation recognized early in the project was the inability to restrict the PI&E treatment rigidly to a given target area called for by the study design. Nashville was designated as the target area to receive the CP initially. An evaluation of the effectiveness of the CP was based on the premise that Nashville could be compared with all other urban target areas that had received only the BSP. Minor leakage of CP information intended only for the Nashville target area was reported. Urban areas other than Nashville had some programs promoting CRD use that were not a part of the project design. These programs likely had an influence on CRD use rates beyond that which the BSP might have had. However, from normal observations, it did not appear that the leakage was sufficient to greatly influence the analysis.

There was another limitation that might have affected CRD use. Nashville, for instance, is the state capital; therefore, there is a larger number of government employees than in other areas of Tennessee. Nashville area residents are more likely than residents of other urban areas to be aware of new legislation because of local publicity. Thus, the use rates in Nashville could have been increased slightly by this difference in characteristics from other areas in the state.

Great care was taken to minimize any leakage of information from the CP into areas in which it had not been introduced. All activities of the program were controlled carefully to minimize any possible effects of external variables.

Data Requirements for CRD Use

Relatively large samples were required to make competent assessments of changes in CRD use. The sample-size calculations were predicated on the need to detect any substantial increases in the use rates of CRDs at critical points in the implementation plan. For example, in tests contrasting urban target areas within a particular operational period, would the pooled CP results give higher CRD use rates than the pooled BSP results? Or, when comparing across time periods for a given target area, would the BSP engender higher CRD use rates than those observed for the baseline? And would the CP result in higher CRD use rates when compared with the BSP across time? A number of such scenarios were investigated.

The appropriate statistical technique to determine if an observed increase is significant is a test of proportions. Figure 3 illustrates the hypothesis that was to be tested.

The next step was to specify the conditions under which the tests would be made. All calculations assumed the following:

1. $\alpha = \beta = 0.10$;
2. The baseline CRD use rate would be low, on the order of 5 to 10 percent;
3. The Δp increase in the CRD use rate induced by the BSP would be about 0.03 for the first six-month period and about 0.01 for the next six-month period;
4. The Δp increase resulting from the CP would be at least 0.05 for each six-month period; and
5. All effects would be additive.

In addition, when comparing across time periods, sample sizes per interval were initially assumed equal, and the following equation was used:

$$n = (4z^2/d^2)(p_1 q_1 + p_2 q_2) \tag{1}$$

where $d = p_2 - p_1$. Figure 4 shows curves for determining sample size by using the above formula for the stated conditions.

To illustrate the calculations for sample size, consider one of the more important comparisons, where the CRD use rates in Knoxville in operational periods 1 and 2 were to be tested to determine if the CP generated a significant increase in CRD use when compared with the BSP results. Let p_1 = expected CRD use rate for Knoxville in the first operational period (BSP) and p_2 = expected CRD use rate for Knoxville in the second operational period (CP). The sample sizes required for various combinations of p_1 and p_2 can be read from Figure 4 or, more precisely, calculated from Equation 1. The results are summarized in the array below:

p_1	0.05	0.05	0.06	0.10	0.08
p_2	0.11	0.10	0.11	0.16	0.13
n	266	363	406	410	491

The first combination ($p_1 = 0.05$, $p_2 = 0.11$, n = 266) also is illustrated in Figure 4. It can be

Figure 3. Basis for the statistical test.

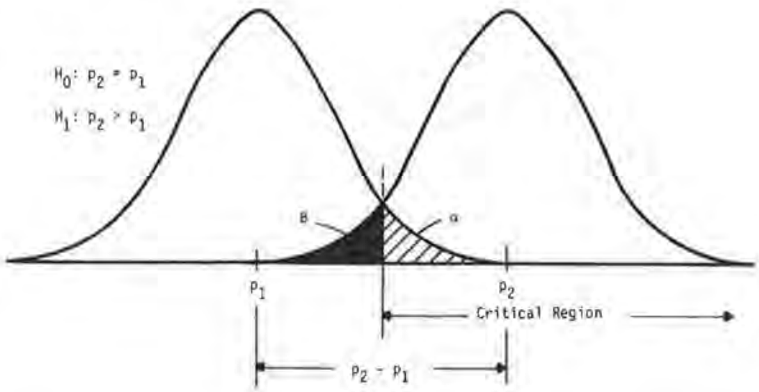


Figure 4. Sample size requirements for CRD use.

