THE IMPACT OF ONTARIO'S CHILD RESTRAINT LEGISLATION ON THE INCIDENCE, SEVERITY AND PATTERNS OF INJURY IN CHILDREN UNDER FIVE YEARS

by

LINDA DEBRA SENZILET

Thesis submitted to
the School of Graduate Studies and Research
in partial fulfilment of the requirements for the
M.Sc. degree in Epidemiology

University of Ottawa

ISBN 0-315-85845-1

ABSTRACT

Motor vehicle crashes claim the lives of more Canadian children than any other cause of injury-related death. More than half of the 672 Canadian children under the age of five years who were killed in motor vehicle crashes between 1981 and 1988 were passengers. Almost one-third of those passengers were killed in the province of Ontario.

Passenger fatalities contribute more than half of the potential years of life lost (PYLL) before age 75 due to all types of motor vehicle crashes. Ontario child passengers under 5 years who died between 1981 and 1988 accounted for almost 30% of the PYLL for Canadian children who were killed as passengers.

In addition, during this time 30% of all hospitalized Canadian child passengers under 5 were hospitalized in Ontario.

In 1983, the Ontario government introduced legislation which mandated the restraint of all child passengers under 50 pounds in restraint systems appropriate to their weight. The efficacy of such restraint systems has been proven, and standards for their manufacture have been set by the government of Canada.

The objectives of this study were to determine whether Ontario's child restraint legislation has resulted in significant and sustained reductions in the incidence and severity of injury, as well as changes in the anatomical patterns of fatal and non-fatal injury. Data sources included the Hospital Medical Records Institute (HMRI) and Transport Canada's Traffic Accident Information Data Bank (TRAID).

The study used the interrupted time-series design and autoregressive integrated moving average (ARIMA) modelling to analyze a variety of rates and indicators calculated for children under 5, as well as for a control group of adults 20-44 years old. The study period encompassed five pre-law years and five post-law years, extending from 1979 to 1988.

Results suggested that there were no significant changes in either the incidence, severity or anatomical patterns of injury in children covered by the legislation. Two possible explanations for the apparent lack of an intervention effect are that either the pre- to post- legislation increase in (proper) usage rates was not large enough, or that any positive effects of the law were too gradual to be detected. These conclusions are supported by evidence that there was a relatively high usage of child restraints prior to the legislation, and that rates of proper wearing of restraints did not exceed 50% in the years following implementation. In addition, pre-existing long-term Canadian trends in motor vehicle casualty reductions may have attenuated any effect of the legislation.

Child restraint laws cannot achieve their objectives without a higher level of sustained compliance. Several means of achieving this objective are presently being implemented by the so-called "95 by 95" program, i.e., the National Occupant Restraint Program that is operating in all provinces, and whose stated goal is a 95% wearing rate of restraints in all age groups by the year 1995. Efforts are being directed at improving police officer training, heightened enforcement, targeting of high-risk groups and non-compliers, elimination of most exemptions to the legislation, installation clinics and public awareness and education.

Manufacturers of child restraints must be encouraged in their efforts to simplify the design and installation procedures in order to reduce the negative impact of improper restraint use. In addition, the availability of "integrated" child restraints in new model automobiles should be strongly promoted.

ACKNOWLEDGEMENTS

I am very grateful to my thesis advisors, Dr. John M. Last and Dr. Rama C. Nair, University of Ottawa, Department of Epidemiology and Community Medicine, for their guidance and encouragement throughout this project.

The assistance of the Bureau of Chronic Disease Epidemiology, Laboratory Centre for Disease Control, in the form of educational leave to complete this project, is most gratefully acknowledged.

A sincere thank-you to Dr. Greg Sherman, Bureau of Chronic Disease Epidemiology, Laboratory Centre for Disease Control, for helping me learn the basics of time-series analysis techniques.

Thank-you to Evelyn Park (formerly of the Bureau of Chronic Disease Epidemiology), Chris Waters and Robert Semenciw (both of the Bureau of Chronic Disease Epidemiology), who provided valuable advice on SAS programming. Chris was also most helpful in explaining the organization of the TRAID data base.

I appreciate the cooperation of Merrilyn Allegakone, of the Bureau of Chronic Disease Epidemiology, who assisted me in retrieving HMRI records via compact disc reader.

The completion of this project would not have been possible without the steadfast and ongoing support and encouragement of my family. To my husband Michael, and our daughter Robin, a special thank you.

TABLE OF CONTENTS

LIST OF TABLES

APPENDICES

LIST OF FIGURES

LIST OF FIGURES (CONT'D)

APPENDICES

N.B. All of the following figures refer to Ontario passengers, 1979-1988

LIST OF FIGURES (CONT'D)

INTRODUCTION

STATEMENT OF THE PROBLEM

Motor vehicle crashes* present a major paediatric public health problem in Canada in that they claim the lives of more Canadian children than any other single cause of injury-related death.[1] Between 1981 and 1988 inclusive, almost one-tenth (9.7%) of deaths in Canadian children under 5 years were due to accidents, poisonings or violence, and nearly one-quarter (23.3%) of those fatalities involved motor vehicles. Of the 672 Canadian children under the age of five years who were killed in motor vehicle crashes, 354 (52.7%) were passengers. Almost 30% of those child passengers were killed in the province of Ontario.[2]

Child passenger fatalities contribute more than half of the potential years of life lost (PYLL) due to all types of motor vehicle deaths. Between 1981 and 1988 there were 25,722 PYLL before age 75 for Canadian children killed as passengers. Almost 30% of these PYLL were accounted for by children from Ontario.[2]

Between 1981 and 1988, motor vehicle crashes accounted for nearly 5% of all injury hospitalizations in Canadian children under five years. Nearly one-half of these victims were car occupants. During this time, 3,685 Canadian child passengers were hospitalized, accounting for 22,981 days of stay. Ontario children comprised approximately 30% of all admissions and hospital days.[2] A total of 11,999 child passengers under 5 years sustained some degree of observable injury in a motor vehicle crash, representing nearly one-quarter of all injured passengers under 16 years.[3]

---

* Injuries are mistakenly referred to as "accidents" because they occur suddenly and appear to be unpredictable and uncontrollable.[4] Motor vehicle crashes are not random events and are preventable. Therefore, the term "crash" has been used throughout this paper instead of the term "accident". In this context, crash also refers to "non-crash" events in which no collision occurs, for example sudden stops, unexpected turns.

The costs associated with such tragedies are many. Direct medical costs include expenditures for physician and hospital care, other professional services (such as rehabilitation and home care services), prescription drugs, health science research, health-related pensions and benefits, wheelchairs and other appliances, and various administrative expenses. Non-medical direct costs include expenditures for police and emergency services, legal and court proceedings, insurance compensation, and modifications to the home.[5 6]

Indirect costs include the value of lost productivity as well as the present value of future earnings lost by people who die prematurely. In Canada in 1986, motor vehicle traffic crashes ranked second after coronary heart disease in the present value of future income lost due to premature mortality.[6] In the United States it has been estimated that the average lifetime (direct plus indirect) costs for motor vehicle crash victims $352,042, $43,409 and $1,570 for fatalities, hospitalized persons and non-hospitalized persons respectively.[5]

Although it cannot be easily calculated in monetary terms, the burden of pain, suffering and mental anguish for both the child and the family is enormous. Child passengers who survive their injuries often have long-term sequelae in the form of permanent disabilities. Motor vehicle crashes are a major cause of permanent brain damage and are the leading cause of spinal cord injuries in children.[7] Survivors with permanent sequelae will be affected in their ability to live independently as adults and/or to participate fully in the labour force.

PHYSIOLOGICAL DIFFERENCES BETWEEN YOUNG CHILDREN AND ADULTS

Physically, children are not just small adults. The head and abdomen, which are very vulnerable to injury, are proportionally much larger. The centre of gravity is higher in children. The child's top-heavy body tends to move with the head as the leading body part under crash conditions. Children, being small and light, are thrown about the vehicle's interior more easily than are adults. An unrestrained child may be propelled head-first into the dashboard, windshield, the back of the front seats or can be ejected through windows or doors.[8 9] A minor impact may injure a small child seriously.[10] The odds of visible injury or death are twice as high as for unrestrained children as for unrestrained adults.[11]

Unlike an adult, the young child's pelvis does not provide an anchor point and contact area for the pelvic restraint (lap belt).[12]

THE DEVELOPMENT OF CHILD SAFETY RESTRAINT SYSTEMS

Childrens' car seats have been around for many years, long before crash protection became an issue. The Bunnybear Company introduced the first child automobile seat in 1933. Initially, child seats were not used to provide crash protection; they elevated the child to window height and provided confinement and support during routine driving manoeuvres and sudden stops. In the mid-1960's, when the safety problems of vehicle occupants during crashes began to receive attention in the United States, the first child restraints designed to eliminate fatalities and diminish injuries were marketed by the Ford Motor Company. General Motors introduced a child restraint in 1967. These original models were very well designed and for many years were the standard against which the effectiveness of other restraints were measured.[13]

The first safety standards for child restraints were published in 1970 in the United States. However, it was subsequently discovered that these initial standards did not provide adequate protection in crashes occurring at 30 miles or more per hour. One year later, the Canadian government adopted a standard with static requirements only, in order to avoid the delay associated with developing the more realistic dynamic (crash) testing requirements. In 1974, Consumer and Corporate Affairs Canada (CCA) issued the first (limited) standards requiring dynamic testing, i.e., crash simulations. In 1980 Transport Canada assumed the responsibility for developing the technical aspects of regulations for restraint systems (under the Motor Vehicle Safety Act) and began crash-testing hundreds of restraints. CCA retained the responsibility for the legal aspects of the regulations under the Hazardous Products Act. Between 1982 and 1984 the Canadian government passed new Motor Vehicle Safety Standards (CMVSS) concerning dynamic and static testing, as well as labelling requirements of infant and child seats and booster cushions.[14] (Booster cushions are devices used to boost children over 18 kg to a height where they can use an adult lap belt safely.) Summaries of these Standards appear in APPENDIX 1.

