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North Carolina's Occupant Restraint Law: A Three Year Evaluation

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> > October 1988 HSRC - PR 158 UNC/HSRC - 88/10/5

NORTH CAROLINA'S OCCUPANT RESTRAINT LAW: A THREE YEAR EVALUATION

by

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University of North Carolina Highway Safety Research Center

October 1988

This study was made possible by a grant from the North Carolina Governor's Highway Safety Program and from Traffic Safety Now, Incorporated, Detroit. The information herein is the sole responsibility of the authors and does not necessarily reflect the views of the sponsors.

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EXECUTIVE SUMMARY

This report describes the results of an evaluation of the effectiveness of North Carolina's occupant restraint law with respect to (1) changes in belt use in the population at large; (2) injury reduction in crashes; and (3) enforcement activities at the state and local level. The principal findings by category are as follows:

Belt Usage:

- Driver belt usage during the pre-law baseline period was 25 percent (based on over 18,000 observations at 72 sites across the State).
- During the 15-month warning ticket phase (October 1, 1985 through December 31, 1986), driver belt usage ranged from 41 to 49 percent.
- During the \$25 citation phase which began January 1, 1987, driver belt usage immediately hit a high of 78 percent (the highest statewide rate ever recorded in the U.S.) and leveled off at around 60 percent nearly one and a half years later. Current usage is at nearly 64 percent.
- NC Belt use is generally <u>highest</u>:
 - In urban areas
 - In the piedmont and coastal regions
 - During commuting hours
 - For car occupants
 - For female drivers
 - For white drivers: pre-law and warning phases non-white drivers: \$25 citation phase
 - For drivers rather than other front seat occupants

Injury Changes:

Warning Phase:

- There was no improvement in fatalities relative to the forecast made from long-term pre-law trends. This is in contrast to an <u>increase</u> of 4.9 percent among those occupants Not Covered by the law.
- Serious and fatal injuries to Covered Occupants showed a significant reduction of 5.4 percent, an estimated <u>annual</u> reduction of 857 such injuries during the 15-month period.

Citation Phase:

• During the first 18 months of the citation phase, fatalities among Covered Occupants improved 11.6 percent. This represents an estimated <u>annual</u> savings of 131 lives.

• During the same period, serious and fatal injuries to Covered Occupants showed a 14.6 percent reduction from the forecasted level, an estimated <u>annual</u> savings of over 2300 serious or fatal injuries.

Enforcement:

- The level of enforcement by the Highway Patrol was 9666 warnings per month during the warning ticket phase, and 4130 \$25 citations per month during the first 21 months of the citation phase (i.e., January 1, 1987 through September 30, 1988).
- The level of enforcement by local police and county sheriffs has been variable across the State.

Conclusions:

- North Carolina has reached and maintained one of the highest levels of statewide belt usage seen in the United States.
- Serious injury and fatality reduction has been consistent with the comparatively high level of observed belt usage.
- Since the law went into effect (i.e., Oct. 1, 1985), injury reductions are estimated at

179 fewer fatalities 4343 fewer serious injuries <u>5821</u> fewer moderate injuries 10,343 fewer total casualties

- Using motor vehicle accident costs recommended by the Federal Highway Administration, the injury and fatality reductions would represent a savings of over \$500 million from October 1985 through June 1988.
- There is a need for increased enforcement (particularly at the local level) along with public information and education.

Part I. Introduction

Background; The North Carolina Law

Seat belt use laws have been common among industrialized nations for many years. Currently over 30 countries--ranging from Canada to Australia and from Brazil to the Soviet Union -- have mandatory use laws. However, the United States lagged behind in this regard, partly because of the divided opinion among scientists and policy makers as to the best means to achieve occupant protection -belt use laws or automatic restraint systems such as air bags (Campbell, 1984a).

In the spring of 1985, the North Carolina General Assembly enacted an occupant restraint law which became effective on October 1, 1985. The law (see Exhibit 1 for the specifics) states that drivers and other front seat passengers, who are sixteen years of age or older, of passenger motor vehicles manufactured with seat belts in compliance with Federal Motor Vehicle Safety Standard (FMVSS) 208, must have the seat belts properly fastened whenever the vehicle is in forward motion on a street or highway in North Carolina. A driver with other front seat passengers under age sixteen (and not required to be in a child safety seat) is responsible for having these front seat passengers properly restrained. Warning tickets were issued to violators of the law during the fifteen-month period between October 1, 1985 and December 31, 1986. As of January 1, 1987, violators have been subject to a fine of \$25. Violation of this law does not result in driver license points, insurance points, or court costs. Exemptions include:

- 1. Persons with medical or physical conditions preventing the use of safety belts or with a professionally certified mental phobia against the wearing of safety belts;
- 2. Rural letter carriers in performance of their duties;
- 3. Delivery vehicles with frequent stops and speeds not exceeding 20 mph;
- 4. Commercial vehicles being used for transporting goods; and
- 5. Vehicles not required by federal law to be equipped with safety belts.

This evaluation of North Carolina's law addresses the warning ticket phase as well as the citation phase utilizing several data files including: (1) statewide accident data, (2) statewide enforcement data, and (3) a probability sample of statewide belt use by front seat occupants. The evaluation examines demographic and geographic patterns of belt use after implementation of the law (warning ticket phase and \$25 citation phase), compared with the before use. For accident victims, changes in injury distributions are addressed in some detail.

Exhibit 1

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GENERAL ASSEMBLY OF NORTH CAROLINA SESSION 1985

RATIFIED BILL

CHAPTER 222 SENATE BILL 39

AN ACT TO MAKE THE USE OF SEAT BELTS IN MOTOR VEHICLES MANDATORY.

The General Assembly of North Carolina enacts:

Section 1. Chapter 20 of the General Statutes is amended by adding a new section to read:

"§ 20-135.2A. <u>Seat belt use mandatory</u>.--(a) Each front seat occupant who is 16 years of age or older and each driver of a passenger motor vehicle manufactured with seat safety belts in compliance with Federal Motor Vehicle Safety Standard No. 208 shall have such a safety belt properly fastened about his body at all times when the vehicle is in forward motion on a street or highway in this State. Each driver of a passenger motor vehicle manufactured with seat safety belts in compliance with Federal Motor Vehicle Safety Standard No. 208, who is transporting in the front seat a person who is (1) under 16 ; years of age and (2) not required to be restrained in accordance with G.S. 2Q-137.1, shall have the person secured by such a safety belt at all times when; the vehicle is operated in forward motion on a street or highway in this State. Persons required to be restrained with G.S. 20-137.1 shall be secured as required by that section.

(b) 'Passenger Motor Vehicle', as used in this section, means a motor vehicle with motive power designed for carrying 10 passengers or fewer, but does not include a motorcycle, a motorized pedacycle or a trailer.

(c) This section shall not apply to any of the following:

- a driver or occupant with a medical or physical condition that prevents appropriate restraint by a safety belt or with a professionally certified mental phobia against the wearing of vehicle restraints;
- (2) a motor vehicle operated by a rural letter carrier of the United States Postal Service while performing duties as a rural letter carrier;
- (3) a driver or passenger frequently stopping and leaving the vehicle or delivering property from the vehicle if the speed of the vehicle between stops does not exceed 20 miles per hour;
- (4) any vehicle registered and licensed as a property-carrying vehicle in accordance with G.S. 20-88, while being used for agricultural or commercial purposes; or
- (5) a motor vehicle not required to be equipped with seat safety belts under federal law.

(d) Failure to wear a seat safety belt in violation of this section shall not constitute negligence or contributory negligence in any action for the recovery of damages arising out of the operation, ownership or maintenance of a motor vehicle, nor shall anything in this act change any existing law, rule or procedure pertaining to any such civil action.

(e) Any person violating this section during the period from October 1, 1985, to December 31, 1986, shall be given a warning of violation only. Therefore, any person violating this section shall have committed an infraction and shall pay a **fine of twenty-five dollars (\$25.00)**. An infraction is an unlawful act that is not a crime. The procedure for charging and trying an infraction is the same as for a misdemeanor, but conviction of an infraction has no consequence other than payment of a fine. A person convicted of an infraction may not be assessed court costs.

(f) No drivers license points or insurance surcharge shall be assessed on account of violation of this section.

(g) The Commissioner of the Division of Motor Vehicles and the Department of Public Instruction shall incorporate in driver education programs and driver licensing programs instructions designed to encourage compliance with this section as an important means of reducing the severity of injury to the users of restraint devices and on the requirements and penalties specified in this law.

(h) The Department of Transportation through the Governor's Highway Safety Program shall evaluate the effectiveness of this act and shall include a report of findings in its report on highway safety no later than October 1, 1988."

Sec. 2. This act shall become effective October 1, 1985. This act shall cease to be effective if, and upon such date as, a final determination by lawful authority is made that the North Carolina law on mandatory safety belt usage does not meet the minimum criteria established by the United States Department of Transportation for State mandatory safety belt usage laws necessary to rescind the federal rule requiring automobile manufacturers to phase in automatic occupant restraints in automobiles.

In the General Assembly read three times and ratified, this the 23rd day of May, 1985.

Robert B. Jordan III President of the Senate

Liston B. Ramsey Speaker of the House of Representatives

Review of Recent Literature

In a recent review paper, Marburger (1985) compiled information from many countries and showed that belt use rates increase sharply with a mandatory belt law -- in some cases a 50 percentage point gain. He also reported that rates in some countries have held steady but in others have declined after inauguration of the law. More recently Campbell and Campbell (1986) examined the seat belt law experience in four foreign countries (Australia, Sweden, West Germany and the United Kingdom) -- all with belt use generally as high as 85 to 90 percent.

Since level of compliance is central to the success of any belt use law, there is interest in the characteristics of users and non-users. Lawson (1985) reviewed findings from several countries, and among other factors reported that belt use tends to be lower among persons with less education and/or lower socio-economic status. This has also been noted by several authors regarding use of child safety seats (Allen and Bergman, 1976; Pless and Rohmann, 1978; Jones, 1979; Philpot, Heathington, Perry, and Hughes, 1979; Freedman and Lukin, 1977; Kielhorn and Westphal, 1980; Hletko, Hletko, Shelness and Robin, 1983). This finding is of special interest since it also may be that the crash risk is higher in this less educated and/or lower socio-economic status group.

Evans and Wasielewski (1983) were among the first to study the association between risk taking and belt usage. Here risk taking was measured by close following in freeway traffic. On the basis of 12,000 headway observations, they conlude, among other things, that shorter headways, corresponding to higher risk, were found for drivers who did not wear a seat belt.

Other, more recent research also indicates that high-risk drivers are less likely to use seat belts. Preusser, Lund, Williams and Blomberg (1988) defined high-risk drivers as the fastest five percent of drivers (traveling at 69 mph or higher) at each of three limited access highways in Westchester County, New York. They were compared with the middle 90 percent (52-68 mph) and the slowest five percent (less than 52 mph). Their results showed that high-speed drivers had lower belt use rates before the law and increased their belt use <u>less</u> than the other two groups in response to the law. A profile of these high-speed drivers showed they were more often male, under 30 years old, more often driving '82-'85 model cars as opposed to older vehicles, and were more likely to have at least one reported crash and at least one traffic citation.