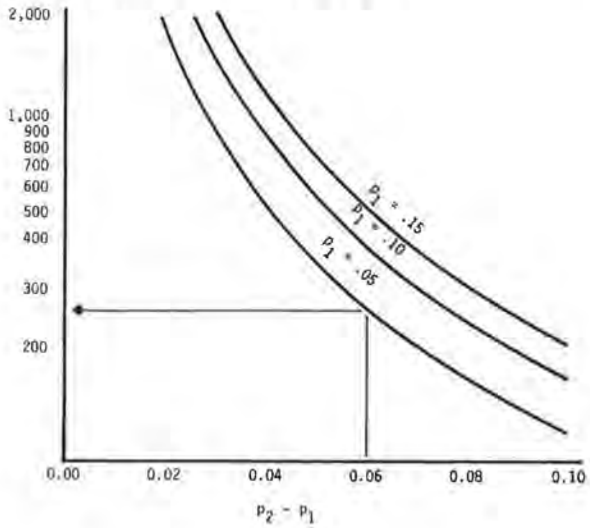
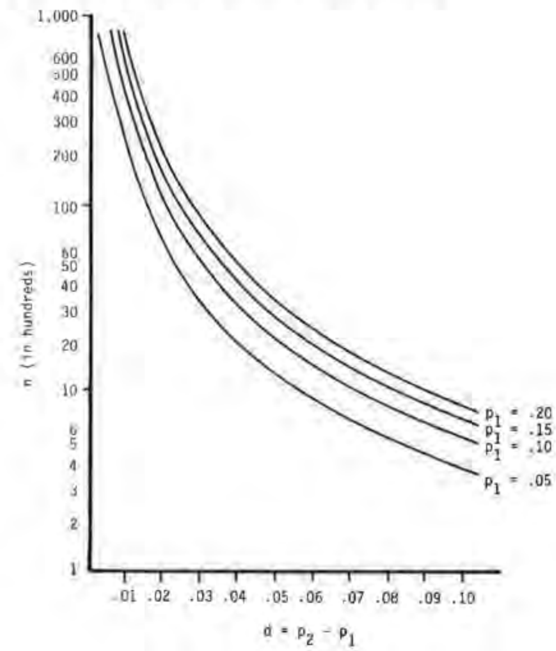


Figure 5. Sample size requirements for seat belt use.



seen that for most of the situations envisioned for this test, a sample size on the order of 400 was indicated.

A number of other test scenarios were investigated in a similar manner. No one sampling plan could satisfy both the budget constraints and the requirements for precision. The compromise solution was to obtain 800 observations for each target area in the baseline period, 400 observations for each target area per BSP operational period, and 500 observations for each target area per CP operational period.

The table below shows a comparison of design sample sizes versus the actual sample sizes:

Item	Design	Actual (avg)
Baseline	800	869
BSP	400	560
CP	500	630

It can be seen that, in general, the design sample sizes were exceeded by a comfortable margin.

Data Requirements for Seat Belt Use

A family of curves was developed for sample-size selection for seat belt use (Figure 5) for both urban and nonurban areas by using the same procedures for CRD use sample-size selection. The sample size for each category was based on a power of test of 0.99 and an alpha level of 0.01. The sample size required for each urban target area was 3800 observations. This sample size was chosen by assuming a 15 percent use rate during the baseline data-collection period and a 19 percent use rate during the first operational data-collection period. The sample size required for nonurban areas was 2913 observations--971 at each nonurban location. The assumption of 5 percent seat belt use by drivers at the nonurban locations was made after preliminary review of one day's data collection at one nonurban location. It was assumed that there would be about the same increase (3 percent) in seat belt use by drivers as the assumed increase in CRD use because of the fact that the PI&E program had an underlying message for all occupants and not just child passengers. It was anticipated that this sample size would be greatly exceeded if all drivers were observed while collecting the sample size for CRD use.

Death and Injury Data Requirements

To determine the death and injury rates resulting from motor vehicle accidents it was necessary to depend on accident records from accident investigation files. Based on the records of previous years, approximately 1000 accident injuries to children under four years of age were expected each year. Fewer than half of these were investigated by the Tennessee Highway Patrol. To compare death and injury rates by CRD use category, the Tennessee Department of Safety provided accident records of child occupants under four years of age involved in vehicle accidents; the specific data came from a supplemental accident data-collection form used by the Tennessee Highway Patrol.