EFFICACY OF CHILD RESTRAINTS

Child restraints systems significantly reduce the risk of serious injury or death among children involved in motor vehicle crashes. Laboratory and staged crash tests as well as engineering analysis have provided overwhelming evidence of their effectiveness. In a comprehensive review of highway accident data from several American states, estimates of the percent reduction in overall injuries were as high as 40-50% when seats were correctly used. A 50-60% reduction in major injuries and a 65-75% reduction in fatalities were suggested.[15]

Decker found that unrestrained children were 10.7 times more likely to die in a crash than were restrained children.[11] Similarly, a comparison by Scherz of deaths among users and non-users of child restraints yielded an odds ratio of 11.1.[16] Agran *et al* found that injuries to properly restrained children under four years were primarily the result of passive mechanisms of injury such as flying glass or intrusion.[17] Child restraints also reduce "non-crash" injuries to child passengers by preventing falls within and outside of the vehicle.[18] Furthermore, restrained children are less likely to experience motion sickness, usually sleep better in cars, and are much less likely to distract the driver and inadvertently cause a crash.[19]

HISTORY OF MOTOR VEHICLE RESTRAINT LEGISLATION IN ONTARIO

In Canada, all regulations governing the compulsory use of occupant restraints fall under provincial jurisdiction. Ontario was the first province to enact seat belt legislation. In February 1976, the Government of Ontario passed a regulation under Section 90 of the Highway Traffic Act (see APPENDIX 3A) mandating the use of seat belts by all motor vehicle occupants five years of age or older, or over 50 pounds.[20] In 1982, an amendment to the regulation was passed, which divided young child passengers into three classes:

- children weighing less than 9 kilograms (20 pounds) are classified as **infants;**
- children weighing nine kilograms or more but less than 18 kilograms (40 pounds) are classified as **toddlers;**
- children weighing eighteen kilograms or more but less than 23 kilograms (50 pounds) are classified as **pre-schoolers.**

The amendment specified that children under 23 kg born **after October 31,**

1982 must be secured in an appropriate child restraint system that conformed to federal safety standards.[21] One year later, on **November 1, 1983**, the same regulation was further amended, mandating the use of appropriate child restraint systems by **all children** weighing under 23 kg, regardless of when they were born.[22]

APPENDIX 2 illustrates the appropriate restraint systems for children from birth to 22 kg. It should be noted that although booster cushions are recommended for children over 18 kg, their use is not required by law (the pelvic restraint of a seat belt assembly may be used instead). APPENDIX 3A contains the original 1976 Highway Traffic Act as well as the 1982 and 1983 amendments to the Act. APPENDIX 3B contains the Regulation relating to seat belts passed under the Highway Traffic Act as well as the 1982 and 1983 amendments to the Regulation.

OBJECTIVES OF THE STUDY

The objectives of the present study were to determine whether Ontario's child restraint legislation has resulted in:

(a) significant and sustained reductions in the **incidence** of injury and death due to motor vehicle crashes in children under 5 years of age; and/or

(b) significant and sustained reductions in the **severity** of such injuries; and/or

(c) significant and sustained changes in the anatomical **patterns** of injury.

CHAPTER 1: LITERATURE REVIEW

The effectiveness of compulsory seat belt legislation in reducing the incidence of morbidity and mortality, as well as in changing the patterns and severity of injury, among motor vehicle passengers has been studied for approximately the last 20 years.

1.1 ADULT SEAT BELT LEGISLATION STUDIES

1.1.1 Incidence of injuries and fatalities

Australia: Australian researchers were among the first to study these effects, since that country was the first in the world to introduce seat belt legislation. In December, 1970, the state of Victoria introduced legislation, followed by New South Wales in October, 1971. Foldvary and Lane compared the frequencies of motor vehicle fatalities and non-fatal injuries in Victoria during two nine-month periods in 1970 and 1971 (i.e., before and after the law became effective in that state), using other Australian states and other road users (who were not affected by the legislation) as controls.[23] Using chi-squared analysis, the investigators concluded that the legislation had caused a significant reduction in fatalities (in metropolitan areas) as well as in non-fatal injuries. Fluctuations in the economy had a marked effect on road casualty frequencies.

Crinion *et al* studied the effect of a seat belt law in South Australia on casualties by comparing all crashes reported during the 12 months before and the 12 months after the effective date of seat belt legislation.[24] The investigators calculated casualty rates that related the number of injured persons to the number of all vehicles involved, whereby the latter represented a measure of the exposure to the risk of being injured. Vehicles were classified according to model year, i.e., pre- and post- 1966, representing two groups of vehicles in which the fitting of seat belts was, and was not, compulsory. Using chi-squared analysis, they found a reduction in the most serious injuries and an increase in the least serious injuries after the implementation of the law. Furthermore, the post-1966 model cars accounted entirely for the 7.5% overall reduction in the fatality rate.

Trinca and Dooley plotted trend lines for vehicle occupant deaths and injuries in the state of Victoria for the years 1960 to 1970.[25] Comparing the projected and actual figures for 1974, they found a 37.4% reduction from the trend line for occupant deaths for 1974 as compared with 1970, as well as a 40.6% reduction in occupant injuries.

McDermott and Hough evaluated the changes from 1955-77 in the incidence of crash-related injuries and fatality rates (per 10,000 registered motor vehicles) in Australia. Using linear regression, they plotted trend lines from 1955 to 1970.[26] They projected the rates until the year 1977 and calculated 95% confidence bands around the projection lines, finding significant decreases in both fatality and injury rates.

Worldwide: Adams compared the road fatality records for 1970-1978 of 13 countries with "effective" seat belt legislation with the records of four countries without such legislation.[27] Together those countries contained over 80% of the world's car population. The road death tolls of all 17 countries were converted to indices, with 1973 (the year of the energy crisis) set to 100. Two composite indices consisting of the average of the indices of the 13 'legislated' countries and the average of the 4 'non-legislated' countries were calculated. The index for the 'legislated' countries fell 17 points between 1972 and 1978, while the index for 'non-legislated' countries fell by 25 points over the same period. A similar comparison for non-fatal injuries yielded similar results. One weakness of this study was that all motor vehicle casualties, including non-occupants, were studied. Adams concluded that perhaps those countries with seat belt laws were subject to a set of influences which, in the absence of legislation, would have caused many more people to be killed on the roads. Alternatively, he suggested, perhaps the countries without legislation were subject to a set of powerful crash-reducing influences that were not operating in the other countries.

Canada: In Canada, two provincial studies, in Ontario and Saskatchewan, were published in 1979 which examined the safety benefits of seat belt legislation in those provinces. In Ontario, enforcement of both seat belt legislation and reduced speed limits on Ontario highways were introduced simultaneously on February 1, 1976. Pierce, of the Ontario Ministry of Transportation and Communications, studied crash data in a number of ways to attempt to disentangle the separate effects of these two countermeasures.[28] The method of least squares was used on rates for 1967-1975 to create straight line predictions for 1976-1978 of fatality rates per 100 million vehicle miles travelled. Rates for vehicle occupants (the only road user group to be affected by seat belt legislation) were plotted separately from those for all other road users. The actual fatality rates for vehicle occupants were much lower than those predicted compared with other road user fatalities; however, the reductions were not statistically significant. The author suggested that those who remained unbelted in the face of seat belt legislation, i.e.,"risk-takers", are at particularly high risk for fatalities. A similar methodology applied to non-fatal injuries showed a statistically significant reduction for vehicle occupants but not for other road users. In a further attempt to separate out the effects of seat belt laws and reduced speed limits, the author examined highway crashes for one year before and one year after speed limit legislation (assuming that seat belt usage would be similar on highways with and without changed speed limits). Pierce found greater percentage reductions in fatality and injury rates (per million vehicle miles travelled) on highways for which speed limits were lowered than on roads for which speed limits remained unchanged. She concluded that on the high-speed roads in Ontario, the speed limit laws had a substantially greater effect than the seat belt law in reducing fatalities, although she acknowledged that there might be an interaction between seat belt use and lower driving speeds.

The province of Saskatchewan passed a mandatory seat belt law on July 1, 1977. Based on the first four months of 1978 data, Bergan *et al* projected injury and fatality rates as well as the number of crashes and the number of vehicle miles driven, to the end of that year.[29] They concluded that 1978 casualty rates decreased in spite of a concomitant increase in the number of crashes and the number of vehicle miles. No tests of significance were used.

Jonah and Lawson, of Transport Canada, studied the impact of four provincial mandatory seat belt laws passed in 1976 and 1977.[30] Regression lines, as well as 95% confidence bands, were plotted for the pre-law years in Ontario, Quebec, Saskatchewan and British Columbia, and projected to 1981. Actual occupant fatality and injury rates per 100 million vehicle kilometres travelled for the post-law years (1976-1981) were then compared with the predicted rates. The results indicated that Ontario experienced significant reductions in fatality rates in five of the six post-law years, and significant injury reductions in all of the post-law years. Quebec's rates did not change after the introduction of the law, with the exception of a marginally significant decrease in injury rates in the first two post-law years. Saskatchewan experienced a significant reduction in injury rates but not in fatality rates, while the reverse was true for British Columbia. Interestingly, an aggregate analysis carried out for the remaining unlegislated provinces showed significant fatality reductions for all but the first "post-law" year, and significant injury reductions in the first four "post-law" years. The authors postulated that the reductions in the legislated jurisdictions may not have been due to the seat belt laws, but to other factors such as reduced speed limits, fuel price increases, safer highway design, drunk driving legislation, safer cars and a growing public awareness of road safety.