Likewise Hunter, Stutts, Stewart and Rodgman (1988), in a study linking observed belt usage of 4505 drivers in North Carolina with their driver histories, found that non-users of seat belts were overrepresented in both accidents and violations. On average, each non-belted driver had 35 percent more accidents and 69 percent more violations per year than did the belted driver. Thus, getting this high-risk group buckled up should lead to a disproportionately greater reduction in crash injuries.

Even with less than perfect compliance, several countries have enjoyed considerable casualty reductions associated with the law. Hedlund (1985), for

example, reviewed data from several countries, including Canada. For the past ten years, Canadian occupant deaths have declined ten percent in provinces with belt laws, but less than one percent in provinces with no such law.

Campbell and Campbell (1986), reporting on the effectiveness of belt usage laws in four foreign countries -- as opposed to the effectiveness of belts per se -- cite fatality reduction estimate ranges of 6 to 21 percent for Australia, 10 to 12 percent for Sweden, 25 to 30 percent in Germany, and 15 to 21 percent in the United Kingdom. They further report on the results of an analysis for the first eight jurisdictions in the United States with seat belt laws. While belt usage clustered in the 40 to 50 percent range, fatality reduction was estimated to be 9.9 percent overall for these eight states. This is consistent with results reported by Lund, Pollner and Williams (1987) who conclude that New York's seat belt law reduced fatalities by about 9 percent during the first nine months of the law where belt usage had declined to less than 50 percent over most of the state by the end of the period.

In a subsequent analysis, Campbell, Stewart and Campbell (1987) report on belt usage and fatality reduction in 24 states plus the District of Columbia. They cite a population-weighted 48 percent belt usage from the most recent survey data available from these jurisdictions. Using time series analyses on Fatal Accident Reporting System data through 1986 they show a reduction in fatalities of 6.6 percent, representing an estimated savings of 1300 lives in the states covered by a law during the time period in question.

Based on Hedlund's view, it would seem that the upper limit of belt law effectiveness in preventing death may be about 40 percent. He projects that number from results in several countries having various levels of belt use. However, Hedlund's analysis shows no clear relationship between level of belt use in a country and level of fatality reduction, possibly because of the small numbers. On the other hand, Hedlund does show such a relationship for injury reduction. Further, his graph curves upward, supporting the notion that, because higher risk drivers tend to be less likely to use belts, there is the potential for a differentially greater casualty reduction at successively higher levels of compliance.

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Part II. Statewide Belt Use Data

Background; Survey Design

Seat belt laws should increase belt usage in the population-at-risk. One dimension of North Carolina's evaluation was to determine the belt usage in the population-at-risk both before and after the law was enacted. To carry out this evaluation, statewide surveys were conducted both prior to the law to provide baseline data and at bimonthly intervals subsequent to passage of the law -- throughout the warning ticket phase and through the first eighteen months of the \$25 citation phase.

In order to carry out this survey, a probability sampling plan was developed which involved seat belt observations of front seat occupants of vehicles covered by the law across factors where belt use is known to vary. In North Carolina these factors include region of the state (coast, piedmont, mountains), rural/urban location, and time of day/day of week. The sampling of statewide belt use by the population-at-risk was carried out within these three important strata. The resources available suggested that we could sample 72 locations from across the state. Thus, each of the three geographical regions included 24 sampling areas. As the coast and mountains are predominantly rural while the piedmont is mostly urban, we purposely oversampled rural counties on the coast and in the mountains and urban counties in the piedmont.

To guarantee that each area was equally likely to be selected within each of the three regions, the counties within the regions were grouped into county units such that each unit had approximately the same population. Then these county units were, in turn, randomly sampled to determine the areas for our rural observations. Likewise, the urban areas (Standard Metropolitan Statistical Areas) in each region were selected with probabilities proportional to population sizes.

With the county units and urban areas selected (see Figure 1), computer programs provided our location designations. Since most of the roadways in North Carolina are listed in the computer inventory file, the process became one of selecting at random locations within each of the selected county units and urban areas. Thus, for example, in the Charlotte area eight locations were selected with probabilities proportional to roadway type, and represented Interstate, US and NC roads as well as city streets. These 72 computer-pinpointed locations then provided the statewide permanent counting sites for seat belt observations in North Carolina. It should be noted, however, that a limited amount of refinement of these locations (due to traffic or site characteristics) was carried out during the actual visits in the baseline data collection effort in September 1985.

Funding resources allowed the scheduling of three major waves of observations annually, covering all of the 72 sites along with interspersed surveys using 12 of the 72 sites. The 12 sites were selected to represent the mountains, coast and piedmont areas as well as the rural/urban composition of the 72 sites.

North Carolina





In addition, they were selected so that the belt usage estimates from the 12 sites in the baseline period represented well the baseline belt usage percentages for the entire 72 sites. These 12 sites included the range of variation in the estimates -- both high and low -- that was found in the 72 sites.

All 72 sites were surveyed in September 1985 to provide baseline data as well as in January, June and October of 1986 to provide data during the warning ticket phase of the law. Citation phase data was collected from the 72 sites in January, June and October of 1987 and January and June of 1988. Twelve site ("mini") surveys were carried out to supplement the major surveys by providing a more continuous picture of belt wearing changes throughout the warning ticket and citation phases. Mini-surveys were conducted in November 1985, one month after the law became effective, as well as in March, April and August of 1986 (warning ticket phase) and March, April and August of 1987 and 1988 (citation phase).

Observational Procedure

The target vehicles surveyed were those in compliance with FMVSS 208 (i.e., manufactured with various lap and shoulder belt systems) and included 1968 and later model passenger cars along with 1971 and later model vans, pickups, and light trucks. Pairs of observers collected data for one and a half hours at each of the designated locations according to a stratified sampling plan which allowed for observations during peak commuting times (7:00 to 9:30 a.m. and 4:00 to 6:30 p.m.), non-commuting hours during the week, and also weekend periods. The observation sites were normally at intersections where the vehicles were forced to come to a stop. Observers positioned themselves so that they could view the front seat occupants for lap belt usage. When necessary to confirm their judgement on usage, the observers tried to engage the occupants in a brief conversation. This allowed for much more reliable data, particularly with respect to lap belt usage.

Site-specific data included the month, day and year of observations, as well as the starting and finishing times, weather condition, pavement type, area type (e.g., rural), and a diagram of the intersection (see Figure A.1 in Appendix A). With respect to the front seat positions of each vehicle subject to the law, the following data were collected (see Figure A.2):

- Vehicle type (passenger car, van, pickup, convertible, or other)
- Sex
- Race (white, non-white)
- Belt status (no restraint, lap only, lap and shoulder belt, child restraint, child restraint improperly used)

In addition, notes were made to describe special situations such as unusual vehicle types.

Statewide Seat Belt Usage

Results of these surveys are presented for the nine major waves covering 72 sites and the ten mini-wave surveys involving 12 sites (see Appendix B). As these estimates are intended to represent statewide usage rates, the individual site percentages for overall usage are weighted according to traffic volume as measured by average daily traffic (ADT). As the data become sparse in certain cells (e.g., vans, pickups) for the mini-wave surveys, the corresponding usage rates are the observed rather than the weighted rates for the various subpopulations (e.g., rural vs. urban). Estimates of the precision of these usage rate estimates (i.e., the standard errors) are presented in Appendix C (see Tables C.1 and C.2). Two methods for obtaining these standard errors -- the Bootstrap method and SAS PROC MEANS -- are described and contrasted in this same appendix.

Overall Usage. One cannot really be sure what the level of belt usage was in North Carolina several months or a year before onset of the law and the publicity which preceded enactment. A national survey of 19 cities estimated that belt usage was as low as 11-13 percent back in the 1970's, and it seems likely that in 1984, for example, belt use in North Carolina was no more than 20 percent. However, no data were collected in North Carolina at that time in order to know the answer to that question.

The first survey of the 72 representative sites was conducted in September of 1985, the final month before the law took effect on October 1, 1985. Already there had been extensive publicity for several months surrounding the legislative debate and the enactment of the law earlier that year. The authors believe that belt usage had already increased by the time of the September survey, though there is no scientifically valid data to support that supposition. In any case, during September the overall level of belt usage was 25 percent for drivers and was 24 percent when other front seat passengers were added in.

As of October 1, 1985, the 15-month warning ticket phase began. No fines were imposed during that period although officers were authorized to issue warning tickets. Driver belt use rose to an average of 45 percent and, throughout the 15 months, held at a level between 41 and 49 percent. This was the highest belt use experienced in North Carolina to that date.

On January 1, 1987, the second phase of the North Carolina law took effect, and officers began giving tickets that could result in a \$25 fine. The North Carolina statute authorizes officers to issue tickets directly for a belt violation by itself. This is in contrast to the policy in many other states whereby an officer may address a belt law violation only after a motorist has been stopped for some other purpose. During January, belt use in North Carolina increased to 78 percent for drivers, the highest statewide figure ever recorded by any state in the United States. Thereafter there was a steady decline and 15 months later (April, 1988) driver belt usage had fallen to 59 percent, dropping below 60 percent for the first time since full enforcement had begun. The usage rate recovered to 65 percent in June and remained at 64 percent in August of 1988. Figure 2 presents the overall



Figure 2. Weighted driver seat belt usage by phase.

statewide trend for driver belt usage based on the bimonthly surveys conducted since September 1985.

At the current level, North Carolina remains one of the top few states in the country in terms of statewide belt usage. It should be noted, however, that it is somewhat questionable to compare one state's results with another's, because differences in the specifics of the survey procedures in the two states can account for differences of several percentage points. Nonetheless, belt use in North Carolina compares quite favorably with that in any other state in the United States.

The data are collected in such a way that they can be broken down according to several factors which will be discussed in the following sections. The data from which the various figures are derived are shown in Table B.1 (drivers) and Table B.2 (all front seat occupants of covered vehicles) in Appendix B.

Rural-Urban Differences. First, the driver data are subdivided according to whether the observations were recorded in a rural or an urban setting. As can be seen in Figure 3, there is a consistent difference with belt use in urban settings being higher than in rural settings. The difference, if anything, is perhaps greater in more recent surveys and was roughly eight percentage points lower in rural areas during these surveys.

Geographic Differences. By a modest margin, belt usage is higher in the central part of the state than in the eastern area while both of these are substantially higher than the western part of the state. As Figure 4 shows, the differences seem somewhat greater in the \$25 citation phase, because values for belt wearing in the western area of North Carolina had dropped more rapidly than in the other areas, a difference of 10-15 percentage points throughout most of the period.