Levels of Data Collection

Three tiers of levels of CRD use data were collected in this project. The tier 1 level was designed to record observed information in a matter of seconds as vehicles passed an observation point. Tier 1 data were not recorded on vehicles specifically exempted by the law. Data were gathered only if those eligible vehicles had at least one child estimated by the observer to be under four years of age. This level of data collection was performed primarily at entrances to parking areas at shopping centers, although a few observations were made at public health centers, pediatricians' offices or clinics, and children's hospitals. The information recorded on the tier 1 instrument included the disposition of the child or children in the vehicle (e.g., restrained or unrestrained), the use of the seat belt by the driver of the vehicle, and the license number of the vehicle for identification purposes.

The tier 2 level of data collection was designed as a combination observation, personal interview, and self-administered questionnaire. This instrument was used to gather specific information about the child, parent or guardian, vehicle, and CRD, if one were present in the vehicle or if one were owned but not present. The self-administered portion of the questionnaire was used to collect demographic data on the parent or guardian. The personal interview took approximately 30-60 s, and the self-administered part took about 60-90 s. Tier 2 level respondents were a subset of those observed at the tier 1 level where only an estimate of the child's age was made. Therefore, the first question at the tier 2 level was the age of the child.

The tier 3 level of data collection involved a questionnaire given to the parent or guardian to be filled out at a later date and mailed to the Transportation Center at the University of Tennessee. (This presentation does not report on any of the tier 3 level of information.)

RESULTS OF ANALYSIS

Baseline Data Results

A sizable number of vehicles (68 884) were observed during the baseline data collection in order to have a sufficient number of vehicles with small children. Only 9.1 percent of the vehicles observed had small children as passengers. The drivers of vehicles with children under four years of age as passengers were the parents of the children in 87.2 percent of the cases observed. The majority of the drivers with children under four were females (53.6 percent). There were more female (58.9 percent) than male drivers observed with children using CRDs. Of the types of CRDs owned, almost 93 percent were car seats and infant carriers. The car seat and infant carrier types account for 79.4 and 13.5 percent, respectively.

The composite use for all target areas combined for the baseline period was 9.2 percent (see Table 3). This percentage is an average of the percentages of use for urban and nonurban areas. A weighted average for just urban areas showed 11.8 percent use compared with 6.5 percent use for nonurban areas.

Table 3. Statewide CRD use rate estimates.

		Operational Period			
Target Area	Baseline	First	Second	Third	Fourth
Nashville	14.0	22.1	19.0	19.1	24.6
Memphis	10.9	13.5[a]	16.5	22.6	18.9
Knoxville	12.8	20.4[a]	22.3	21.5	26.9
Chattanooga	10.9	16.5[a]	9.2[a]	15.0	23.7
Tri-Cities	10.7	17.9[a]	15.1[a]	19.9[a]	20.6
Urban average[b]	11.8	18.3	17.0	20.0	22.9
Nonurban average	6.5	12.5[a]	9.7[a]	13.0	14.5
Statewide estimates[c]	9.2	15.4	13.4	16.5	18.7

[a] BSP.
[b] Weight according to sample size.
[c] Estimates = (1/2) (nonurban + urban average).

A contingency table analysis of use for the baseline period revealed that there is a significant relationship between CRD use and the age of the child. The use rate was highest for the youngest children and lowest for three-year-olds. The number of children under four years of age in the vehicle had a significant bearing on use rates. The use rate was greatest when two or more children under four were present in the vehicle. Other significant relationships between selected variables and use included family income, marital status, number of adult passengers in vehicles, employment status of respondent, employment status of the couple, educational status of respondent, educational status of the respondent's mate, and educational status of the couple.

Seat belt use of all drivers observed during the baseline data-collection period was only 7.0 percent. The percentage of seat belt use by drivers with small children was even smaller at 4.1 percent.

There was a significant relationship between the driver's decision to use seat belts and the driver's decision to place a child in a CRD. It was discovered that, of those drivers who used seat belts themselves, 44 percent placed their children in CRDs. Of those drivers not using seat belts themselves, only 7.3 percent had their children restrained in CRDs.