In order to separate the effects of seat belt legislation from the effects of those other factors, Jonah and Lawson compared the percentage difference between occupant and non-occupant casualty rates in each of the legislated provinces with the percentage difference in the unlegislated provinces. They called the results the "Relative Casualty Changes" and ascribed these changes to the effects of the seat belt laws alone. The results showed that Quebec did not experience a reduction in occupant casualties following passage of the legislation. Ontario's occupant fatalities were relatively lower subsequent to the legislation, but occupant injuries showed little change. Although Saskatchewan and British Columbia experienced large decreases in occupant fatalities and injuries relative to non-occupants and to the unlegislated provinces, much of the relative casualty reduction was the result of increases in motorcycle registrations (and subsequent motorcycle fatalities and injuries) in those two provinces. Jonah and Lawson offered three hypotheses to account for the fact that the observed impact of seat belt laws on casualty reduction was less than anticipated. The first was that limitations in the experimental design (these so-called 'threats to validity' will be discussed below) and the measures of effectiveness (limitations in the quality and availability of casualty data) militated against observing stronger effects. The second hypothesis was that seat belt laws were not optimally effective because once protected by seat belts, some drivers compensated by driving more dangerously (this is similar to Adams' contention). The third hypothesis put forward was that the laws had not been adequately publicized and enforced.

United Kingdom: In the United Kingdom, McCarthy observed trends in routinely collected mortality and road crash statistics (for all road users) between 1976-1987, encompassing seven years before and five years after the implementation of seat belt legislation.[31] No formal statistical analysis of the trends was undertaken. The author concluded that since the net effect on all road deaths (including pedestrians and motor cyclists) was a slow downward trend, the data suggested little impact of the law.

United States: In the United States, McCartt *et al* evaluated the New York state mandatory occupant restraint law by comparing the actual and predicted number of crash-involved persons in each injury category (i.e., no injury, mild, moderate or severe injury, fatality) for 1985, the first post-law year. Predictions were derived by applying the ratio of crash-involved persons in each injury category in the baseline period (1982/1984) to the total number of crash-involved persons in 1985. The investigators calculated the percentage differences between the actual and predicted frequencies in each category of injury and found a reduction of 18% reduction in fatalities, a 19% reduction in severe injuries, a 21% decrease in moderate injuries and less than 1% reduction in mild injuries. However, no test of significance was used in the analysis.

Reinfurt *et al* evaluated the effects of North Carolina's occupant restraint law, using state-wide police-reported casualty data.[32] Like several of the studies described above, the investigators used pre-law trends to project the number of casualties to the post-law period. However, regression techniques were not used. Instead, a forecast for the 12 post-law months was derived based on the trends of the 57 pre-law months, using the autoregressive, integrated, moving average (ARIMA) technique, or time-series analysis. (This technique and its advantages over regression analysis are described in Chapter 2.) This forecast was then compared to actual casualty data for the one-year post-legislation period. The investigators found significant decreases in the number of injuries, but no significant change in fatalities. However, the investigators did not use injury **rates** and therefore did not control for possible increases in exposure (i.e., vehicle miles travelled).

1.1.2 Patterns of injury

Budd studied the effect of seat belt legislation on the incidence of sternal fractures seen in the emergency room of a British hospital two years before and after seat belt legislation.[33] Using chi-squared analysis, he found a three-fold increase in the incidence of sternal fractures (90% of these were caused by the seat belt itself) seen since the introduction of the law, coupled with an increase in the number of people surviving high speed crashes as well as in the number of people wearing seat belts. He concluded that given the possible alternative of multiple and/or fatal injuries due to non-wearing of a restraint, an uncomplicated fracture of the sternum is an acceptable price to pay for the compulsory wearing of seat belts.

1.2 STUDIES OF THE IMPACT OF CHILD RESTRAINT LEGISLATION

1.2.1 Incidence of injuries and fatalities

There are several published American evaluations of state seat belt laws relate specifically to child restraint legislation, and many of these studies used time-series analysis. Wagenaar[34] and Wagenaar and Webster[35] studied the effects of Michigan's child restraint law at 9 months and 21 months after the passage of the legislation. Two features of the design of these studies are notable. First, multiple age groups of occupants were included for comparison to increase the confidence that observed changes in injuries were in fact the result of the child restraint law and not of other coincidental factors such as safer roads and cars, economic factors, etc., which would affect occupants of all ages. Second, a special form of ARIMA modelling called 'intervention, or interrupted, time-series analysis, time was used, whereby significant post-law discontinuity, or shifts in the level of injuries, could be detected. (Intervention analysis is described in Chapter 2.) In both studies, significant declines occurred in the level of crash-related casualties (injuries plus fatalities) in children under 4 years; however, similar, though less dramatic, results were observed for 25-34 year old occupants and 18-24 year old occupants respectively.

In a later study, Wagenaar *et al*[36] studied the effect of child restraint legislation on the aggregate fatal injury rates of 11 states. Using intervention analysis, they found no significant decline in the number of fatalities per 100,000 population of children aged 0-4 following implementation of the laws. The investigators offered several theories for the discouraging result. First, young children who are killed in traffic crashes are typically unrestrained. Second, it is impractical to evaluate state-specific child restraint laws on the basis of fatality rates alone, because the numbers of fatalities are so small and are subject to a great deal of random variation. Third, the effectiveness of the legislation varied considerably from state to state, possibly owing to socio-demographic characteristics, the level of restraint use prior to the law, the publicity surrounding the implementation of the law and the level of enforcement of the law. Fourth, even after passage of the laws, many children were riding either unrestrained or the safety seats were not being used correctly. Finally, the lack of significant results may have been due to non-compliance with the law by high-risk drivers.

A study by Guerin and MacKinnon used the interrupted time-series technique to analyze California police reports for 5 years before the child restraint law and 1 year after its implementation.[37] The investigators used a control time series of 4-7 year olds, as well as a control series of 0-4 year olds from the state of Texas, a state without child restraint legislation. While there was a significant reduction in the frequency of injuries, there was no significant change in the level of fatalities in those affected by the California law. The authors noted the small monthly number of fatalities (approximately 4) would make it difficult to detect such a change.

Sewell *et al* studied the effects of New Mexico's child passenger law. Data from police reports was collected for 30 months before and 15 months after the law was passed.[38] The investigators calculated the percentage change in the crash-related injury and fatality rates between the two periods and found a 32.7% drop in fatality rates and a 12.6% drop in non-fatal injury rates. However, they did not employ any tests of significance in the analysis.

1.2.2 Patterns and severity of injury

Two American studies examined the clinical effects of child restraint legislation. Agran *et al*[39] collected emergency room data from nine hospitals in Orange

County, California for 2 years before and after the passage of the law. Crash-involved children up to 14 years of age were divided into two groups: 0-4 year olds (covered by the law) and 4-14 year olds (not covered). The investigators found that the percentage of children under 4 who had injuries, especially to the head and face, had significantly dropped following the law. In contrast, the percentage of older children determined to be injured remained remarkably stable. It was not possible to do a similar analysis for fatalities, since there were too few seen in the emergency rooms of the participating hospitals.

Finally, a study of the clinical effects of Michigan's child restraint legislation was conducted by Margolis *et al,* collecting 27 months of pre-law and 45 months of post-law inpatient data from 16 Michigan hospitals.[40] They used interrupted time-series analysis, controlling for changes in population, vehicle miles travelled and the number of crashes during the study period. In addition, they used average length of stay as a proxy for the severity of injury. The investigators found a significant decline in hospitalization rates for head and extremity injuries. Furthermore, the rate of injured occupants requiring a short stay (less than two days) declined by 48%, and the rate of those requiring a long stay (more than seven days) declined by 25.5%. The authors acknowledged that while economic and insurance pressures had long been encouraging shorter hospital stays, this trend failed to account for the pronounced decline found beginning in the exact month the child restraint law was implemented.

1.3 INTERRUPTED TIME-SERIES DESIGN AND ANALYSIS

In 1963, Campbell introduced a class of research designs, called quasi-experimental designs, to deal with situations in which research must proceed without the benefit of experimental control.[41] One of these designs, the so-called "interrupted time-series design", could be used to evaluate the impact of a discrete intervention on a social process. According to Campbell, "the essence of this quasi-experimental design is the presence of a periodic measurement process on some group or individual and the introduction of an experimental change" (at a specific point in time) "into this time-series of measurements, the results of which are indicated by a discontinuity in the measurements recorded in the time series." The time-series design was illustrated by the following notation:

......O O O O X O O O O......,

whereby the O's represent time-sequenced observations over a period of time, and the X's represent a discrete intervention which divides the time series into pre- and post-intervention segments.

The interrupted time-series design may yield findings almost as interpretable as experimental findings at a fraction of the cost of a true experiment, and is also the most useful one for evaluating legal interventions.[42]

Campbell and Ross demonstrated the use of the interrupted time-series design in their evaluation of the impact of the Connecticut speeding crackdown on the number of highway fatalities.[43] Since then, this design has been used to test and measure the impacts of a variety of legal interventions such as gun control laws,[44] [45] air pollution measures[46] and drunk driving laws.[47] One well-known epidemiological study using the interrupted time-series design examined the contribution of medical measures to decreases in mortality from ten infectious diseases in the US during the twentieth century.[48] Time-series analysis has also been used to examine the effect of the introduction of computer tomography on the use of alternate neuro-diagnostic procedures in Greece.[49]

The usefulness of time-series design and analysis in epidemiological research has been demonstrated in recent years, particularly in relation to the evaluation of influences on injury rates. In 1987, Catalano and Serxner[50] expressed dismay that despite the interest of epidemiologists in the occurrence of disease by person, place and time, they rarely employed these designs in their studies. In order to demonstrate the usefulness of the time-series methodology to epidemiologists, they tested the hypothesis that increased employment affect the rate of accidental injuries per worker month among manufacturing workers, and concluded that the rate of disabling accidents per manufacturing worker increases with the size of the labour force.

In 1989, Martinez-Schnell and Zaidi[51] used monthly time-series models in the analysis of selected fatal injuries (including motor vehicle crashes) in the United States from 1972 to 1983. After confirming that motor vehicle fatalities increased as vehicle miles travelled increased, they examined the effect of a legislative intervention that occurred in 1974, namely the reduction of speed limits to 55 miles per hour. They hypothesized that legislations would have resulted in a decrease in the number of motor vehicle fatalities. They detected a statistically significant reduction in the number of fatalities in 1974, even after adjusting for vehicle miles travelled and calendar effects (the number of weekends and holidays in each month).