Differences Related to Time of Day. As can be seen in Figure 5, observations were categorized as to those taken during morning and evening peak travel hours versus all other hours of the daytime. It should be noted that all observations were made during the day because observers ordinarily cannot see the belts at night. By a slight margin, belt usage is higher during these to-and-from work hours than during other daylight hours. The differences are in the range of 2-4 percentage points.

Differences by Vehicle Type. Throughout the survey period considerable differences in belt usage have been observed among occupants of vehicles of various types. Standing at the top of the list with the highest belt usage are passenger cars, with vans and pickup trucks lagging behind by as much as 20 percentage points in some surveys (see Figure 6). Part of this difference is certainly attributable to differences in the kind of belts in these respective vehicles.

Almost all passenger cars on the highways today are equipped with shoulder belts which have been standard equipment since the 1968 models. Observers can readily see shoulder belts if worn. On the other hand, a greater proportion of vans



Figure 3. Belt usage by urban/rural location.



Figure 4. Belt usage by region of state.

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Figure 5. Belt usage by time of day.



Figure 6. Belt usage by vehicle type.

and pickup trucks have only lap belts since shoulder belts became standard equipment on these vehicles several years later than for passenger cars. Although a lap belt in use could not be observed by our survey personnel when they stood by the roadside recording the data, when in doubt the survey personnel did follow the practice of asking the motorist if they were wearing their lap belt. Thus, we believe that this equipment variable does not account for the magnitude of the difference observed, and that belt use is truly considerably lower in vans and pickups than in passenger cars.

Differences by Sex. Figure 7 shows a consistent and sizable difference in belt use by sex of driver. Females wear their seat belts more often than males -- that trend was seen consistently before the law, during the warning phase, and since enforcement began. If anything, the difference has grown larger with the passage of time, exceeding a difference of 10 percentage points in some recent surveys. This is especially important in that crash statistics show that male drivers account for a disproportionately high number of crashes. Thus, it is one illustration that unfortunately often those at higher risk of crash involvement are less likely to use seat belts.

Differences by Race. Figure 8 shows consistent differences within study periods in belt wearing when observations are differentiated by white and non-white drivers. During the pre-law baseline and the warning phase of the law, belt use was higher among white drivers. Since enforcement began, the data show a reversal with belt usage among white drivers now lower than among non-white drivers. This difference is 3-5 percentage points in the major 72 site surveys. The same findings hold for other front seat occupants of vehicles covered by the seat belt law.

This is a rather noteworthy finding since a number of past research studies show that belt use is lower among persons in lower socioeconomic or educational categories. Since non-white persons more often fall into such categories, it is not surprising that previous research conducted in North Carolina and many other places have consistently shown belt use to be lower among non-white drivers. Since the warning ticket period ended, however, and enforcement began, belt usage among non-white drivers has been higher than that of white drivers in every single survey. The authors know of no other instance in the research literature in which this finding has been noted with regard to use of seat belts.

Race/Sex Interaction. Figure 9 illustrates a cross-tabulation of race and sex combined, with the data grouped to combine surveys taken during a given enforcement phase. Thus, Figure 9 shows the three study phases: baseline, warning ticket period, and full enforcement period. It is seen that during the baseline period the race difference was larger than the sex difference, such that belt usage among white females and white males was higher than for non-whites of either sex. However, data from the enforcement period shows a regrouping such that sex differences are now greater than race differences. Thus, belt usage among non-white females and white females is now higher than that for non-white males and white males; i.e., the race difference is now relatively smaller while the sex difference is larger.



Figure 7. Belt usage by sex.



Figure 8. Belt usage by race.



Figure 9. Belt usage by race and sex.

Summary of North Carolina Belt Usage Experience. It is clear from the foregoing that belt usage in North Carolina varies considerably among the various subsets of the data. In summary, driver and occupant belt usage is consistently higher in the following categories:

- Urban areas
- Piedmont and coastal regions
- Commuting hours
- Car occupants
- Female drivers
- White drivers: pre-law and warning phases Non-white drivers: \$25 citation phase

The reversal over time for the last category is perhaps the most surprising result of the belt usage surveys.

Belt Use in North Carolina Compared to Other States

Finally, the belt use trends shown in North Carolina compare quite favorably with other states having seat belt use laws. North Carolina has consistently had observed rates which are near the top in the nation. It should be emphasized again that different states use somewhat different rules for counting belt use and therefore some part of the differences noted are a product of the specific observation procedure used.

Table 1 shows the latest figures available to these authors in terms of belt use in various states having belt laws. Several of the states are now in the process of collecting data, and therefore the most recently available results are nearly one year old in some cases. However, these data do give an indication of belt use in other states with seat belt use laws.

Rej	ported	State	Reported
State Belt	Use %		Belt Use %
Maryland Hawaii North Carolina Florida Connecticut Iowa Texas Virginia Wisconsin District of Columbia Washington California Colorado Michigan New York	66 66 64 60 56 56 56 56 56 56 55 55 52 50 50 48 48 48	Oregon Indiana Kansas Nevada New Jersey New Mexico Illinois Missouri Louisiana Ohio Minnesota Oklahoma Tennessee Utah	$\begin{array}{c} 47\\ 43\\ 42\\ 42\\ 41\\ 41\\ 40\\ 40\\ 40\\ <40\\ <40\\ <40\\ <40\\ <40\\ <$

1 able 1. Delt usage reported by 29 states with beit lay	Table 1.	Belt usage	reported	by 29	states	with	belt]	laws
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Part III. Statewide Accident Data

Data Issues

This portion of the analysis concerns injury reduction associated with the onset of the seat belt law. Reportable crashes in North Carolina are examined for the period January 1981 through June of 1988. First, the 15-month warning ticket phase is contrasted with nearly five years prior to the law. This is carried out in considerable detail to show the various issues that must be addressed. Secondly, results are presented which contrast the first 18 months with a \$25 citation with the period prior to the citation phase (i.e., pre-January 1, 1987).

Although only front seat occupants of passenger cars, vans, utility vehicles, pickups and other small trucks are required to wear belts, the existence of the law has apparently influenced more than just the group strictly covered. Thus, the following groups are compared:

- 1. Covered Occupants: front seat occupants of vehicles targeted by the law;
- 2. Non-Covered Occupants: rear seat occupants of vehicles targeted by the law; front seat occupants of other vehicles not covered by the law; and
- 3. Non-Occupants: pedestrians, riders of two-wheeled vehicles, farm equipment operators, etc.

To examine injury and fatality changes over time within each of these study groups, one would normally utilize the belt usage data in the crash file. However, with the onset of the seat belt law, there has been an inordinately large increase in reported belt usage by crash victims in both the warning ticket and \$25 citation phases -- among Covered Occupants and also among Non-Covered Occupants.

Figure 10 shows reported seat belt usage by Covered Occupants in crashes which rose from 30 percent the month before the law to 68 percent during the first month of the law, then declining to nearly 62 percent at the end of the warning ticket phase. Also shown is the population-at-risk usage by Covered Occupants during the same time period. Here the usage rate rose from a baseline of 25 percent to between 41 and 49 percent during the warning ticket phase. Similar increases are shown for both groups during the citation phase.

Previous experience indicates that belt use in crashes is less -- not more -than in the population-at risk. It seems probable that the main reason for the dramatic increase in reported belt usage in crashes in both time periods comes from persons falsely telling the investigating police officer that they were using their belt at the time of the crash -- after all, most people are aware that "It's the Law!" This apparent discrepancy necessitated an analysis approach that was independent of the police-reported seat belt usage information in the crash data.



Figure 10. Belt use in crashes versus population-at-risk for Covered Occupants.

Analysis and Results

Two levels of analysis are presented. The first is a descriptive comparison of injury distributions for Covered Occupants, Non-Covered Occupants, and Non-Occupants for both the warning ticket phase and the first eighteen months of the \$25 citation phase. The second consists of a time series analysis (see Appendix D for details) that uses injury experience over a period of nearly five years to project an expected injury distribution assuming there was no intervention and compares this distribution with the observed warning ticket phase and citation phase injury outcomes.

Descriptive Analysis. With respect to the first analysis, Figure 11 enumerates serious injury consequences among occupants targeted by the law. All North Carolina accident-reporting personnel (local police, State Highway Patrol, county sheriffs) use a similar form and rate injury on a five-point scale (ANSI D16.1, 1976):

- 1. No injury
- 2. C -- minor injury
- 3. B -- moderate injury
- 4. A -- serious injury
- 5. K -- fatal injury

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Figure 11. Injury distribution for Covered Occupants (based on a per month average of 27,136 occupants).

In Figure 11, the plot (labeled "A+K Injury %") shows the 3-5 percent of the distribution who sustained a serious or worse (A or K) injury. Fatality numbers were too small for separate analysis.

Several points are apparent from the plot. First, there is a clear break at the onset of the law (i.e., warning ticket) and also at the beginning of the citation phase, with an obvious lowering of the serious or fatal injury rate. Second, there appears to be some seasonal variation, with the percent seriously injured generally lower in winter and higher in summer.

The data for Figure 12 derive from a combination of rear seat passengers in the same vehicles depicted in Figure 11 plus front seat occupants of, for example, larger trucks (i.e., a secondary target group). Members of this combined group were not required by law to be restrained. Examination of this figure reveals several points. First, as before, there appears to be an initial downward shift in injury corresponding to the law's onset, and perhaps also at the beginning of the citation phase. Second, because of smaller numbers, the variability is greater while seasonality is not readily apparent.

Figure 13 depicts the serious or fatal injury distribution for the Non-Occupant Group. As expected, there is no hint of an effect on serious or fatal injuries associated with the onset of the belt use law or with the enforcement phase of the law. Again, the small frequencies produce the greater variability observed.

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Figure 12. Injury distribution for Non-Covered Occupants (based on a per month average of 4139 occupants).



Figure 13. Injury distribution for Non-Occupants (based on a per month average of 573 non-occupants).

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From the figures it appears that changes have taken place and that these changes are most apparent within the group where they <u>should</u> be most apparent and less apparent or not seen at all in groups not targeted or expected to be affected by the law. These changes are generally in the direction of reduced injuries and deaths. In addition, they occur the very months in which the warning ticket and citation phases took effect, namely, October 1985 and January 1987.

Time Series Analysis. The important question to be answered by the time series analysis is, "How much of an injury reduction occurred compared to the level expected had no seat belt law been introduced?" The estimates or projections for the warning ticket phase and the citation phase were made by fitting time series models to the monthly injury data. The model building was carried out using the computer routine STAMP (Structural Time Series Analyzer, Modeller and Predictor). Basically each month of crash data is examined in relation to each other month. This routine permits considering seasonal variation, cycles, slopes or trends, etc. (See Appendix D for the methodology and the complete results.)

Briefly, the procedure is as follows. Once the 57 month pre-law trends are described mathematically (i.e., once models are determined which fit the data), a forecast is made of what would have been expected during the next 15 months (the warning ticket phase) if the existing trends had continued. This forecast is then compared to what actually occurred in the warning ticket phase. A similar procedure is followed with respect to examining the effect of the citation phase.