Data Results of Operational Periods

CRD Use

Data were collected at each of the target areas each six months for a total of four data-collection periods after the law went into effect January 1, 1978. Thus, data were compiled over a period of two years after the law went into effect. Table 3 provides a summary of the statewide CRD use rate estimates for the baseline and four operational data-collection periods. It can be seen from Table 3 that there was generally an increase in CRD use rates for both urban and nonurban areas. Figure 6 shows the urban and nonurban CRD average use rates for the baseline and four operational periods.

It is interesting to note from Figure 6 that the second observational period showed a decrease in CRD use rates from the first operational period. The reasons will not be discussed in detail in this paper, but it was believed that this decrease was attributable to the enforcement program. The general public seemed to perceive that there would be strong enforcement at the beginning of the implementation of the law. However, the plan was to provide a strong educational program for the general public and then begin a strong enforcement program at a later date. When the enforcement did not occur at the beginning, the public most likely thought that enforcement was not going to occur. However, when it was substantiated that the general public did understand the legislation and was knowledgeable of its requirements, a strong enforcement program was emphasized. This began toward the end of the second operational period. From that point, there was a continual increase in CRD use rates.

Figure 7 is helpful in illustrating CRD use rates by target area and PI&E plan. This figure reveals that in every contrast indicated by arrow pairs, each BSP CRD use rate is significantly higher than its corresponding baseline value. In turn, each CP CRD use rate is significantly higher than its corresponding BSP value. It also shows that Nashville's four periods of the CP led to significantly higher rates compared with its baseline measure.

In summary, significant increases in CRD use were observed at each target area by the end of the two-year program. CRD use statewide was improved by more than 100 percent over the baseline rate of 9.2 percent. Comparisons across time indicated that the BSP resulted in a significant increase over the baseline and the CP generated a significant increase over the BSP rates. Comparisons within time periods tended to confirm these PI&E results. Nonetheless, the increases were relatively small in absolute terms, and, therefore, the cost-effectiveness of the programs becomes more important.

Comparisons with Another Study

The Child Passenger Safety Program measurements of CRD use were independently verified by another agency that was monitoring CRD use rates in two of the urban target areas. The Insurance Institute for Highway Safety investigated CRD use not only in Knoxville and Nashville, Tennessee, but also in Lexington and Louisville, Kentucky. By using a different methodology than the Child Passenger Safety Program, the Insurance Institute for Highway Safety collected data on cars exiting from shopping centers (14). CRD use rates were measured three times--August 1977 (pre-law), April 1978, and May 1980.

The Insurance Institute for Highway Safety was interested both in a comparison of pre-law and post-law CRD use in Tennessee and in a comparison of Kentucky and Tennessee rates, the most important difference being that Kentucky had neither a law nor an extensive PI&E program.

The CRD use rates obtained by the Child Passenger Safety Program for Knoxville and Nashville are superimposed on the Insurance Institute for Highway Safety results in Figure 8. The general trend for the Tennessee target areas, as measured by the two agencies, is the same: a low baseline rate, a moderate but significant increase shortly after implementation of the law, and a substantial increase in CRD use rates by the end of the study. The levels of CRD use for Tennessee, measured by the two agencies, are comparable as well.

The pattern for Tennessee, however, is in sharp contrast to that observed for Kentucky. While the two states had roughly the same initial CRD use experience, by the end of the study Kentucky's use rate had regressed to 14 percent, near its 1977 level, while Tennessee's use rates had climbed to nearly 30 percent. If Kentucky is a valid control, then the final result is vivid evidence of the long-term impact of the PI&E and law enforcement combination.

Figure 6. CRD use rates.

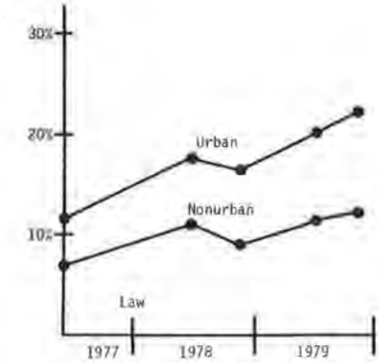
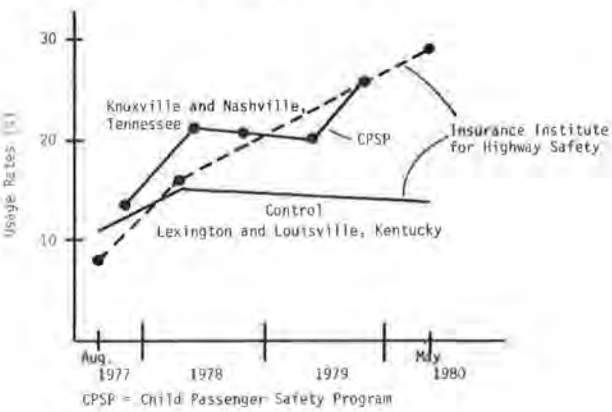


Figure 7. Comparison of use rate changes.