In general, researchers involved in population studies must be mindful of the potential for a bias that may occur because an association observed between variables on an aggregate level does not necessarily represent the association that exists at an individual level (ecological fallacy).[52] However, this design has been cited by Morgenstern as the <u>preferred</u> method of evaluating the effectiveness of population countermeasures. He stated that the ecological fallacy is a moot issue in a population intervention study, provided that the link between a modifiable risk factor and the disease has already been established and if the modification of the risk factor can favourably affect disease outcome (i.e. the treatment is efficacious).[53] As has been amply demonstrated, these conditions certainly hold true with respect to the link between child restraint use and the reduced incidence and severity of injury or death.

CHAPTER 2: METHODOLOGY

2.1 STUDY DESIGN

This study has used the interrupted time-series design to evaluate the impact of Ontario child restraint legislation on the incidence, severity and patterns of casualties in children under five years.

2.1.1 Types of intervention effects

In general, the possible types of effects which might be expected to follow an intervention can be characterized according to their onset and duration. An impact may be either abrupt or gradual in onset and either permanent or temporary in duration.[54] For example, Figure 1 illustrates a hypothetical example of an **abrupt permanent effect** (i.e., step change in level), whereby there is a precise point of intervention and compliance is achieved instantaneously.

FIGURE 1: ABRUPT PERMANENT EFFECT

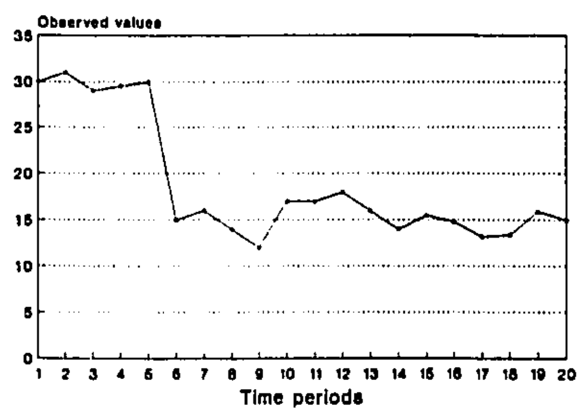
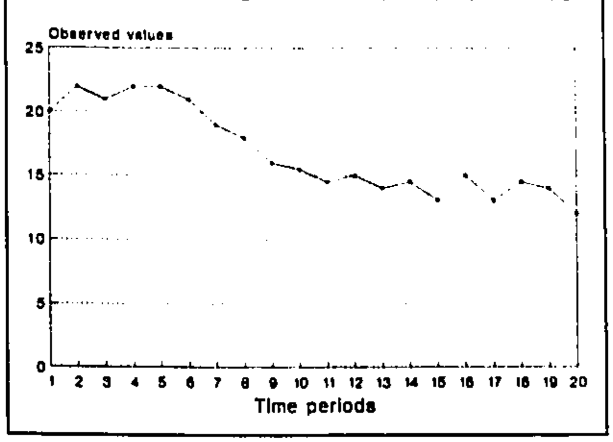


Figure 2 illustrates a hypothetical example of a **gradual permanent effect** whereby there is a precise point of intervention and compliance is achieved gradually.

FIGURE 2: GRADUAL PERMANENT EFFECT



An abrupt temporary effect is characterized by an immediate, but short-lived response to an intervention, followed by an immediate return to the original level.

2.1.2 Threats to validity

If a statistically significant intervention effect is found (statistical analysis of time series' is discussed below in Section 2.2), one may conclude that the null hypothesis of no intervention effect may be rejected **provided that rival explanations of the intervention effect are implausible.** These rival explanations were referred to by Campbell as threats to validity.[41] These 'threats' include factors which disguise experimental effects as well as produce pseudo-effects, as follows:

<u>History</u>

Description: The effect of history refers to the fact that some specific event(s) which is (are) unrelated to the intervention, but which are temporally coincident with it, could have caused a pre-to-post intervention difference in the dependent variable.[43] Such coincident interventions could include other highway safety legislation, safe driving educational campaigns or heightened enforcement of existing legislation (i.e., speed limits, drunk driving).

How possible effects of history were dealt with in study: The ability to test for such confounding effects is the major strength of the **control group time-series design,** in which a series of a control group which covers the same period of time is used. Because such interventions would be expected to affect all age groups of car passengers, a control group time-series design was undertaken in this study, utilizing as the control group the adult passengers in the age group 20-44 years of age who were injured or killed in a motor vehicle traffic crash between January 1, 1979 and December 31,1988. This is the age group that is most likely to represent the parents of the children under 5.[35] The assumption was made that the control group (20-44 year olds) is the most likely of all age groups to have been involved in the same motor vehicle crashes as the study group of children. Therefore, selection of the 20-44 year age group as the control group maximized the potential for the two groups to be matched in terms of the circumstances of the crash (the vehicle in which they were travelling, the crash severity, the roads being travelled at the time of the crash and the driving conditions at the time of the crash).

Diffusion

Description: This refers to the tendency for the experimental effect to modify not only the experimental group but also the control group.[43]

How possible effects of diffusion were dealt with in study: The use of a control group of older children aged 5-15 was not considered to be suitable for this study because of a potential spillover, or diffusion, effect of the legislation, i.e., that parents who restrained their under 5's **in response to the legislation** were more likely to restrain their 5-15 year old children as well.[36]

Studies have found that the use of an appropriate child restraint was observed much more frequently when the driver was using a seatbelt. [55 56] Hence it is likely that adult passengers were likely to be matched with the study group in terms of restraint use. However, it was believed that the benefits of matching the study group and controls in terms of the crash circumstances outweighed the disadvantages of matching with respect to restraint use.

Maturation

Description: Maturation refers to continuous trends as opposed to discrete historical events. In this study, this would refer to such factors as coincident gradual improvements to the safety of motor vehicles, improvements to the planning and construction of roads and highways, and improvements in emergency response and trauma care.[43]

How possible effects of maturation were dealt with in study: The control group design has the advantage of controlling for the impact of any maturational trends.

Instrumentation

Description: Another threat to validity is called instrumentation, which refers to the possibility that a pre-to-post intervention change in the time series is due to a coincidental change in the monitoring process.[42]

How possible effects of instrumentation were dealt with: In order to mitigate any instrumentation effects resulting from the change in 1978 from the ICD-8 international classification of diseases to the ICD-9 version, only HMRI data collected since 1979 was utilized. Minor revisions to the structure of the TRAID data base in 1984 were accounted for in the statistical extraction of data.

Regression

Description: Regression refers to the possibility that a pre- to post-test difference reflects the general phenomenon of regression to the mean, i.e., that extremely high or extremely low observations tend to be followed by ones which are closer to the mean.[42]

How possible effects of regression were dealt with: The length of the pre- and post-legislation periods in this study helps to mitigate the possible effects of regression. The study period extended from January 1,1979 to December 31,1988, thereby encompassing 5 pre-law years and 5 post-law years. Each year was divided into four quarters (January-March, April-June, July-September and October-December), thus resulting in 20 quarters (data points) in the pre-law period and 20 quarters in the post-law period.

2.2 STATISTICAL ANALYSIS OF TIME SERIES DATA

2.2.1 Original approach to time-series analysis

Time-series analysis, like ordinary least-squares (OLS) regression, seeks to fit a model, or equation, to a series of data points. While in regression analysis the series is described as a function of some independent variable(s), the time series model describes the series as a function of **its own past values.**

When Campbell first described the interrupted time-series quasi-experiment, he suggested several approaches to significance testing, each of which relied on ordinary least squares (OLS) regression, which requires the assumption that residuals, or error terms, associated with each time series observation, be independent. However, in time series, events that are closer to each other in time tend to be more correlated with each other than with events that are more remote in time, and hence the error terms of consecutive observations are correlated with one another. This type of correlation is known as serial correlation, or **autocorrelation.**

A t test is often used to test the null hypothesis that the pre-intervention OLS parameter is not significantly different than the post-intervention OLS parameter; i.e., H_o: $b_{pre} - b_{post} = 0$, where

$$t = \frac{\text{estimated change in post-treatment series}}{[SE(b_{pre})^2 + SE(b_{post})^2 - 2\,cov(b_{pre}, b_{post})]^{1/2}}$$

The effect of ignoring the autocorrelation in the error terms (on significance testing) is to bias (usually downwards since autocorrelated observations would be less variable) the standard errors of the pre-and post- intervention OLS parameter (*b*) estimates. Since the standard errors of the OLS parameters comprise the denominator of the t statistic, the value of the resulting t statistic may seriously overstate the statistical significance of an intervention effect.[57]

2.2.2 ARIMA modelling

In 1976, Box and Jenkins developed the autoregresssive integrated moving average (ARIMA) modelling techniques that were designed to permit unbiased estimates of the error in a time series.[58 44] The ARIMA process identifies a model which describes a time series as a function of its own past values by determining the extent of autocorrelation, i.e., the manner and degree to which an observation may be predicted by an earlier observation(s). The model accounts for the <u>predictable</u> portion of the time series, the remainder being attributable to random error, or white noise.[54 57] In effect, ARIMA modelling is a method of controlling for autocorrelation among time series observations.

ARIMA models are usually either autoregressive (AR) or moving average (MA) models, although in theory they can be mixed. In AR models the value of an observation is predicted by the value of an observation(s) at a time period *k* lags prior. Lagging a time series forward by *k* units means pushing the entire series forward. For example, when the series:

Y_1 Y_2 Y_3 Y_4 Y_5 Y_6 Y_7 is lagged once:

Y_1 Y_2 Y_3 Y_4 Y_5 Y_6 Y_7;

and when lagged twice:

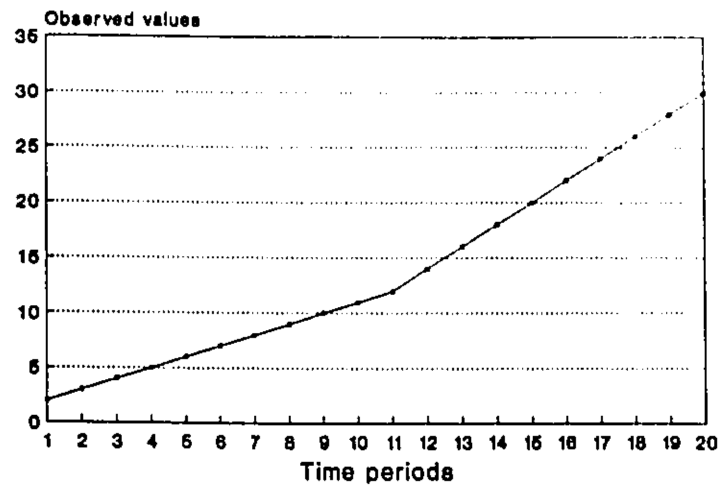
Y_1 Y_2 Y_3 Y_4 Y_5 Y_6 Y_7; etc.