As can be seen by the details which follow, the seat belt law was much more effective in reducing injuries and deaths during the eighteen-month \$25 citation phase than during the preceeding 15-month warning ticket phase. This would be expected based on the experience of other jurisdictions with seat belt laws. In addition, it is consistent with the belt wearing rates seen in the population at risk, namely, 59 to 78 percent and 41 to 49 percent for the citation phase vs. the warning ticket phase, respectively. Table 2 presents the results for the two periods by level of injury with respect to forecasted vs. actual injuries and the resulting percentage change (or reduction).

With respect to the detailed results for the warning ticket phase, Figure 14 shows graphically the monthly injury data for the period January 1, 1981 through December 31, 1986 -- the end of the warning ticket phase. Note the sizable drop in actual percent moderate or worse injury at the onset of the warning ticket phase in contrast to the projected percent (i.e., the dotted curve). The shaded area between the curves represents the difference between "actual" compared with "projected" moderate or worse injuries for the 15-month warning ticket phase.

More specifically, the observed number of moderate or worse (B, A, or K) injuries for Covered Occupants was 5.1 percent less than forecasted, and the downward shift (or intervention effect) corresponding to October 1985 was statistically significant (see Table D.1 in Appendix D). The 5.1 percent reduction represents an estimated savings of 2812 moderate or worse injuries.

Table 2. Forecasted vs actual deaths and injuries for the various study groups during the Warning Ticket Phase and the \$25 Citation Phase.

		Cov	ered Occu	pants		
	Level of Injury	Forecast ·	- Actual = %	= Savings Reduction*	Non-Covered Groups %	Reduction*
WARNING TICKET	Moderate +	54,864	52,052	2812 -5.1 <i>%</i> ***	Rear Seat Occs. Other Veh. Occs. Non-Occupants	+0.1% ^{n.s.} -7.7% ^{n.s.} +2.4% *
PHASE	Serious +	19,746	18,675	1071 -5.4% ***	Rear Seat Occs. Other Veh. Occs. Non-Occupants	+1.2% ^{n.s.} -21.1% ^{n.s.} -2.7% ^{n.s.}
	Fatal	1281	1299	-18 +1.4% **	Rear Seat Occs. Other Veh. Occs. Non-Occupants	+4.9% $n.s.$ t +1.1% $n.s.$

		Cov	ered Occuj	pants		
\$25 CITATION PHASE	Level of Injury	Forecast	- Actual = %	= Savings	Non-Covered Groups %	Reduction [*]
	Moderate +	64,724	57,193	7531 -11.6% ***	Rear Seat Occs. Other Veh. Occs. Non-Occupants	-8.9% ** -14.1% n.s. +0.1% ^{n.s.}
	Serious +	23,679	20,228	3451 -14.6% ***	Rear Seat Occs. Other Veh. Occs. Non-Occupants	-10.2% * -12.0% ^{n.s.} +0.9% ^{n.s.}
	Fatal	1702	1505	197 -11.6% *	Rear Seat Occs. Other Veh. Occs. Non-Occupants	+6.3% $n.s.$ +4.4% $n.s.$

* Significance of intervention effect:

n.s. = non-significant * = .05 ** = p < .05 *** = p < .01

[†] Sample sizes for fatalities too small to forecast.



Figure 14. Percent of front seat covered occupants with moderate or worse injury -- actual vs. forecast through Warning Phase.

A second analysis addressed serious or fatal (A or K) injuries. In the Covered Group, these injuries were 5.4 percent less than forecasted, with a statistically significant downward shift corresponding to October 1985. The 5.4 percent reduction is an estimated savings of 1071 serious or fatal injuries.

Among the Non-Covered Occupant group (i.e., Rear Seat Occupants), fatalities were considerably higher (4.9 percent) than the forecasted level. For the Covered Group, the increase was smaller, but there was also no sign of a favorable break in fatalities as there was for injuries.

In summary, injuries showed a significant favorable break in the five-year trend at the October 1985 onset of phase one (warning ticket) of the law. It is estimated that over five percent fewer serious or fatal injuries occurred during the warning ticket phase due to the occupant restraint law. Fatalities showed relatively little change compared with the forecasted number.

To examine the effect of the first eighteen months of the \$25 citation phase (January 1, 1987 through June 30, 1988), the 72 month (=57 month pre-law + 15 month warning ticket) pre-citation phase trends were, as previously, described mathematically and a forecast was made of what would have been expected if the existing trends had persisted. This forecast was then compared to what actually happened in the citation phase.

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With respect to moderate or worse (B, A, or K) injuries, the observed number of this level of injury for Covered Occupants was 11.6 percent less than forecasted with the downward shift corresponding to January 1, 1987, again statistically significant (see Tables 2 and D.1). For comparison purposes, percentage changes (i.e., actual vs. forecast) are again presented for rear seat occupants in covered vehicles, for occupants of vehicles not covered by the law, and for non-occupants. The reductions in these comparison groups are generally more modest than those seen for occupants covered by the law, with by far the least reduction in the Non-Occupant Group as would be expected. In most every case, the intervention effects are non-significant for the various comparison groups. The 11.6 percent reduction for the Covered Group represents an estimated <u>annual</u> savings of 5021 moderate or worse injuries.

With respect to serious or fatal (A or K) injuries, for the Covered Group they were 14.6 percent less than forecasted with a significant downward shift or intervention corresponding to January 1, 1987. For Non-Covered Occupants, there were also reductions but none was statistically significant (at p = 0.05). As expected, the least reduction (+0.9 percent) was seen in the Non-Occupant Group. The 14.6 percent reduction represents an <u>annual</u> reduction for the Covered Group of 2301 serious or fatal injuries.

For fatalities (K), these injuries for the Covered Group were 11.6 percent lower than forecasted, with a nearly significant (p = 0.07) downward shift (or intervention) corresponding to the onset of \$25 citations, i.e., January 1, 1987. Note from Table 2, fatalities were up 6.3 percent for rear seat occupants of covered vehicles and 4.4 percent for non-occupants, with neither group showing significant intervention effects. The 11.6 percent reduction in fatalities for Covered Occupants for the first eighteen months of the citation phase translates into an estimated <u>annual</u> savings of 131 lives in North Carolina since January 1, 1987 due to the seat belt law and its enforcement.

Part IV. Statewide Enforcement Data

The effectiveness of any traffic law depends to a great extent on the level of enforcement accompanying it. This is particularly true for laws mandating the use of safety belts. The North Carolina law authorizes an officer to stop and cite a motorist on the basis of a belt law violation alone. This provision is called <u>primary</u> enforcement, and North Carolina is one of eight states with such a provision. Other states have what are called <u>secondary</u> enforcement laws. Under these provisions, an officer may address a belt law violation only if he has stopped a motorist for some other reason.

Campbell, Stewart and Campbell (1987) have shown that belt usage is higher in primary enforcement states and lower where a secondary enforcement policy prevails. Likewise, regardless of the state's primary or secondary enforcement status, when the enforcement level is low, belt usage tends to be lower. This section dscribes the level of enforcement seen in North Carolina during both the warning and \$25 citation phases of the law.

Enforcement data were obtained from the North Carolina State Highway Patrol as well as from some municipal police departments and county sheriff's offices. The Highway Patrol provided information from its records on the numbers of warning tickets and \$25 citations issued statewide with respect to the law. Enforcement at the local level was assessed from three separate mail surveys of North Carolina police departments and sheriff's offices. The surveys were conducted in the spring of 1986 (warning ticket phase), summer of 1987 (six months into the citation phase), and summer of 1988 (18 months into the citation phase).

N.C. State Highway Patrol Data

The N.C. Highway Patrol compiles data on the number of warning tickets and citations issued by its officers on a weekly basis. During the first month that the North Carolina belt law was in effect, the Patrol issued warnings to 10,220 motorists in violation of the law. During the entire 15-month warning period (October 1, 1985 through December 31, 1986), 144,991 warnings were issued, for an average of 9,666 warnings each month. This represents a considerable educational effort by the N.C. Highway Patrol.

During the first year of the **citation phase** (January 1 through December 31, 1987), the N.C. Highway Patrol issued \$25 citations for failing to wear a seat belt to 37,624 motorists, for an average of 3,135 per month. Activity through the first nine months (January through September) of 1988 is higher -- 49,098 total citations, for an average of 5,455 citations per month.

Figure 15 shows a weekly plot of seat belt citations issued by the N.C. State Highway Patrol from January through September, 1988 (40 weeks). The peaks in the data around weeks 22 and 27 (roughly the first of June and first of July) follow



Figure 15. Weekly seat belt citations issued by the North Carolina State Highway Patrol, January 1 - October 2, 1988.

upon a series of statewide law enforcement workshops held in the spring, Lifesavers Month in May, and distribution of video training tapes on enforcement of the seat belt law to all police and sheriff's departments in the State.

Local Seat Belt Law Enforcement Activities

Enforcement of the North Carolina seat belt law at the local level is carried out by the approximately 350 police departments and 100 county sheriffs offices in the State. An **initial survey** of these law enforcement agencies mailed in February, 1986 yielded data on enforcement activities during the first four months of the law's enactment. Results of this survey suggested an overall modest level of enforcement by the local police departments and a generally low level of enforcement by the county sheriffs during the initial few months of the warning period. Of the 152 police departments responding, 40 percent reported issuing one or more written warnings for failure to comply with the seat belt law, while 10 percent of the 29 sheriff's offices responding reported issuing written seat belt warnings. These percentages likely overestimate the statewide level of local seat belt law enforcement activities at this time, since one would expect a lower level of enforcement activity by the sizable proportion of non-respondents. Thus, most local police departments in North Carolina appear not to have issued written warning tickets during this period.

It should be noted that not all North Carolina police departments use warning tickets to enforce traffic laws, and even fewer sheriff's offices use the warning tickets. Also, many of the sheriff's offices refrain from enforcement of traffic laws altogether, leaving this to the Highway Patrol. Finally, a frequent comment from both police departments and sheriff's offices was that verbal warnings accomplish the same purpose as written warnings, with less risk of antagonizing the recipients. This was particularly true for some of the smaller towns and more rural localities.

A second survey was carried out in July, 1987 to capture information on enforcement activities during the initial six months (January through June, 1987) after the \$25 fine went into effect. Given the overall low level of traffic enforcement activities by the county sheriff's offices, this survey focused only on the local police departments. A limited follow-up effort helped to increase overall returns to 187.

Results of this second survey showed that 46 percent of the responding departments had issued at least one written warning during the 15-month warning phase of the law. This is a slightly higher number than in the earlier survey, but was based on the entire 15 months of the warning phase rather than just four. Of those 86 agencies reporting issuing written warnings, the average number of such warnings issued per month was 18.

During the first six months of the citation phase, 86 percent of the 187 reporting departments issued at least one \$25 citation for non-compliance with the seat belt law. Again, of those departments issuing citations, the average
number of citations issued per month during this initial six-month citation period was 6.5.