	Baseline	BSP (average)	CP (average)
Nashville	14.0		21.2
Memphis	10.9	13.5	19.3
Knoxville	12.8	20.4	23.6
Chattanooga	10.9	12.9	19.4
Tri-Cities	10.7	17.6	20.6
Urban Average	11.8	16.1	21.0
Nonurban Average	6.5	11.1	13.8
Statewide Estimates	9.2	13.6	17.4

Figure 8. Observed CRD use rates by agency.



Seat Belt Use

While the use of seat belts for all drivers declined overall after the initial measurement (baseline period), the use rate increased for those drivers with small children. There was less use in nonurban areas than in urban areas. Nonurban areas had 2.2 percent use of seat belts by all drivers, while the urban areas had 7.0 percent use for the operational periods.

The change in seat belt use rates for drivers with small children went from 4.5 percent to 7.1 percent in urban areas while in nonurban areas use shifted from 2.7 percent to 2.8 percent. Generally, the subset of drivers with small children had lower initial use than the set of all drivers.

The relationship between drivers' use of seat belts and restraint of children in CRDs, which proved to be significant for baseline data, was also significant when tested by using operational frequencies for the variables. The percentage of drivers observed as seat belt users and who also had children in CRDs increased between the two time periods from 44 percent during the baseline period to 55.3 percent in the operational periods. On the other hand, those drivers who did not use seat belts used CRDs for the children with them at only a 19.7 percent rate; but this percentage is a tremendous improvement over the 7.3 percent observed for the baseline period.

Babes-in-Arms Clause

The legislation in Tennessee permitted an older person to hold a child rather than placing the child in a CRD while traveling in an automobile. There are numerous data that indicate that this is a very serious and dangerous manner in which to transport children in an automobile. Many thought that parents and guardians in Tennessee would use this exemption within the law to circumvent using CRDs; however, the proportion of children under four being held by older passengers in the vehicle did not change significantly after implementation of the legislation and the PI&E program. Twenty-six percent of children in the baseline period and 22.6 percent of children in the operational periods were held by older passengers. Thus, the expectations of circumventing the law by holding children did not occur. (The clause permitting children to be held by older passengers was later removed.)

Accident Analysis

A supplemental accident data-collection form was developed for the Tennessee Highway Patrol and used in the investigation of accidents involving children under four years of age. The Tennessee Highway Patrol normally investigates accidents on state highways and would not normally be involved in the investigation of an accident on a road that was not under state jurisdiction. Thus, the total accidents analyzed and reported on here are less than the total that occur in the state.

Data taken from these supplemental forms for a three-year period (1978-1980) are reported in Table 4. It is seen from Table 4 that 350 observations were made on accidents in which CRDs were used. In addition, 964 observations were made on accidents in which CRDs were not used. The data were broken down into accidents in which there were no injuries to children, those in which there were injuries, and those in which fatalities occurred. It is also seen from Table 4 that an injury rate was calculated for CRD nonusers. Some 47.1 percent of CRD nonusers involved in accidents sustained no injuries; however, 49.5 percent of CRD nonusers involved in accidents did sustain injuries and 3.4 percent resulted in fatalities. It is immediately apparent that CRD users have two major advantages over the unrestrained if they are involved in automobile accidents: (a) CRD users are more likely to escape without injury and (b) CRD users have almost no risk of fatality. Other data also indicate that CRD users have less risk in each injury category (i.e., minor injury and major injury).