In MA models, the value of the current observation is determined to some extent by the persistent effect of a random shock(s) to the system at a time period *k* lags prior. (Random shocks, or "white noise", are characterized as the residuals or error terms associated with each observation in a time series, and summarize the factors that produce the variation observed in the series.)

If no ARIMA model is identifiable according to the process described below, the model is identified simply as "white noise". This type of model is characterized by the lack of autocorrelation among values in the time series.

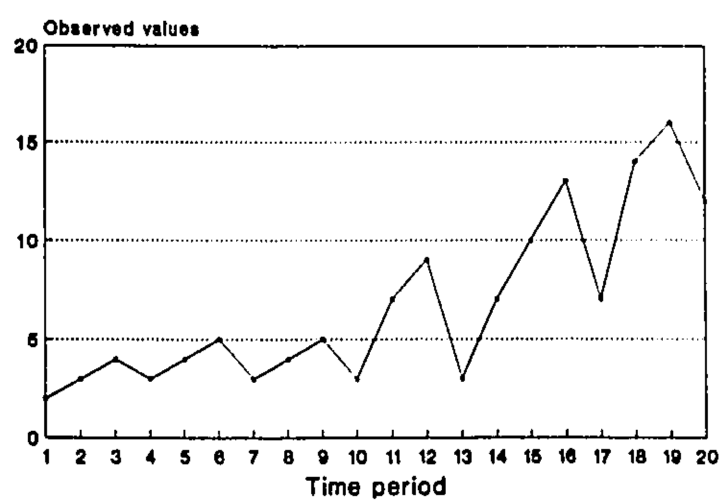
Before a time series may be modelled it must be made stationary, i.e., the mean and variance must be constant over time. Figure 3 illustrates a series which is non-stationary in the mean.

Figure 3: Non-Stationarity of the Mean



Stationarity of the mean can be accomplished by <u>differencing</u> the time series, that is, the first observation is subtracted from the second, the second from the third, the third from the fourth, and so on; these differences are then used to replace the original values in the time series. Figure 4 illustrates a series which is non-stationary in the variance.

Figure 4: Non-Stationarity of the Variance



Stationarity of the variance can usually be accomplished by applying a power transformation (either the natural logarithm, the square root or the inverse) of each value of the time series.

The correlation coefficient between Y_2 and Y_1 is called the 'autocorrelation at lag 1'; similarly, the correlation coefficient between Y_3 and Y_1 is called the 'autocorrelation at lag 2'. The autocorrelations at each time lag can be plotted and are called the **autocorrelation functions (ACF's)**. (Figure 5)

Autocorrelation is a measure of the unconditional dependence between observations that are separated by lag *k*. Partial autocorrelation, however, is a measure of the conditional dependence between observations that are separated by lag *k*, **i.e., with the effects of the intervening observations removed.** The partial autocorrelations at each time lag can be plotted and are called **partial autocorrelation functions (PACF's)**. (Figure 6) Confidence bands are drawn for each time lag such that correlation coefficients outside plus or minus 2 standard deviations can be identified as being statistically significant at the .05 level.

FIGURES 5 AND 6: AUTOCORRELATION AND PARTIAL AUTOCORRELATION PLOTS OF A HYPOTHETICAL TIME SERIES

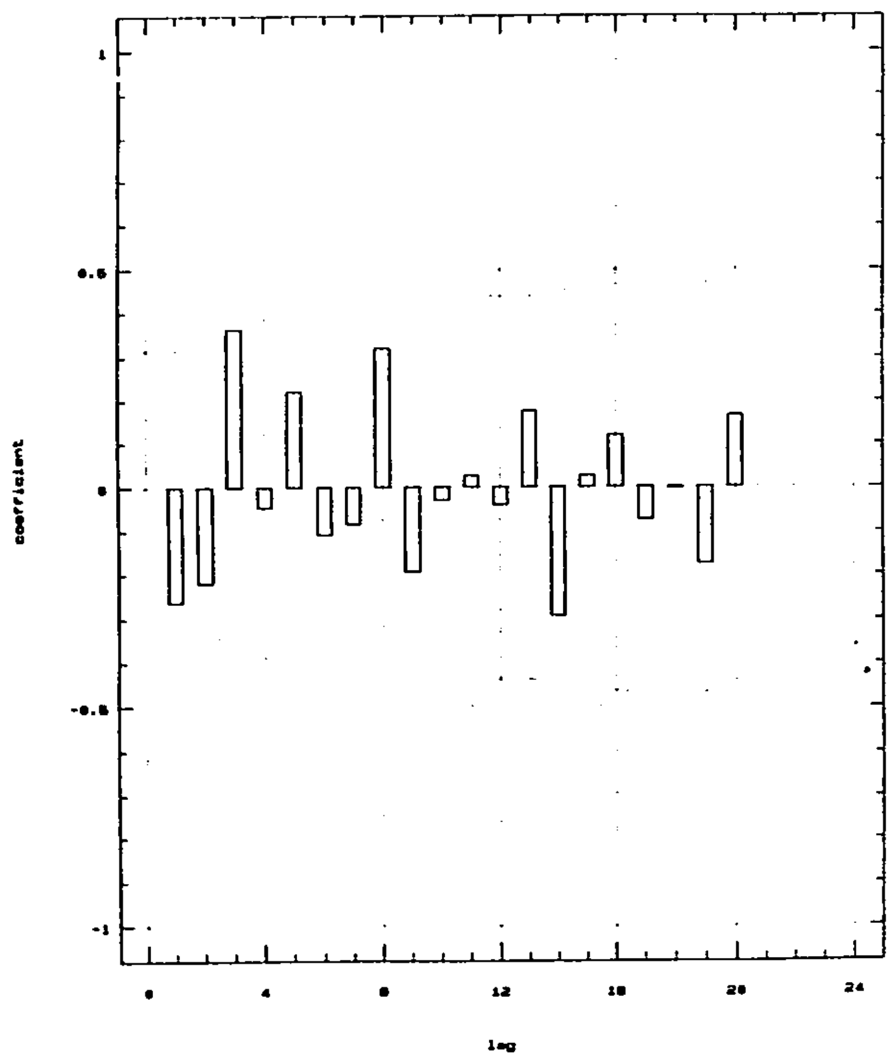


FIGURE 5: SAMPLE AUTOCORRELATION PLOT

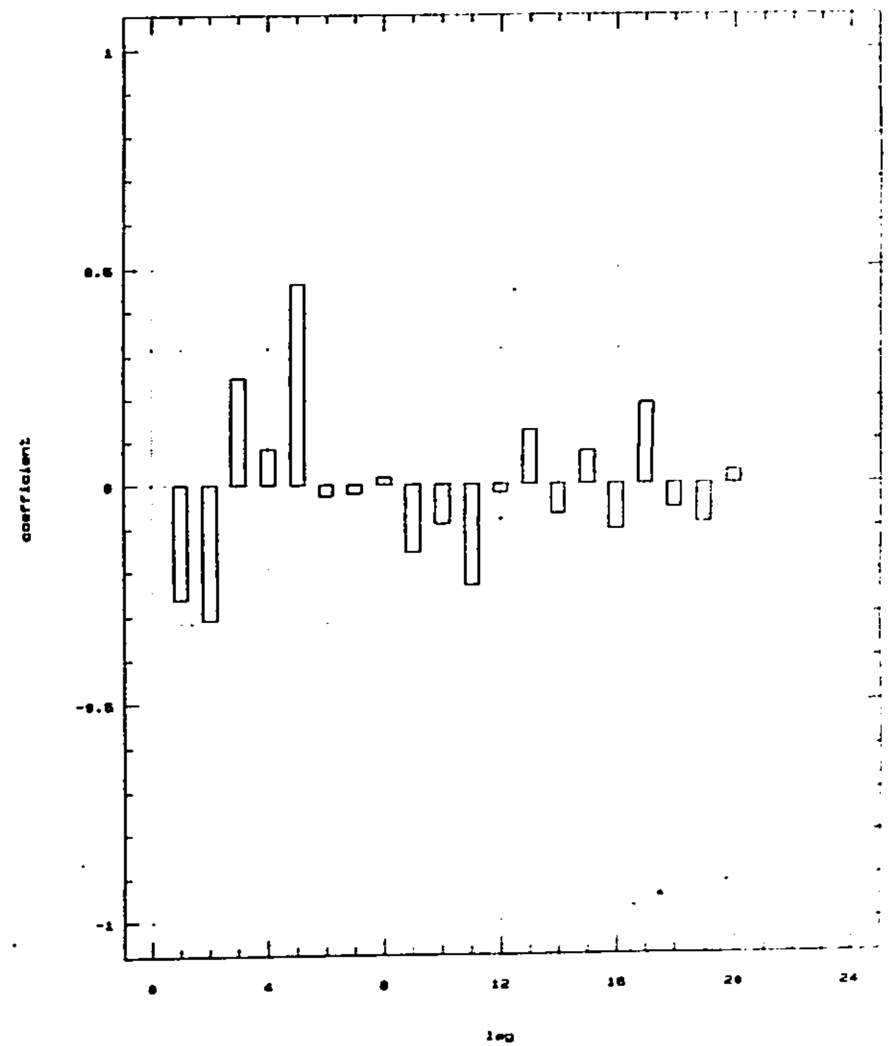


FIGURE 6: SAMPLE PARTIAL AUTOCORRELATION PLOT

The patterns of significant ACF's and significant PACF's indicate whether the model is autoregressive (AR) or moving average (MA). For example, in a 'lag 1' AR model, the **PACF** will be zero after the first (significant) lag, which means that the current observation in the series may be predicted only from the value of the observation one time period previously. The reverse is true for moving average models: in a 'lag 1' MA model it is the **ACF** which will be zero after the first (significant) lag, which means that the current time series observation may be predicted from the error term (random shock) associated with only the observation one time period previously. Figures 7 and 8 illustrate possible autocorrelation and partial autocorrelation plots for lag 1 and lag 2 AR and MA models.*

The autoregressive parameter, ϕ, and the moving average parameter, θ, are types of correlation coefficients that describe the **magnitude** of the dependency between adjacent time series observations. The size of ϕ in an autoregressive model indicates the extent to which the previous value in the series allows us to predict the current value. The size of θ in a moving average model indicates the extent to which the previous random shock allows us to predict the current value in the series. Because ϕ and θ are correlation coefficients, their values must lie between -1 and +1.