A final survey conducted in July, 1988 yielded the most current information on seat belt law enforcement activities at the local level in North Carolina. The survey was an expanded version of the earlier surveys and was mailed to both police departments and sheriff's offices. A copy of the survey is included as Appendix E. In addition to requests for numbers of citations and written and oral warnings issued for non-compliance with the seat belt law, other questions focused on enforcement of the North Carolina child restraint law; additional seat belt enforcement or education activities engaged in by the department; response to the recent video training tape produced in North Carolina and mailed to each department; perceived level of community belt use; willingness of officers to enforce the law; adjudication experience with respect to the law; etc.

Response to the survey was considerable, particularly from the local police departments: survey forms were returned by 246 of the 352 police departments for a response rate of 70 percent, and by 50 of the 100 sheriff's offices for a response rate of 50 percent. A number of additional phone calls were received, either to say that the enforcement information requested was not available or, in the case of the sheriff's offices, that they did not routinely enforce traffic laws.

Table 3 gives the percentage of police departments responding for various size communities as defined by population groups. While the response rate was

Population	Surveys Mailed	Surveys Returned	Percent Returned
< 2,500	197	133	67.5%
2,500 - 9,999	106	73	68.9%
10,000 - 49,999	37	28	75.7%
50,000 +	12^*	12	100.0%
Overall	352	246	70.0%

Table 3. Distribution of 1988 enforcement survey returns by city/town population (police departments only).

* Includes two surveys mailed to and received from county police departments.

higher for the larger cities, returns on the whole represent a balanced crosssection of the larger and smaller communities across the state.

Information on the number of **seat belt citations** issued by these 246 police departments is contained in Table 4. While the survey form asked for total numbers of citations issued (1) during 1987 and (2) during the period January -May, 1988, the data in Table 4 are presented in terms of the average number of citations issued each month -- both overall and within population groups. During 1987, over half of the departments (54 percent) issued, on average, less than one citation per month. (Thirty-one percent actually issued no citations during the entire year.) In contrast, nine percent of the reporting departments issued, on average, 10 or more citations per month.

Ave. No. Seat Belt	1987 Citations				19			
Citations Per Month	<2,500	2,500 - 24,999	25,000+	Total	<2,500	2,500 - 24,999	25,000+	Total
<1	93	30	0	123	72	23	0	95
	(75.6)*	(34.9)	(0.0)	(53.5)	(59.0)	(26.1)	(0.0)	(40.9)
1 - 3	26	37	1	64	41	45	3	89
	(21.1)	(43.0)	(4.8)	(27.8)	(33.6)	(51.1)	(13.6)	(38.4)
4 - 9	2	14	6	22	6	12	4	22
	(1.6)	(16.3)	(28.6)	(9.6)	(4.9)	(13.6)	(18.2)	(9.5)
10+	2	5	14	21	3	8	15	26
	(1.6)	(5.8)	(66.7)	(9.1)	(2.5)	(9.1)	(68.2)	(11.2)
Total***	123 [53.5]**	86 [37.4]	21 [9.1]	230	122 $[52.6]$	88 [37.9]	22 [9.5]	232

Table 4. Average number of seat belt citations issued monthly by size (population) of community.

* Column percent

** Row percent

*** 16 departments with missing information for 1987 14 departments with missing information for 1988 The 1988 numbers show generally an increased level of enforcement by these departments. The number of departments issuing less than one citation per month decreased from 123 (54 percent) to 95 (41 percent), while the number of departments issuing 10 or more citations increased.

Table 4 also presents this information by size (population) of community. As expected, police departments in larger communities issue greater numbers of citations: in 1987, 76 percent of communities with populations less than 2,500 issued less than one citation per month and only three percent issued four or more citations per month. In contrast, two-thirds of the communities with populations over 25,000 issued 10 or more citations per month.

All total, the police departments participating in this survey reported issuing 9600 citations in 1987, for an average of 800 citations per month. During the first five months of 1988, they reported issuing 5200 citations, for an average of 1040 per month. As these results represent over two-thirds of the total number of police departments in North Carolina and include the vast majority of cities with populations greater than 20,000, they likely do not underestimate by too great an amount the total number of seat belt citations issued by <u>all</u> municipal police officers in the State.

Table 5 presents the actual numbers of seat belt citations per month reported by the police departments in North Carolina cities with populations greater than 20,000. The numbers cited for Raleigh far exceed those of any other city. The results for the other cities are most variable, with some cities showing a higher per month rate in 1988 (e.g., Fayetteville, Havelock) and others showing a lower rate (e.g., Charlotte, Greenville).

In contrast to the police departments, a full two-thirds of the 50 responding sheriff's offices reported issuing no \$25 seat belt citations since the belt law went into effect, and an additional 15 percent left this question blank or noted that they did not routinely engage in traffic law enforcement activities. Of the remaining, only three had issued more than 10 citations.

In addition to inquiring about citations, the police were asked whether written warnings were issued for failure to comply with the seat belt law. Fiftyseven percent of the police departments responded affirmatively, with no significant differences by size of community. There were also no significant differences among the departments in terms of the average number of written warnings issued. Interestingly, of the responding departments, a large majority reported giving verbal warnings or reminders to persons observed not wearing seat belts (85 percent of police departments and 70 percent of sheriff's offices). Departments in the smaller communities were just as likely as those in the larger communities to engage in this form of enforcement activity.

A series of questions on the survey asked about other seat belt enforcement or education activities engaged in by the department. These results are summarized in Table 6. Of the activites listed, both police and sheriff's departments were most likely to have made presentations about seat belts to

City	Population (July 1986 Est.)	1987 Reported Seat Belt Citations Per Month	1988 Reported Seat Belt Citations Per Month (January - May)
Charlotte	368,212	94.2	34.0
Raleigh	201,447	157.9 *	150.2*
Greensboro	181,039	17.9	15.8
Winston-Salem	148,631	30.3	46.4
Durham	115,750	14.1	17.4
Fayetteville	71,108	26.7	94.2
High Point	66,791	12.3	16.2 *
Asheville	60,218	4.2 *	10.0 *
Wilmington	54,967	11.4	15.2
Gastonia	52,989	9.0	11.4
Rocky Mount	47,214	9.6	4.4
Greenville	41,912	21.3	2.2
Burlington	38,354	30.2	22.0
Cary	37,305	8.3 *	26.0 *
Wilson	36,767	20.8 *	15.0 *
Chapel Hill	35,251	8.6	3.2 *
Goldsboro	34,710	11.5	13.2 *
Kannapolis	32,158	†	16.2
Jacksonville	29,012		
Concord	28,171	7.3	3.8
Kinston	25,718	2.0	5.2
Hickory	25,558		
Salisbury	24,086	12.3	4.0
Havelock	23,067	1.4	18.4

Table 5.Seat belt law enforcement activities for the larger North
Carolina cities (population 20,000 or greater).

* Approximate numbers.

[†] Data not available.

	Percent Responding "Yes"			
Seat Belt Enforcement/Education Activity	Police	Sheriffs		
Conducted "seat belt checks" at roadblocks, etc.	48.6%	21.3%		
Issued press releases, news stories, etc. about seat belts.	38.4%	17.0%		
Made presentations about seat belts to church, civic, business, or school groups.	54.7%	36.2%		
Sponsored special events or activities for Child Passenger Safety Awareness Week.	24.1%	17.0%		
Sponsored special events or activities for Buckle Up America Week or Lifesavers Month.	29.0%	19.1%		
Other seat belt activities.	18.0%	14.9%		

Table 6.Participation by police and sheriff's departments in other seat
belt enforcement or education activities since January 1988.

church, civic, business or school groups (55 percent of police departments and 36 percent of sheriff's offices). Also, nearly half of the police departments (but a much smaller percentage of sheriff's offices) had conducted "seat belt checks" at roadblocks, parking lot locations, etc.

The remainder of the survey attempted to gauge police perception of the importance of the law and of public reaction to it. Certainly enforcement efforts should be strongly related to this perception. Thus, in a more open-ended format, the police and sheriffs were asked to comment on their experience in enforcing the North Carolina seat belt law, including willingness of officers to issue citations, public response to enforcement activities, support of city or town officials, adjudication problems, etc. Nearly a third of the 252 responding police departments indicated that they had experienced no problems in enforcing the seat belt law. Only 10 percent noted some reluctance on the part of officers to enforce the law; however, four percent (10 departments) stated that they only issued seat belt citations to persons already stopped for other offenses (secondary enforcement), and nine percent (22 departments) said they thought warnings were sufficient enforcement of the seat belt law. Concerning community support for the law, of the 83 police departments that commented, more said they thought their community supported the law (41 departments) than did not support the law (27 departments), although quite a few (15 departments) noted a mixed public reaction. (An additional 12 noted that the public wants to have the choice to wear or not wear seat belts.) Response to the law by public officials as perceived by the police was generally more positive -- 34 departments felt that their public officials strongly supported the law, versus only nine that stated a lack of official support for the law.

Finally, only a few departments made comments regarding adjudication experience with respect to the seat belt law. Of the 18 comments, half were favorable ("no problems," "strong judicial support," etc.) and half were unfavorable. Several of the departments noted that they had to pay overtime for appearances in court and thus preferred that officers not issue citations for seat belt offenses.

Part V. Discussion

The North Carolina belt law results to date show that the legislative intent -namely, increased statewide belt usage with subsequent injury and fatality reduction -- is being met, and the pattern of benefits is consistent with the events that have so far unfolded. During phase one (warning ticket only), North Carolina's seat belt law influenced the behavior of approximately one in five persons. Twenty-five percent were already using the belt prior to the law, and reduced casualties for that group were already present in the pre-law baseline data (hence, cannot be separated out). When phase one of the law took effect, an additional 17-19 percent buckled up. Thus, as would be expected, the phase one casualty reduction was rather modest when compared to the \$25 citation phase. In fact, fatalities for Covered Occupants increased slightly (1.4 percent) -although not as much as for Non-Covered Occupants (4.9 percent). On the other hand, the improvement in injury was 5.4 percent for serious or worse and 5.1 percent for moderate or worse injury.

During the first eighteen months of phase two (\$25 citation), the injury reduction experience was much more favorable, as expected. This period was marked by high belt use rates reaching a peak of 78 percent for drivers and then tapering off to nearly 60 percent toward the end of the period. Encouragingly the last two surveys show statewide usage for covered occupants rising to approximately 64 percent -- one of the highest rates in the U.S. Consistent with the increased belt usage during the citation phase, favorable casualty reductions were seen including an improvement in fatalities of 11.6 percent below forecast, serious or fatal injury of 14.6 percent, and moderate or worse injury of 11.6 percent. The fatality improvement represents a savings of 197 lives during the 18 -month period. Overall, during this phase approximately 7530 persons in crashes in North Carolina benefitted from the seat belt law in terms of reduced moderate or worse injuries.

Thus, it is clear that changes have taken place with respect to injury reduction and that these changes are most apparent within the group where they should be most apparent, and are less apparent or not seen at all in groups not targeted or expected to be affected by the law. These changes are generally in the direction of reduced injuries and deaths. And, in addition, the changes occur the very months in which the warning ticket and citation phases took effect, namely, October 1985 and January 1987.