If one assumes that these same injury rates for CRD nonusers would apply to CRD users involved in accidents if they did not use CRDs, one can develop an expected number of no injuries, injuries, and fatalities for the CRD user category, as shown in the table below:

Type of Injury	Expected for CRD Users	Observed	Savings for Three-Year Period (expected-observed)
No injury	165	232	-67
Injury	173	116	+57
Fatality	12	2	+10

Thus, based on the table, one could expect 165 no-injury accidents for a three-year period, but 232 were observed. Thus, there was an increase of 67 noninjuries through the use of CRDs. In addition, if the CRD users had not used CRDs, one would have expected 173 injuries, but 116 were observed. Thus, there were 57 injuries that did not occur because of the use of CRDs. Even more important, one would have expected 12 fatalities to occur in this three-year period; however, only two occurred. Thus, there was a saving of 10 fatalities through the use of CRDs in this three-year period.

The total number of deaths and injuries of children under four in the state did not decrease under the Child Passenger Safety Program but remained in the same range as before implementation of the law. However, the total number of deaths fluctuates (i.e., ≈ 10 to 30) from year to year without significant changes in population, motor vehicle miles traveled, number of drivers, or other variables that tend to influence the number. Thus, the use of the actual number of death reductions as a sole measure of effectiveness is not really appropriate. It is more useful to investigate individual accidents to determine the death and injury rates for CRD nonusers, and then to apply these rates to CRD users to estimate the saving that most likely occurred with the use of CRDs.

CONCLUSIONS AND RECOMMENDATIONS

The evaluation of the PI&E program involved the measurement of the effectivensss of two intensity levels of application. The highest-intensity level, the CP, was applied in progression to specific target areas during the study. The lower-intensity level, the BSP, was used statewide for the entire period after implementation of the law. An evaluation was made of the two intensity levels by comparing the target areas having the CP with target areas having only the BSP.

There were factors that may have influenced the CRD use rates that were practically uncontrollable. These factors included the leakage of information, which only CP target areas were to receive, to other urban areas and independent programs in the urban areas, both of which were outside the control of this study. However, it is believed that the impact of this leakage was minor and, if completely eliminated, would give even more importance to the CP.

The results of this study should have application for similar situations in other states. The implications of the results of this study are included in the following summary of the major conclusions and recommendations:

1. The rate of CRD use was significantly increased in Tennessee after implementation of a law, a PI&E program promoting child passenger safety, and a law enforcement campaign. This conclusion is based on evaluation after two years of operation, assuming no seasonal variation. The final CRD use rate was 103 percent higher than the baseline rate, based on statewide estimates.

Every state should develop methods to increase child passenger protection. Legislation requiring the use of CRDs by small children should be one of the more important methods developed.

2. The CP, when applied to target areas during

Table 4. Automobile accidents for children under four years of age.

Type of Injury	CRD Users				CRD Nonusers				
	1978	1979	1980	Total	1978	1979	1980	Total	Injury Rate (%)
No injury	78	72	82	232	175	110	169	454	47.1
Injury	34	38	44	116	148	163	166	477	49.5
Fatal	-	-	2	2	3	17	13	33	3.4
Total	112	110	128	350	326	290	348	964	

the operational period of this research, was significantly more effective in increasing CRD use than the BSP. The actual size of the difference was partially masked by the bleeding of information into BSP areas. The CP is also substantially more costly than the BSP.

The decision of whether or not to use a CP as defined in this project should also be based on economic considerations. A lower-intensity plan, such as the BSP in this study, has a relatively low cost. Since the CP campaign had a definite impact, low-cost mass media programs should be considered. Any PI&E program should be coordinated with a law enforcement campaign.

3. There were no reductions in overall fatalities or serious injuries during the Child Passenger Safety Program for children under four; however, the children in CRDs had significantly more protection than those that were not in CRDs. Of the 35 individual deaths investigated in a three-year period, 33 involved children without CRDs. By this measure, use of CRDs prevented at least 57 injuries and 10 fatalities during the three years. This estimate is a minimum because the child deaths and injuries investigated are a subsample of the total child deaths and injuries of the state.

Since the frequencies of fatalities are low, this should not be used as a measure of effectiveness of this type of safety program. The best measure of effectiveness of the program is to apply the injury and fatality rates of unrestrained children to the group using CRDs.

4. The proportion of children under four being held by older passengers in the vehicle did not change significantly after the implementation of legislation and the PI&E program; 26.0 percent of children in the baseline period and 22.6 percent of the children in the operational periods were held by older passengers. However, holding children while traveling in an automobile is very dangerous.