---

* Figures 7 and 8 reprinted from Kendall M, Ord JK. Time Series 3rd ed. New York, Oxford University Press.

FIGURES 7 AND 8: THEORETICAL AUTOCORRELATION AND PARTIAL AUTOCORRELATION PLOTS FOR AUTOREGRESSIVE AND MOVING AVERAGE MODELS OF LAG 1 AND LAG 2

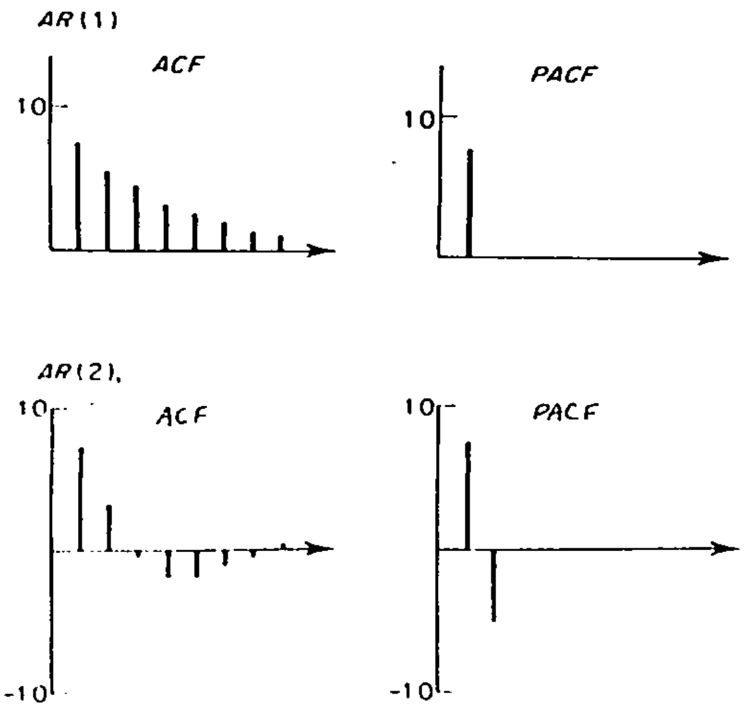


FIGURE 7: LAG 1 AND LAG 2 AUTOREGRESSIVE MODELS AUTOCORRELATIONS (ACF) AND PARTIAL AUTOCORRELATIONS (PACF)

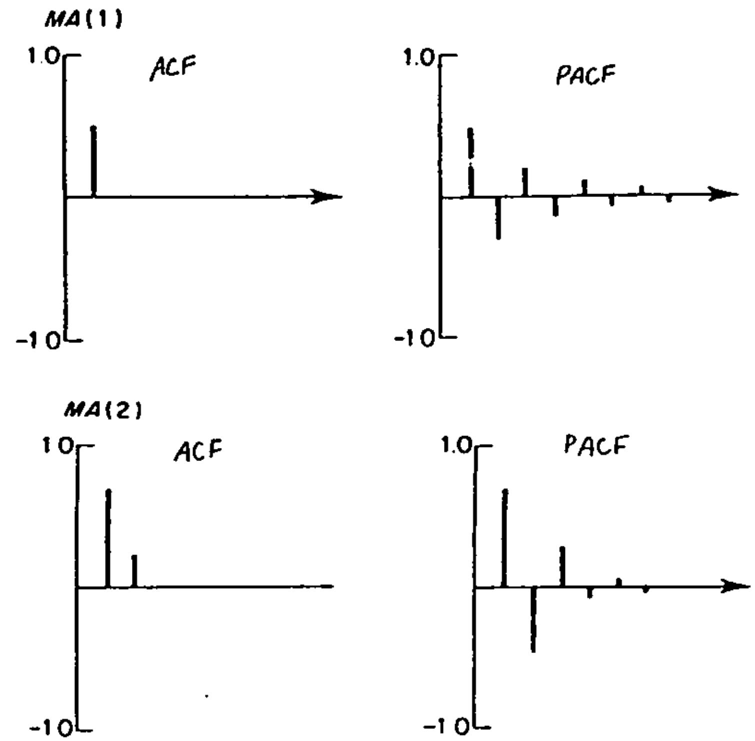


FIGURE 8: LAG 1 AND LAG 2 MOVING AVERAGE MODELS AUTOCORRELATIONS (ACF) AND PARTIAL AUTOCORRELATIONS (PACF)

2.2.3 ARIMA modelling with intervention detection using AUTOBOX

The AUTOBOX PLUS (version 2.0) software is a comprehensive package designed to perform statistical analyses of time series data.[59] One of its main components is ARIMA modelling with intervention detection. The following is a generic summary of the steps involved in analyzing a single time series. However, APPENDIX 12 contains a complete sample AUTOBOX printout of the results of the analysis for "Fatalities per 1,000 children 0-4 involved in a motor vehicle crash". "Section Numbers" which are indicated at the end of each step below refer to APPENDIX 12.

Step 1. The programmer must first instruct AUTOBOX as to the periodicity of the time series (i.e., whether the data represent monthly, quarterly or yearly observations), the choice of filtering strategy to be followed, as well as the confidence level for inclusion of significant step and pulse interventions.

The information pertaining to periodicity, or seasonality, gives AUTOBOX clues about possible autocorrelations among observations separated at lag k. For example, with quarterly data, AUTOBOX would look for relationships among observations at lags which are multiples of 4 (i.e., 4, 8, 12, etc.).

When filtering strategy #1 is specified, the program first models the series and then performs intervention detection on the residuals. Conversely, when filtering strategy #2 is specified, AUTOBOX performs ARIMA modelling after intervention detection has been completed. If the series is non-stationary because of a true intervention effect, the use of strategy #1 could possibly lead to <u>over-differencing</u> and hence to missing a significant intervention point. On the other hand, if the series is non-stationary in the mean (with no intervention effect) the use of strategy #2 could possibly lead to <u>under-differencing</u>, whereby a change in the mean may be spuriously interpreted as a significant level shift.

AUTOBOX was instructed to use filtering strategy #1 for all series' in the present study, since this was considered to be the more conservative of the two approaches; i.e., the risk of detecting spurious intervention effects was less desirable than the risk of missing a significant intervention effect. Furthermore, the risks associated with the first strategy would be decrease as the strength of an intervention effect increased.

The confidence level for detecting step or pulse interventions was set to 95%. (See Appendix 12, page 1)

Step 2. AUTOBOX first examines the stationarity of the variance of the time series, in order to determine whether a power transformation of the observations is required. The program tests a variety of so-called "lambda values" until it finds the one which results in the lowest sum of squares, i.e., the one which results in the greatest reduction of the variance in the series. The value of lambda may be anywhere from +1 to -1, whereby +1 indicates the original values (no transformation), 0 indicates the natural logarithm of each value, .5 indicates the square root of each value, and -1 indicates the inverse of each value. (Section 2)

AUTOBOX determined that the optimal lambda value for this series is 0, indicating that a series consisting of the natural logarithm of each observation will be modelled.

Step 3. AUTOBOX then examines the ACF and PACF plots of the series in order to determine the appropriate level of differencing required. In addition, the patterns of the ACF and PACF give the program clues as to the type of parameters (autoregressive or moving average) that may be needed in the model. (This is referred to as "Identification".) (Sections 3-12)

AUTOBOX determined that since there were no significant autocorrelations or partial autocorrelations at the first few seasonal lags (i.e., lag 4 or lag 8), differencing of this series is not required.

Step 4. The parameters of the first tentative model are estimated, a step known as "Estimation". The coefficients of the parameters indicate the strength of the relationship between observations at lag k. If the model is identified as autoregressive, the autoregressive parameter ϕ is estimated; if the model is identified as moving average, the moving average parameter θ is estimated. Both ϕ and θ are estimated using the method of least squares. (Sections 13-19)

The first tentative model tried by AUTOBOX consists only of a mean; this model does not explain any of the variance ($R^2 = 0$).

Step 5. AUTOBOX then performs diagnostic checks of the tentative model. The first diagnostic check, for statistical significance, is done by means of a t test, whereby the null hypothesis is that the parameter is not significantly different from 0. This is exactly analogous to the significance testing of b, the regression coefficient in ordinary least squares regression.

The second diagnostic check is to ensure that the coefficients of the parameters are in the range -1 to +1. This is known as invertibility.

The final diagnostic check is for model sufficiency, i.e, that the estimated parameters adequately explain the structure of the time series. This is accomplished by examining the ACF and PACF plots of the residuals to ensure that there is no discernable pattern which would indicate the need for additional parameters to be added to the model. (Section 20)

Since the first model did not pass the sufficiency test, AUTOBOX must add another parameter to the model; it adds a moving average parameter of lag 12.

Step 6. If the tentative model fails one or more of these checks, a revised model is identified, estimated and rechecked. This iterative process is continued until a satisfactory model is found. (Sections 21-37)

The revised model now explains 6.8% of the variance ($R^2 = .06866$). The new model, with a moving average parameter added, passes all of the diagnostic tests; therefore no further parameters are required.