What does this translate into with respect to cost savings for the State of North Carolina? An estimate can be made using the motor vehicle accident costs advocated by the Federal Highway Administration (FHWA, 1988), namely

> \$1,500,000 per fatality 39,000 per A injury 12,000 per B injury

These costs are based on studies carried out for the Federal government using a

"willingness-to-pay" model, which includes both direct and indirect costs. It "reflects the value which individuals are willing to pay to reduce the number or severity of accidents or to ensure continued health and safety." If one uses these cost estimates, the injury reductions for the warning and citation phases combined represent a savings of over \$500 million since October 1, 1985.

It is worthwhile to consider why the injury trends are not even more favorable. Certainly research on belt effectiveness indicates that, with full compliance, belts are capable of producing a much greater casualty reduction (Hedlund, 1985; Campbell, 1984b) than observed herein. The level and nature of belt use (both before and after the law) is precisely the answer. Consider the following:

- a. First, belt laws don't apply to all. The North Carolina law exempts rear seat occupants; it exempts all commercial and farm vehicles being used in commerce; it exempts older cars; it provides for both medical exemptions and for slow-moving delivery vehicles; and the law doesn't apply to bicyclists, motorcyclists, pedestrians, etc. All in all, at least 30 percent of those in crashes fall in categories NOT covered by the law.
- b. Second, not everyone buckles up. During the citation phase, belt use for front seat occupants of Covered vehicles has averaged around 65 percent.Using 25 percent as the average rate at which occupants were buckled up over the six years prior to January 1, 1987, the citation phase of the law resulted in an increment of 40 percent (= 65% minus 25%) of crash victims that would be restrained after the law that would not have been buckled up otherwise. Thus, a net of 28 percent (=40% of 70%) of the crash victims should be restrained <u>due</u> to the law and hence be affected.
- c. Third, belt effectiveness in reducing death is in the range of 40 to 50 percent. Thus one might expect to see an 11 percent (= 40 percent of 28 percent) to 14 percent (= 50 percent of 28 percent) reduction in fatalities among Covered Occupants affected by the \$25 citation phase.
- d. Other less quantifiable factors that would suppress the effectiveness estimate even further include:
 - 1. North Carolina's population and driving mileage continue to grow. With this growth, there would be an expected growth in accidents and likewise fatalities which would affect some of the belt law benefits.
 - 2. Significant changes in the economy exercise a considerable influence on traffic deaths above and beyond that accounted for by changes in driving mileage. During economic growth (as has been the case in North Carolina), deaths rise. The belt law is working against this rising tide.
 - 3. Next, there is scientific evidence that drivers with the highest crash risk are the ones least likely to buckle up; i.e., the 35 percent who do

not buckle up in North Carolina will account for more than 35 percent of the total crashes.

4. Finally, in mid-August, 1987, the speed limit was raised to 65 mph on nearly two-thirds of North Carolina's 1798 miles of rural Interstate highways. This would be expected to slightly reduce some of the benefits of the belt law statewide.

The bottom line is that the 11.6 percent estimate of fatality reduction is clearly consistent with the level of belt usage observed both before and after implementation of the \$25 citation.

Clearly the answer to increased benefits is greater compliance particularly by the high-risk drivers. Williams and Lund (1987) demonstrate that compliance can be raised considerably through a combined enforcement and publicity campaign. Belt use rates in Elmira, New York -- a state with a belt law -- went from 49 percent before the program to 77 percent right after and settled at 66 percent two months later. In Glen Falls, New York, a comparison city without such a program, belt use declined from 43 percent to 37 percent during this same time period.

Unfortunately, in North Carolina (and the United States), the climate still does not completely favor very high levels of compliance even though we continue to have one of the highest statewide usage rates at over 60 percent. As found time and again in our annual surveys of local police departments, some agencies do not fully support the law, and thus enforcement in many cases is not very intense. Some of the state laws other than in North Carolina restrict enforcement either by limiting the penalty to a warning or by prohibiting enforcement except <u>after</u> the motorist is already stopped for some other offense. Fortunately, North Carolina has primary enforcement which has been shown to be associated nationally with higher belt usage (Campbell, Stewart and Campbell, 1987).

In addition, seat belt laws came into being in the United States in the context of the 15 year consideration of air bags. This is one burden the United States has that perhaps no other country has had to contend with -- the dispute both in scientific circles and among policy makers between the two approaches to occupant restraint, i.e., bags vs. belts.

Nevertheless, the results seen here in North Carolina are most encouraging. Few (if any) injury reduction countermeasures have shown the degree of success that statewide implementation of our seat belt law has demonstrated.

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APPENDIX A

Data Collection Forms for Field Observations of Belt Usage

Observation Site # _____ County _____ Date _____/ 85 Time: Start ____: Finish _____ Finish _____ Н 24-hour time clock 1 - Clear, sunny 3 - Rain 2 - Cloudy 4 - Snow, ice Weather 07:30 for 7:30 a.m. Pavement type 1 - Paved 2 - Unpaved 14:30 for 2:30 p.m. ____ Area type 0 - Rural 5 - Urban Observers (initials): _____ and ____ Comments: (People's reactions, problems with site location, visibility problems, observation method) Indicate observer position, traffic signs and signals and for Diagram of site location: ALL intersections: roads, lanes on each road, names of roads, etc. Indicate North : :

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Version 2

Site	*	Observer (1	nitials) <u> </u>	Page # of			
Veh#	Veh. Type	Driver Race & Sex Belt	Center Front Race & Sex Belt	Right Front Race & Sex Belt	Notes		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
Page c	ount: <u>Restra</u> Tot	al]				
	Vehicle Type	e Ra	ce & Sex	Belt Statu	s		
1	blank Passenger C Convertibl	car WM e WF	White Male White Female	Nor – N L Lano	o restraint nIv		
	V Van	W?	White Unknown	S Lap a	nd shoulder belt		
	 Pickup O Other (specific 	cify) BF	Black Female	C Child X Impro	restraint oper child restraint		
	? Unknown	B? ?	Black Unknown Unknown	? Unknown			

Comments

Figure A.2

APPENDIX B

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Driver and Front Seat Occupant Belt Usage Rates by Time Period

Table B.	1. Driver	belt	usage	rates	in	North	Carolina.
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	PRE-LAW		POST-LAW Warning Ticket Phase					
	Sept. 1985 (72 sites)	Nov. 1985 (12 sites)	Jan. 1986 (72 sites)	March 1986 (12 sites)	April 1986 (12 sites)	June 1986 (72 sites)	Aug. 1986 (12 sites)	Oct. 1986 (72 sites)
Overall Driver Usage %: Observed [Weighted] (No. vehicles)	25.4 [25.5] (18,212)	45.0 [46.5] (6734)	41.9 [44.3] (19,927)	45.4 [47.0] (3380)	47.7 [49.0] (3339)	43.7 [44.8] (19,159)	40.8 [41.0] (4260)	43.8 [44.8] (21,859)
Rural/Urban Rural Urban	22.1 28.4	40.5 49.0	38.2 45.4	41.3 48.8	42.8 51.6	41.0 47.0	36.5 43.9	40.5 47.6
Region Mountains Piedmont Coast	23.5 27.6 25.1	40.8 48.5 49.2	43.7 44.2 37.9	40.5 47.6 50.8	42.2 50.4 51.3	41.9 46.5 42.5	34.5 45.2 44.0	41.9 46.6 43.4
Time of Day Commuting Non-Commuting	27.2 24.0	47.3 44.0	43.2 41.1	42.6 46.7	47.3 47.9	46.3 41.8	42.1 40.1	47.0 41.6
Vehicle Type Car Van Pickup Other	26.6 25.9 18.5 31.1	45.8 49.3 39.0 50.4	45.1 34.2 30.1 43.2	48.1 48.8 33.3 51.3	50.4 48.2 36.8 42.2	46.5 45.2 31.3 51.3	43.3 44.1 28.8 45.5	47.4 44.5 30.5 42.7
Sex of Driver Male Female	23.7 28.0	43.0 47.7	37.2 49.2	41.8 50.4	45.9 50.5	39.9 49.9	38.8 43.7	38.8 51.3
Race of Driver White Black	26.5 15.5	45.1 43.8	43.0 34.9	45.3 46.0	47.9 46.8	44.5 35.7	41.3 38.1	44.7 36.0

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	POST-LAW Citation Phase							
	Jan. 1987 (72 sites)	March 1987 (12 sites)	April 1987 (12 sites)	June 1987 (72 sites)	Aug. 1987 (12 sites)	Oct. 1987 (72 sites)	Jan. 1988 (72 sites)	March 1988 (12 sites)
Overall Driver Usage %: Observed [Weighted] (No. vehicles)	77.7 [77.9] (15,847)*	71.3 [69.9] (3042)	67.4 [66.6] (3150)	64.0 [66.6] (17,971)	63.1 [60.6] (3537)	62.7 [64.7] (21,423)	60.0 [61.6] (21,341)	60.2 [60.0] (38 2)
Rural/Urban Rural Urban	75.7 80.1	69.7 72.4	61.8 71.5	59.3 69.2	61.6 64.7	58.7 67.4	54.6 65.0	57.8 62.3
Region Mountains Piedmont Coast	71.9 78.9 81.1	63.8 75.3 76.3	59.9 74.7 68.3	56.9 69.5 64.3	57.4 68.2 63.4	53.7 67.8 65.8	46.8 65.3 66.6	51.0 66.3 66.6
Time of Day Commuting Non-Commuting	80.2 75.5	70.5 72.2	66.3 68.4	65.8 62.5	61.4 64.3	66.1 60.0	62.2 57.4	60.1 60.2
Vehicle Type Car Van Pickup Other	80.3 72.9 69.5 76.7	75.4 63.7 58.3 70.3	70.6 69.4 53.5 64.8	68.1 55.7 50.1 66.6	67.4 51.9 48.6 53.8	66.4 51.7 50.3 64.9	64.7 52.3 43.7 59.8	65.2 41.4 45.6 56.6
Sex of Driver Male Female	73.8 84.4	67.4 77.3	64.3 72.0	59.6 71.0	58.7 69.9	57.5 70.3	53.5 69.9	55.2 68.2
Race of Driver White Black	77.2 80.4	70.6 74.0	65.9 73.6	63.8 65.7	62.3 66.4	62.7 62.8	58.8 65.4	59.6 62.9

*Survey methodology modified to collect data only for vehicles completely stopped.

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Table B.1. Continued.