Legislation should not permit an older passenger to hold a child while traveling in an automobile. (The Tennessee law's babes-in-arms clause has been rescinded.)

5. There was no increase in seat belt use by all drivers observed between the baseline and operational measurement periods. However, when a subset of drivers who had small children with them was measured, there was a significant increase in seat belt use. Drivers who are users of seat belts tend to protect their children by placing them in CRDs; i.e., there was a significant relationship between the drivers' decision to use seat belts and their decision to place their children in CRDs.

To increase the use rates of both seat belts and CRDs and thus to decrease deaths and injuries, a passenger-restraint use law for all vehicle occupants should be passed and strictly enforced.

6. The variables that best distinguish between users and nonusers of CRDs were identified. By using these variables as descriptors, a nonuser is (a) less likely to be wearing a seat belt, (b) more likely to have a lower educational-attainment level, (c) more likely to have more passengers in the vehicle, (d) more likely to be transporting older children (under four years of age), (e) less likely to be the parent of the child, (f) more likely to be in a lower income bracket, and (g) less likely to own the vehicle.

The major focus of PI&E campaigns should be directed toward the specific target groups that fit characteristics of the nonuser.

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Automobile-Restraint Controversy: Analysis and Recommendations

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Some of the costs and benefits of motor vehicle passenger-safety systems and policies, including passive seat belts, air bags, and a mandatory seat-belt-use law, are analyzed. This paper argues that since the last alternative is significantly more cost effective than the first two, the federal government should have offered it as an option to states instead of abolishing the passive restraint requirement.

In October 1981 (1), the Reagan Administration abolished the most significant regulatory action of the National Highway Traffic Safety Administration (NHTSA) by eliminating the passive restraint requirements from Federal Motor Vehicle Safety Standard (FMVSS) 208 (2). This regulation required cars manufactured after September 1982 to be equipped with passive restraints for front-seat occupants. Unlike conventional seat belts, passive restraint systems require no action by either driver or passenger in order to be activated, thus providing automatic protection to automobile occupants in almost every accident. These systems are aimed at the heart of the problem with current seat belt systems--the low use rate. Only about 10 percent of U.S. drivers wear their seat belts.

Manufacturers are planning to meet the pending requirement by using one of two systems: passive belts or air bags. Passive belts are standard seat belts that are automatically buckled up as the occupant enters the vehicle while air bags consist of large pillows that inflate in case of an accident, thus restraining the occupants' movement. A more detailed technical description of these systems is provided later in this paper.

The analysis offered in this paper shows that the recent action by the Reagan Administration can be easily justified on the basis of cost-effectiveness considerations. In order to be justified, though, it has to be compared with an alternative course of action--the implementation and enforcement of a mandatory seat-belt-use law. A comparison of this alternative with the passive belt and air bag solutions suggests that the federal government should have complemented its recent action by instituting a seat-belt-use law.

The federal safety concern is motivated by the high number of automotive accidents, which cause more than 50 000 deaths and 2 million injuries every year in the United States (3,4). The regulation under consideration concerns roughly 60 percent of the fatalities (or about 30 000 deaths) that are automobile occupants; the others include mainly pedestrians, bicyclists, motorcyclists, and streetcar occupants. All the alternative courses of action mentioned above are designed to save as many of these lives as possible as well as reduce the number and severity of injuries and ease the economic hardship associated with automotive accidents. This paper chooses the number of automobile-occupant fatalities as the key criterion in evaluating the effectiveness and costs of the three aforementioned alternatives. This criterion should, however, be treated only as a measure of effectiveness; the reduction in the number and severity of injuries may be a much stronger impact of these courses of action.

The paper is organized as follows. First, the passive restraint provisions set forth in FMVSS 208 are summarized, some background on the functioning of seat belts is presented, and the concept of effective use rate that is used in the analysis that follows is described. Second, analyses of the three alternatives are presented, i.e., passive belts, air bags, and mandatory belt use. This presentation includes a technical description as well as a discussion of effectiveness, costs, and other considerations. Third, the three alternatives are compared with each other in terms of several measures and, finally, the last sections summarize and conclude the paper with an outline of an implementation strategy.

The paper does not report new experimental results but rather tries to shed light on the controversy through a comparative evaluation of the major alternatives by using existing data. [An abridgment of this paper is given elsewhere (5).]

BACKGROUND

This section provides background information for the