	POST-LAW Citation Phase						
	April 1988 (12 sites)	June 1988 (72 sites)	Aug. 1988 (12 sites)				
Overall Driver Usage %: Observed [Weighted] (No. vehicles)	59.8 [58.6] (4089)	62.4 [65.0] (24,183)	62.7 [63.6] (3768)				
Rural/Urban Rural Urban	55.1 63.7	58.5 66.5	60.6 65.1				
Region Mountains Piedmont Coast	50.2 68.2 63.1	55.5 67.7 64.0	58.1 66.7 64.7				
Time of Day Commuting Non-Commuting	59.1 60.5	63.3 61.6	62.0 63.3				
Vehicle Type Car Van Pickup Other	63.7 54.9 45.4 64.4	67.1 47.6 47.5 64.0	68.4 49.3 44.4 63.7				
Sex of Driver Male Female	54.7 67.3	56.5 70.9	57.0 71.5				
Race of Driver White Black	58.5 66.5	62.0 65.1	61.9 67.1				

	PRE-LAW		POST-LAW Warning Ticket Phase						
	Sept. 1985 72 sites)	Nov. 1985 (12 sites)	Jan. 1986 (72 sites)	March 1986 (12 sites)	April 1986 (12 sites)	June 1986 (72 sites)	Aug. 1986 (12 sites)	Oct. 1986 (72 sites)	
Overall Usage %: Observed [Weighted] (No. occupants)	24.1 [24.1] (25,084)	42.3 [44.1] (8858)	39.7 [42.6] (26,722)	42.8 [45.0] (4647)	45.8 [47.1] (4549)	42.2 [43.3] (26,546)	38.9 [39.7] (5675)	42.0 [43.3] (29,982)	
Rural/Urban Rural Urban	21.2 27.0	38.0 46.5	35.8 43.6	38.7 46.4	41.9 49.1	40.0 45.3	34.9 41.9	39.0 45.5	
Region Mountains Piedmont Coast	22.5 26.2 23.8	38.4 46.8 45.4	41.8 42.3 35.2	38.2 44.5 48.5	41.2 48.7 47.9	41.2 44.6 40.6	33.4 42.6 42.3	40.4 44.3 41.5	
Time of Day Commuting Non-Commuting	25.8 22.9	44.1 41.6	40.7 39.1	39.5 44.5	45.4 45.9	44.4 40.7	39.5 38.6	45.3 39.8	
Vehicle Type Car Van Pickup Other	25.5 24.8 16.3 30.2	43.3 45.4 35.8 50.3	42.9 33.3 27.4 40.4	45.3 49.1 31.1 47.3	48.5 48.8 33.5 44.6	45.1 44.2 29.5 49.4	41.6 40.9 26.3 43.1	45.5 44.0 28.3 41.6	
Sex of Occupant Male Female	22.3 25.9	40.3 44.2	34.9 45.7	39.9 46.1	43.5 48.6	38.3 47.0	36.7 41.4	36.8 47.9	
Race of Occupant Non-black Black	25.2 14.4	42.7 39.4	41.1 31.2	42.9 42.7	46.3 43.2	43.2 32.5	39.5 35.5	43.1 32.8	

Table B.2. Front seat occupant belt usage rates in North Carolina.

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Table B.2. Continued.

	POST-LAW Citation Phase							
	Jan. 1987 (72 sites)	March 1987 (12 sites)	April 1987 (12 sites)	June 1987 (72 sites)	Aug. 1987 (12 sites)	Oct. 1987 (72 sites)	Jan. 1988 (72 sites)	March 1988 (12 sites)
Overall Usage %: Observed [Weighted] (No. occupants)	75.8 [76.4] (21,675)*	69.1 [68.0] (4142)	65.3 [64.3] (4273)	61.7 [64.9] (25,033)	60.4 [58.3] (4870)	60.5 [62.6] (28,946)	57.6 [59.8] (28,467)	59.1 [59.3] (4945)
Rural/Urban Rural Urban	74.0 78.2	67.6 70.3	60.5 69.0	57.1 67.0	58.7 62.1	56.8 65.1	52.9 62.7	57.5 60.7
Region Mountains Piedmont Coast	70.7 76.9 79.0	62.2 72.9 73.6	58.3 72.8 65.3	54.4 67.6 62.0	55.5 64.8 60.8	51.7 65.8 63.7	45.1 63.0 65.3	50.5 64.4 66.4
Time of Day Commuting Non-Commuting	78.0 74.1	68.1 70.4	64.8 65.7	63.1 60.6	58.0 62.0	63.4 58.4	60.0 55.5	58.6 59.6
Vehicle Type Car Van Pickup Other	78.8 70.3 66.5 78.0	73.3 61.4 56.1 68.9	68.4 64.8 51.7 66.2	65.8 53.0 47.8 63.8	64.8 45.5 46.1 50.7	64.4 49.1 47.1 63.4	62.6 49.9 41.5 58.3	64.3 39.0 44.0 58.3
Sex of Occupant Male Female	71.7 81.3	65.3 74.1	62.0 69.2	57.3 67.1	56.3 65.6	54.9 67.0	51.8 65.0	53.1 67.3
Race of Occupant Non-black Black	75.6 77.5	68.6 71.1	63.9 70.6	61.4 63.5	59.9 62.7	60.6 60.2	57.0 61.6	58.5 62.1

*Survey methodology modified to collect <u>only</u> for vehicles completely stopped.

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	C	POST-LAW Sitation Phas	e
	April 1988 (12 sites)	June 1988 (72 sites)	Aug. 1988 (12 sites)
Overall Usage %: Observed [Weighted] (No. occupants)	57.6 [56.7] (5448)	60.7 [63.7] (32,590)	62.2 [63.5] (5002)
Rural/Urban Rural Urban	53.1 61.6	56.9 65.1	60.1 64.7
Region Mountains Piedmont Coast	48.4 65.5 61.2	53.7 66.2 62.9	58.5 65.4 63.9
Time of Day Commuting Non-Commuting	56.6 58.6	61.1 60.4	61.2 62.9
Vehicle Type Car Van Pickup Other	61.5 54.6 42.6 63.3	65.6 45.8 44.9 63.1	68.2 51.3 41.6 66.4
Sex of Occupant Male Female	52.2 64.4	54.3 68.1	55.4 70.5
Race of Occupant Non-black Black	56.5 63.2	60.3 63.5	61.7 64.9

APPENDIX C. DERIVATION OF THE STANDARD ERRORS FOR THE WEIGHTED BELT USAGE RATES

Due to the complexity of the sampling scheme, two methods for obtaining estimates of the precision of these weighted belt usage rates were utilized and the results compared. The first is a resampling procedure called the Bootstrap method and the second uses a SAS procedure that accounts for differing sampling rates. As will be seen, both procedures yield very similar estimates.

The Bootstrap method is a resampling plan that utilizes a Monte Carlo algorithm to sample randomly from the observed belt usage rates using the average daily traffic (ADT) rates as the sampling probabilities. The mean is then calculated for each of B Bootstrap samples. The variance of the B means then estimates the variance of the weighted belt usage rates.

More specifically, let $\underline{p} = (p_1, p_2, \dots, p_{12})$ be the vector of ADT proportions for a given mini-wave survey where $\begin{array}{c} 12\\ \Sigma\\ i=1 \end{array}$ proportions for a given mini-wave survey where $\begin{array}{c} 12\\ \Sigma\\ i=1 \end{array}$

 $\underline{X} = (X_1, X_2, \dots, X_{12})$ be the vector of belt usage rates for the twelve sites. To perform the Monte Carlo algorithm, take a Bootstrap sample

$$\underline{x}_{b}^{*} = (x_{1}^{*}, x_{2}^{*}, \ldots, x_{12}^{*})$$

where $\underline{X}_{b}^{\star}$ represents twelve independent draws with replacement from \underline{X} , where $\underline{X}_{1}^{\star}$ is selected with probability p_{1} . A total of B Bootstrap samples are drawn yielding $\underline{X}_{1}^{\star}$, $\underline{X}_{2}^{\star}$, $\underline{X}_{3}^{\star}$, ..., $\underline{X}_{B}^{\star}$. For each

Bootstrap sample, calculate $\bar{x}_b^* = \sum_{i=1}^{12} x_{ib}^*/12$. The estimated variance of the i=1

overall weighted belt usage rate is then the variance of all B Bootstrap means,

i.e.,
$$\hat{\sigma}_{B}^{2} = \sum_{b=1}^{B} (\bar{x}_{b}^{\star} - \bar{x}^{\star})^{2} / (B-1)$$
 where $\bar{x}^{\star} = \sum_{b=1}^{B} \bar{x}_{b}^{\star} / B$

Alternatively, using the SAS PROC MEANS estimation procedure, let X_1, X_2, \ldots, X_{12} be the belt usage rates from the twelve sampling sites for a given time period, and let $f(X_1)$, $f(X_2)$, ..., $f(X_{12})$ be the ADT proportions where

 $f(X_{i}) = \frac{ADT_{i}}{12}$. The variance of the weighted sample $\sum_{\substack{i=1}}^{12} ADT_{i}$

rate X_w is given by the following:

$$VAR(X_w) = \sum_{i=1}^{12} f(X_i)(X_i - X_w)^2$$

The standard error is then calculated by dividing the variance obtained from PROC MEANS by 12, and taking the square root.

A comparison of the Bootstrap (B = 100 samples) and the SAS PROC MEANS estimates of the standard errors for each of the mini-wave surveys is presented in Table C.1. As can be observed, the differences are minimal. Thus, due to computational ease, standard errors (S.E.'s) are provided in Table C.2 for the weighted belt usage rates (for both drivers and all front seat occupants) for all nineteen surveys using the SAS PROC MEANS program.

		Standard Error (S.E.)	
Year	Month	Bootstrap $(B = 100)$	SAS PROC MEANS
1985	November	2.51	2.51
1986	March April August	2.44 2.53 2.49	2.52 2.73 2.57
1987	March April August	$1.92 \\ 2.16 \\ 1.76$	1.91 2.20 1.59
1988	March April August	2.51 2.33 2.22	2.53 2.25 2.14

 Table C.1. Comparison of Bootstrap and SAS PROC MEANS

 standard errors for weighted <u>driver</u> belt usage rates.

			DRIVER		FRONT SEAT OCCUPANTS	
Year	Month	Number of Sites	Weighted Rate	S.E.	Weighted Rate	S.E.
1985	September	72	25.5	0.92	24.1	0.89
	November	12	46.5	2.51	44.1	2.50
1986	January March April June August October	72 12 12 72 12 72	44.3 47.0 49.0 44.8 41.0 44.8	$1.11 \\ 2.52 \\ 2.73 \\ 1.02 \\ 2.57 \\ 1.21$	42.6 45.0 47.1 43.3 39.7 43.3	1.16 2.47 2.46 1.00 2.64 1.21
1987	January	72	77.9	0.76	76.4	0.72
	March	12	69.9	1.91	68.0	1.87
	April	12	66.6	2.20	64.3	2.04
	June	72	66.6	1.02	64.9	1.02
	August	12	60.6	1.59	58.3	1.69
	October	72	64.7	1.06	62.6	1.07
1988	January	72	61.6	1.28	59.8	1.31
	March	12	60.0	2.53	59.3	1.04
	April	12	58.6	2.25	56.7	0.87
	June	72	65.0	0.95	63.7	1.00
	August	12	63.6	2.14	63.5	0.84

Table C.2. Overall weighted belt usage rates and standard errors (SAS PROC MEANS).

APPENDIX D. Time Series Analysis of North Carolina Crash Injury Data (January 1981 - June 1988)

A time series X_t , t = 1, 2, ..., T is a sequence of observations of some quantity, X, made at consecutive points over time. The values of X_t at different time points are not assumed to be independent observations, but, rather, it is assumed that there exists a stable autocorrelational pattern which relates a value X_t to previous values of the series. By analyzing this autocorrelational structure, models can be fit to time series data which, in turn, can be used to produce forecasts of the series that would be expected under various hypotheses.

In this application, since <u>reported</u> belt usage was considered most unreliable, time series models were fit to monthly data series on the percent of crash victims injured at some specified level for each of four study groups:

- 1. Front seat occupants of vehicles covered by the occupant restraint law (covered occupants);
- 2. Rear seat occupants of covered vehicles;
- 3. Non-occupants (pedestrians, bicyclists, etc.);
- 4. Occupants of vehicles not covered by the law.

For each of the first three categories, models were fit to

- % K (killed)
- % A+K (seriously injured or killed)
- % B+A+K (moderately injured or worse)

No modelling was done for the K series of category 4 since many of these frequencies were 0 or 1. Thus, models were fit to 11 data series.

For each series, a model was fit over the entire span of observations (Jan. '81 - June '88) which contained two intervention variables: one corresponding to the warning ticket phase of the seat belt law (Oct. '85 - Dec. '86), and the other corresponding to the \$25 citation phase (Jan '87 - June '88). An intervention for the warning ticket phase which assumed its maximum value for the first three months, half this value for the next three months, and then vanished fit the covered occupant series better than did either the usual step function type intervention or the one that assumed its maximum value and then decreased uniformly to zero over the 15 month period.

Models were also fit to data series over the time intervals Jan.'81 -Sept.'85, and Jan.'81 - Dec.'86. Forecasts were made of counts of injuries at the various severity levels over the <u>warning</u> ticket period and the <u>citation</u> phase, respectively. Forecasted values were then compared with actual values.

These analyses were all carried out using the computer routine STAMP (Structural Time Series Analyzer, Modeller and Predictor). Structural time

series models were formulated in terms of stochastic (randomly varying) levels, slopes, seasonal effects, cycles, and a purely random or irregular component. The simplest such model contains only a stochastic slope and an irregular component. It has the form

$$y_t = \mu_t + \varepsilon_t$$
, where
 $\mu_t = \mu_{t-1} + \delta_t$

Both ε_t and δ_t are random terms each having mean zero and variances σ_{ε}^2 and σ_{δ}^2 , respectively. Thus, the value of the series y_t at time t is the level μ_t plus an error term ε_t . The value of the level μ_t is its value at time t-1, namely, μ_{t-1} plus a second error term δ_t .

Note that the only fixed parameters in this model are the variances σ_{ϵ}^2 and σ_{δ}^2 . Slopes, seasonal effects, cycles, etc. add other terms and variances to the equation. Advantages of such models over ARIMA (Autoregressive Integrated Moving Average) models are that concepts such as trends and seasonal effects are somewhat intuitive; the models are easier to fit; and the program provides informative graphs of smoothed estimates which illustrate what is happening with the models and forecasts.

In all, 33 models were fit to these data series. The primary results of these models are summarized in Tables D.1 - D.4. Plots of actual vs. predicted injuries are shown in Figures D.1 - D.3 for the warning ticket phase and in Figures D.4 - D.6 for the \$25 citation phase for front seat occupants covered by the law. As is clear in both Table D.1 and the respective figures, there was a clearly greater effect on injury and fatality reduction brought about by the enforcement phase (Jan. '87) of the law than by the warning ticket phase.

Intervention	Percent Killed Percent A+K		Percent A+B+K	
WARNING Oct 85 Intervention (decreasing) *	Effect =040 t = -1.92 ** p < .05	Effect =471 t = -2.74 p < .005	Effect = -1.26 t = -3.41 p < .001	
Totals	Predicted = 1281	Predicted = 19,746	Predicted = 54,864	
Oct 85 - Dec 86	Actual = 1299	Actual = 18,675	Actual = 52,052	
Difference	+ 18	- 1071	- 2812	
% Decrease	+ 1.4%	- 5.4%	- 5.1%	
CITATION	Effect =030	Effect =606	Effect = -1.36	
Jan 87	t = -1.52	t = -3.05	t = -3.04	
Intervention	p ≈ .07	p < .005	p < .005	
Totals	Predicted = 1702	Predicted = 23,679	Predicted = 64,724	
Jan 87 - Jun 88	Actual = 1505	Actual = 20,228	Actual = 57,193	
Difference	-197	- 3451	- 7531	
% Decrease	-11.6%	- 14.6%	- 11.6%	

Table D.1. Covered front seat occupants.

* An intervention effect which assumed its maximum value for the first three months, half that value for the next three months, and then vanished was chosen on empirical grounds for the warning phase intervention.

For the enforcement phase intervention, the usual step function was used.

** p-values shown are for one-sided tests for occupants of covered vehicles -two-sided tests in other cases.

Intervention	Percent Killed	Percent A+K	Percent A+B+K
WARNING Oct 85 Intervention (decreasing)	Effect = .009 t = .160 p > .20	Effect =284 t = -1.21 p > .10	Effect =356 t =863 p > .10
Totals	Predicted = 103	Predicted = 1551	Predicted = 4835
Oct 85 - Dec 86	Actual = 108	Actual = 1570	Actual = 4839
Difference	+ 5	+ 19	+ 4
% Decrease	+ 4.9%	+ 1.2%	+ 0.1%
CITATION	Effect = .026	Effect =297	Effect =632
Jan 87	t = .565	t = -1.61	t = -1.767
Intervention	p > .20	p ≈ .06	p < .05
Totals	Predicted = 128	Predicted = 1932	Predicted = 6079
Jan 87 - Jun 88	Actual = 136	Actual = 1735	Actual = 5541
Difference	+ 8	- 197	- 538
% Decrease	+ 6.3%	- 10.2%	- 8.9%

Table D.2. Rear seat occupants of covered vehicles.

Table D.3. Occupants of vehicles not covered by seat belt law.

Intervention	Percent Killed	Percent A+K	Percent A+B+K
WARNING Oct 85 Intervention (decreasing) Totals Oct 85 - Dec 86 Difference % Decrease	Insufficient Data	Effect =216 t = -1.20 p > .20 Predicted = 365 Actual = 288 - 77 - 21.1%	Effect =736 t =974 p > .20 Predicted = 936 Actual = 864 -72 -7.7%
CITATION Jan 87 Intervention Totals Jan 87 - Jun 88 Difference % Decrease	Insufficient Data	Effect = 152 t = 697 p > $.20$ Predicted = 383 Actual = 337 - 46 - 12.0%	Effect = 938 t = -1.20 p > $.20$ Predicted = 1080 Actual = 928 -152 -14.1%

Intervention	Percent Killed	Percent A+K	Percent A+B+K
WARNING Oct 85 Intervention (decreasing)	Effect = .240 t = .628 p > .20	Effect = 1.42 t = .657 p > .20	Effect = 1.80 t = 1.83 .05 < p < .10
Totals	Predicted = 446	Predicted = 3414	Predicted = 6027
Oct 85 - Dec 86	Actual = 451	Actual = 3321	Actual = 6173
Difference	+ 5	- 93	+ 146
% Decrease	+ 1.1%	- 2.7%	+ 2.4%
CITATION	Effect =165	Effect = 2.72	Effect =058
Jan 87	t =419	t = 1.03	t =058
Intervention	p > .20	p > .20	p > .20
Totals	Predicted = 478	Predicted = 3728	Predicted = 7024
Jan 87 - Jun 88	Actual = 499	Actual = 3760	Actual = 7028
Difference	+ 21	+ 32	+ 4
% Decrease	+ 4.4%	+ .9%	+ 0.1%

Table D.4. Non-occupants.



Figure D.2. Percent of front seat covered occupants seriously injured or killed -- actual vs. forecast through Warning Phase.

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Figure D.1. Percent of front seat covered occupants killed -actual vs. forecast through Warning Phase.

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Figure D.3. Percent of front seat covered occupants with moderate or worse injury -- actual vs. forecast through Warning Phase.

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Figure D.4. Percent of front seat covered occupants killed -actual vs. forecast through Enforcement Phase.



Figure D.5. Percent of front seat covered occupants seriously injured or killed -- actual vs. forecast through Enforcement Phase.



Figure D.6. Percent of front seat covered occupants with moderate or worse injury -- actual vs. forecast through Enforcement Phase.

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VDFENDIX E

Questionnaire for the Law Enforcement Survey



N.C. Seat Belt Law Enforcement Survey June 1988

1.	Name of Department:
2.	Total number of (Traffic) Law Enforcement Officers in Department:
	Less than 5 5-9 10-19 20-49 50 or more
За.	Please give the following information on \$25 seat belt citations issued since Jan. 1, 1987 for non-compliance with the N.C. Seat Belt Law (G.S. 20-135.2A):
	Total citations issued January-December 1987 (Check here if approximate [])
	Total citations issued January-May 1988 (Check here if approximate])
b.	Please give the following information on \$25 child restraint citations issued since Jan. 1, 1987 for non-compliance with the N.C. Child Passenger Protection Law (G.S. 20-137.1):
	Total citations issued January-December 1987 (Check here if approximate <a>[])
	Total citations issued January-May 1988 (Check here if approximate 🔲)
4a.	Does your Department issue written warnings for non-compliance with the N.C. Seat Belt Law?
	No Yes —→ Approximately how many per month?
	Comments:
b.	Does your Department issue written warnings for non-compliance with the N.C. Child Passenger Protection Law?
	No Yes — Approximately how many per month?
	Comments:

5a.	Does your Department issue verbal warnings for non-compliance with the N.C. Seat Belt Law? No Yes Approximately how many per month? Comments:	
b.	Does your Department issue verbal warnings for non-compliance with the N.C. Child Passenger Protection Law?	
6.	Below are listed some seat belt enforcement/education activities. Please indicat whether your Department has engaged in any of these since January 1988 :	te Io
	Conducted "seat belt checks" at roadblocks, etc	
7.	The N.C. Governor's Highway Safety Program and the UNC Highway Safety Research Center distributed a video training tape with "The Need for Seat Belts" and "North Carolina's Seat Belt Laws," to all N.C. law enforcement agencies in April. In reference to this program,	
	a. About what percent of your traffic officers have viewed the tape?	percent
	b. How has this program affected the level of enforcement of the Seat Belt Law in your department?	
	 Decreased Increased Stayed about the same c. How has this program affected the level of enforcement of the Child Passenger Protection Law in your department? 	
	Decreased Increased Stayed about the same d. Do you plan to use the tape in future training sessions? Yes No Maybe / Don't know	

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