Step 7. AUTOBOX examines the residuals of the final model for potential outlier, or intervention, variables, which if added to the final ARIMA model, might further reduce the error sum of squares.

An intervention variable may be in the form of either a step or pulse variable. A step variable is given a value of 0 prior to the time period at which the intervention occurred (intervention point) and a value of 1 at and following the intervention point. This would indicate that the intervention had an abrupt, **permanent** effect on the time series by changing the overall level of the post-intervention series either upward or downward. A pulse variable is given a value of 0 prior to the intervention point, a value of 1 at the intervention point, and a value of 0 following the intervention point. This would indicate that the intervention had an effect only in a single time period, i.e, an abrupt, but **temporary,** effect on the time series.

The program sequentially "tries" a series of outlier variables, each of which puts the (step or pulse) intervention point at a different time period, until a significant one(s) is (are) discovered. Significant intervention variables are called "transfer function" parameters. (Sections 38-39)

AUTOBOX determines that there is a potential outlier in the form of a step intervention at time period 14 (i.e., the second quarter of 1982).

Step 8. Using a technique called transfer function modelling, AUTOBOX again goes through the entire iterative process of identification, estimation and diagnosis of the final model, this time incorporating the newly-discovered transfer function parameter(s) into the model. As in ARIMA modelling, the statistical significance of the intervention variable is determined in the "diagnosis" stage by performing a *t* test on the estimated transfer function coefficient to see whether it is significantly different from 0. (Sections 40-67)

At the final estimation stage, AUTOBOX indicates, for each significant transfer function parameter, the time period at which the effect was detected, as well as the type of intervention (i.e., step or pulse). (Section 69)

It can be seen that AUTOBOX detected a significant step intervention at the second quarter of 1982. This so-called transfer function parameter is highly significant; furthermore, as a result of the intervention effect having been controlled for, the significance of the existing moving average parameter has increased (from $t=-1.69$ to $t=-3.94$). The model now explains 37.3% of the variance ($R^2=.37331$). A final diagnostic check reveals that this model passes the invertibility, sufficiency and necessity checks.

Finally, AUTOBOX goes through a process known as backcasting, whereby residuals from time period 13 through 40 are used to "forecast back" to estimate the residuals in time periods 1 to 12, since in a lag 12 model these are set to 0. It then uses this new information to re-estimate the model. In the final analysis, the MA parameter is even more significant ($t=-21.48$) and 64.4% of the variance is explained ($R^2=.64439$).

2.2.4 Null hypothesis

The null hypothesis tested was that there were no significant intervention effects of any type following full implementation of Ontario's child restraint legislation (i.e.,post-1983) on either the incidence of severe or fatal injuries, the severity of injury or the anatomical patterns of injury.

However, the AUTOBOX program was not restricted to detecting significant intervention effects at the fourth quarter of 1983, but rather, it searched for both abrupt permanent ('step') and abrupt temporary ('pulse') effects at all time periods in the series'. Gradual changes would be indicated by a sequence of pulses.

By restricting the search to a one or several time periods corresponding to the date of implementation, one would risk missing intervention effects that may have occurred either prior to, or following, the date of legislation, for several reasons. First, the law was not implemented in an abrupt fashion, but rather phased in over a two-year period. Second, a very extensive public education program was initiated in Ontario in late 1981, a full year prior to the first phase of the legislation. Third, child car seats had been available on the market since the mid-1970's, and many safety conscious parents had been protecting their children in cars long before the legislation. Fourth, factors other than child restraint legislation could have had an impact on the incidence and severity of motor vehicle injuries, such as other traffic legislation and enforcement, as well as continuing trends over many years (before and after child restraint legislation) in both vehicle safety and road safety.

Because of the influence of these factors (alone or in combination), the intervention effect could have been detectable anywhere within a wide range of time periods surrounding the date of full implementation of the law.

2.3 SOURCES AND RECORD SELECTION CRITERIA

2.3.1 Hospital Medical Records Institute

Records selected: Data pertaining to both non-fatal and fatal hospital admissions were gleaned from the Hospital Medical Records Institute (HMRI) morbidity data base for the province of Ontario, which contains hospital discharge data on every patient who has been discharged from a hospital in Ontario. There was 100% coverage by HMRI of Ontario hospital discharges for the duration of the ten-year study period.[60]

Non-fatal hospital admissions were defined as "those admissions in which the person sustained injuries while a passenger in a motor vehicle involved in a traffic crash, whose injuries were serious enough to warrant admission to hospital for treatment of those injuries, and who was discharged alive from hospital".

Fatal hospital admissions were defined as "those admissions in which the person sustained injuries while a passenger in a motor vehicle involved in a traffic crash, whose injuries were serious enough to warrant admission to hospital for treatment of those injuries, and who died in hospital."

If a person was discharged home following hospitalization for injuries suffered in a MVTA and subsequently died **at home**, this person would, of course, not be included in the "fatal hospital admissions" category. (They would, however, be captured in the TRAID data base as a fatality, as long as they met the necessary criteria (these are discussed below). A person who was pronounced dead at the scene, or who was treated in the emergency room and released would not be in the HMRI data base; however, fatalities at the scene would be included in the TRAID data base.

HMRI records were selected via compact disc reader according to the following criteria:

1. **Province of Admission**: Ontario
2. **Ages**: Between 0 and 4 years of age inclusive (study group), or between 20 and 44 years of age inclusive (control group);
3. **Dates of Admission**: Admitted to an Ontario hospital between January 1, 1979 and December 31, 1988;
4. **Diagnostic Codes**: At least one of the fifteen secondary diagnostic codes had to be one of the following E codes:

   E 810: MVTA involving collision with train

   E 811: MVTA involving re-entrant collision

   E 812: Other MVTA involving collision with another motor vehicle

   E 813: MVTA involving collision with other vehicle

   E 814: MVTA involving collision with pedestrian

   E 815: Other MVTA involving collision on the highway

   E 816: MVTA due to loss of control without collision on the highway

   E 819: MVTA not otherwise specified

The "E" codes of the International Classification of Diseases (ICD-9) classify the external causes of injuries. E codes 810 to 819 refer to "Motor Vehicle Traffic Accidents" (MVTA's), whereby an MVTA is defined as:

-an accident involving vehicles other than aircraft and spacecraft, watercraft, railway and other road vehicles; and,

-an accident which is assumed to have occurred on the highway unless another place is specified, except in the case of accidents involving only off-road motor vehicles which are classified as non-traffic accidents unless the contrary is stated.

Two categories of E codes were excluded from the MVTA grouping of codes E 810-819. **E 817** refers to a non-collision MVTA while boarding or alighting a motor vehicle. One may safely assume that a child cannot be restrained in an appropriate restraint while alighting or boarding a motor vehicle. **E 818** refers to other non-collision MVTA's which result from the following:

- accidental poisoning from exhaust gas generated by/ breakage of any part of/ explosion of any part of/ fall, jump, or being accidentally pushed from/ fire starting in/ hit by object thrown into or on/ injured by being thrown against some part of, or object in/ injury from moving part of/ object falling in or on/ object thrown on, motor vehicle while in motion
- collision of railway train or road vehicle except motor vehicle, with object set in motion by motor vehicle
- motor vehicle hit by object set in motion by railway train or road vehicle
- pedestrian, railway train or road vehicle hit by object set in motion by motor vehicle.

Although child restraints can prevent or lessen the injuries incurred by "being thrown against some part of, or object in the motor vehicle while in motion", most of the 'scenarios' represented by E 818 are those in which the occurrence or severity of injury would not have been diminished by the use of a child restraint; therefore it has been excluded.

The fourth-digit subdivision ".1" was used with categories E810-816 and E 819 to identify the injured person as a passenger in motor vehicle other than a motorcycle.

Records excluded: Any record which met one or more of the following criteria was deleted following selection by compact disc:

1. **Residence code indicating residence outside of Ontario:** County of residence codes on selected HMRI records were recoded into ten region categories in accordance with the Ontario Ministry of Health regions (APPENDIX 4). Because the legislation does not apply to vehicles registered outside the province of Ontario, it was decided to exclude all cases whose residence was outside the province.

2. **At least one of the sixteen ICD-9 diagnostic codes in the first (or only) admission being between 905 and 909 or E 929.0 to E 929.9:** This indicates that the person was admitted for treatment of the late effects of injuries. This was done since it could not be verified that the original crash occurred within the study period.

Combining multiple admissions into one record: Using SAS programming, records in each group were matched to one another on date of birth and OHIP number, if this number was known. (Records for which the OHIP number was not known were treated as single admissions.) Records pertaining to these multiple admissions were combined in such a way that each individual would account for only **one observation** regardless of the number of times he or she was admitted to hospital. However, the data pertaining to all admissions was preserved, as illustrated in Figure 9:

FIGURE 9: Algorithm for combining hospital discharge data for multiple admissions

Before transformation:

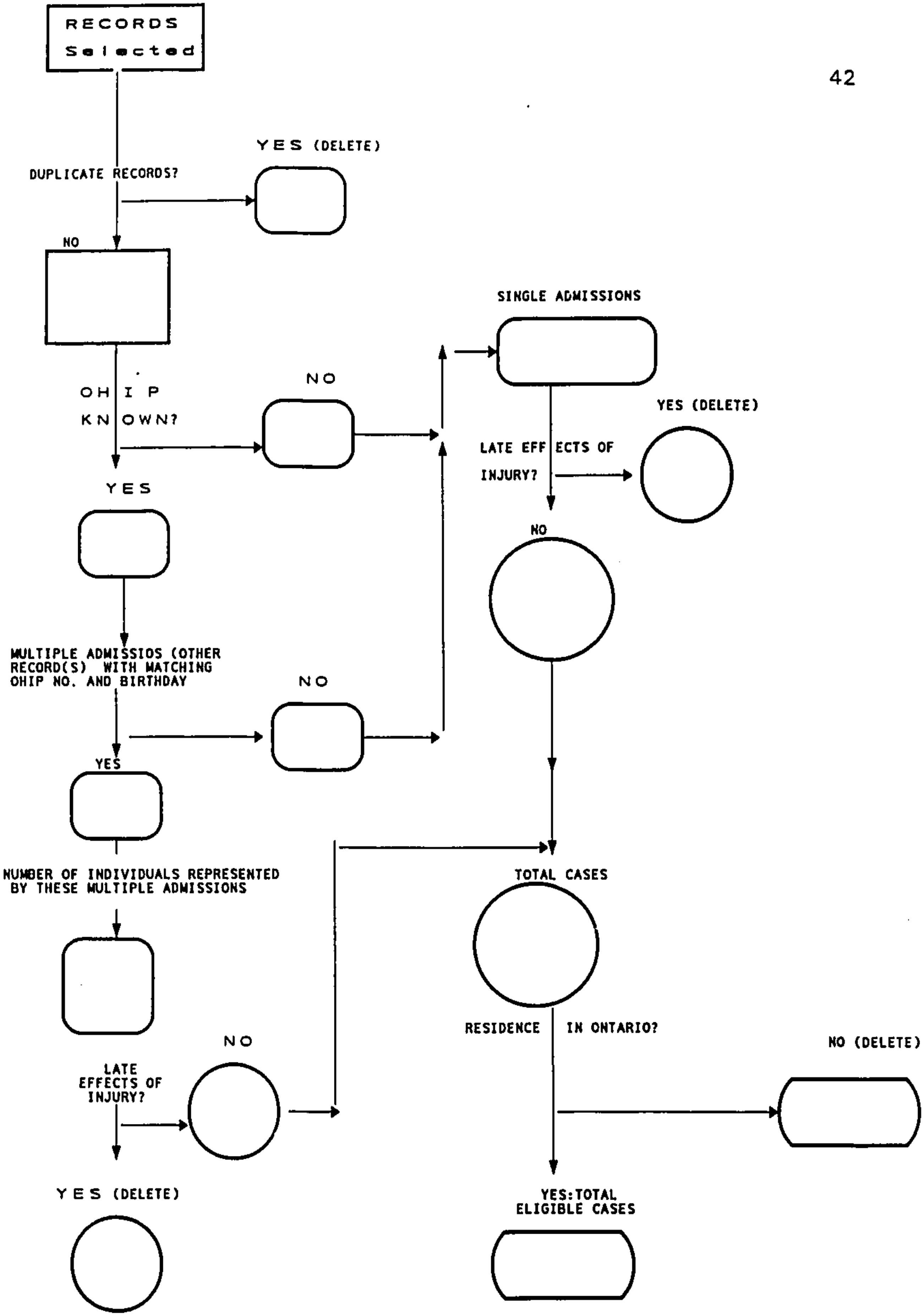
First admission: **OHIP, BIRTHDATE,** $ADMDATE_1$, $DISDATE_1$, $DIAG1_1$ .....$DIAG16_1$...

Second admission: **OHIP, BIRTHDATE,** $ADMDATE_2$, $DISDATE_2$, $DIAG1_2$ .....$DIAG16_2$...

Following transformation:

OHIP, BIRTHDATE, $ADMDATE_1$, $DISDATE_1$, $DIAG1_1$ ....$DIAG16_1$, $ADMDATE_2$, $DISDATE_2$, $DIAG1_2$....$DIAG16_2$, etc., where the subscript indicates the admission sequence (first, second etc.)

Figure 10 (below) illustrates the algorithm for selecting, excluding and combining HMRI records.


RECORDS Selected
DUPLICATE RECORDS?
YES (DELETE)
NO
OHIP KNOWN?
NO
YES
SINGLE ADMISSIONS
LATE EFFECTS OF INJURY?
YES (DELETE)
NO
MULTIPLE ADMISSIOS (OTHER RECORD(S) WITH MATCHING OHIP NO. AND BIRTHDAY
NO
YES
NUMBER OF INDIVIDUALS REPRESENTED BY THESE MULTIPLE ADMISSIONS
TOTAL CASES
RESIDENCE IN ONTARIO?
NO (DELETE)
NO
LATE EFFECTS OF INJURY?
YES (DELETE)
YES:TOTAL ELIGIBLE CASES

Categorization of most responsible diagnoses: The diagnoses which were most responsible for the length of stay ('Most Responsible Diagnosis') for each admission (or for the first admission when there were multiple admissions) were categorized according to the 'Nature of Injury' codes in ICD-9, chapter 17: Injury and Poisoning 800-999 (see APPENDIX 5). The codes for the most responsible diagnoses for the (first) hospital admissions were also recoded into seven categories of anatomical regions (APPENDIX 5).

2.3.2 Traffic Accident Information Data Bank (TRAID)

The Traffic Accident Information Data Bank (TRAID) contains data from police reports on motor vehicle traffic crashes which have occurred on public roads. Data tapes are sent yearly by the individual provincial Ministries of Transport to the federal Ministry of Transport (Transport Canada). Tapes containing records of **injury-related crashes** (i.e those crashes in which at least one person in one of the vehicles involved in the crash has suffered some degree of observable injury) were made available to the investigator from Transport Canada via the Laboratory Centre for Disease Control, Health and Welfare Canada.

Records selected: The following TRAID record selection criteria were used:

1. **Province of crash**: Ontario
2. **Date of crash**: Between January 1,1979 and December 31,1988 inclusive.
3. **Vehicle type**: Automobiles; pick-up or light van under 5000 kg.; passenger vehicles -unspecified.
4. **Person's position in vehicle**: Passenger (excludes drivers).

It should be noted that the involved persons' province of residence could not be ascertained.

Recoding of Personal Injury Scores: Each person involved in an injury-related crash is assigned a "Personal Injury Score which reflects the extent of physical injury according to the readily observable degree of medical/hospital treatment received. In this scale, a score of "0" refers to uninjured - no observable degree of injury; a score of "1" refers to minimal injury (no hospital treatment); a score of 2 refers to a person who was treated without being admitted to hospital; 3 refers to hospitalized; and 4 refers to fatal injury. The injury severity field was simplified by being recoded into two categories - Injured and killed, whereby the category "Injured" would include persons whose injuries were not serious enough to warrant admission to hospital (even though the person may have been seen in an emergency room or private physician's office) as well as those who were admitted to hospital. (In the TRAID data base, uninjured persons could not be distinguished from those persons for whom no injury score was specified, as they were grouped together in the same category).

Injured persons are followed up by police for a specified period of time following the crash (in Ontario this period is 30 days) or until the fiscal year end (March 31), whichever comes first. (Interestingly, this time period for followup is not uniform across provinces and ranges from 8 days in Quebec to 12 months in PEI.) If a death occurs within the followup period then the injury severity code on the person's record is altered to denote a fatality.

TRAID fatalities also include those persons whose injuries were so severe that the patient expired either at the scene, en route to hospital, or in the emergency room of the hospital, i.e., persons who were never admitted to hospital.

Variables calculated: Using SAS programming, the following variables were calculated for each of the 40 quarters (between 1979 and 1988) based on the selected records:

a. The total number of vehicles involved in injury-related crashes;

b. The total number of passengers (all ages) involved in injury-related crashes, even if they themselves were not injured;

c. The number of passengers 0-4* and 20-44 years of age who were involved in injury-related crashes (even if they themselves were not injured);

d. The total number of injured passengers of all ages;

f. The total number of injured passengers 0-4 and 20-44 years of age;

g. The total number of passengers (all ages) who were killed;

h. The number of passengers 0-4 and 20-44 years of age inclusive who were killed.

2.3.3 Statistics Canada

The number of cubic meters of motor gasoline sold in Ontario for each quarter between 1979 and 1988 inclusive was obtained.[61] This variable serves as a proxy measure of kilometres driven and therefore of the exposure to the risk of being in an injury-related crash. However, it is acknowledged that improvements in fuel efficiency over the ten-year study period may have rendered 'gasoline sales' increasingly less useful as a marker for distance travelled.

Annual population estimates for each year between 1979-1988 were obtained from Statistics Canada via the MORTCON program at the Laboratory Centre for Disease Control for the age groups 0-4 and 20-44.[2] Quarterly population estimates were not available at the time of the study.

---

* Until 1988, children under one year of age were given an age code of 01; thus it is not possible to distinguish those children who were under one year from those who were one year old.

2.4 STUDY RATES AND INDICATORS

The study examined three aspects of motor vehicle crash casualties during the study period 1979-1988, namely the **incidence** of injury/death, the anatomical **patterns** of injury and the **severity** of injury. This was accomplished by constructing a variety of rates that were calculated **for each of the 40 quarters** in the study period. The same rates were calculated for both the study group (0-4 years) and the control group (20-44 years), although only those calculations for the study group are detailed below.

Rates marked with an asterisk are considered to be key indicators. With respect to incidence indicators, those with "number of involved vehicles" and "number of involved persons" in the denominators are the most sensitive, since they reflect only those vehicles and persons that were actually involved in injury-related crashes. The "case fatality rate" and the "average length of stay" were considered to be the most sensitive severity indicators, since the ultimate severity of injury is death and because hospital lengths of stay are usually related to the injury severity. Finally, rates pertaining to head and skull injuries were considered to be key "patterns of injury" rates, since these injuries most often result in the greatest disability or death.

2.4.1 Incidence rates

The following incidence rates examined the occurrence of injury or death relative to a variety of denominators. The terms that are used in the numerators and denominators, as well as their sources, are listed below in Table 1.

TABLE 1: EXPLANATION OF TERMS USED IN RATES AND INDICATORS

TERM	REFERS TO	SOURCE
Injured	All persons injured (regardless of severity) who survived their injuries	TRAID
Killed	Fatally injured persons who died at the scene, en route to hospital, in or outside of hospital (within 30 days)	TRAID
All ages	Persons of all ages, including unknown age	TRAID
Non-fatal hospital admissions	Persons who were admitted to hospital and who were discharged alive	HMRI
Fatal hospital admissions	Persons who were admitted to hospital but who died in hospital	HMRI
Involved	Persons who were uninjured, injured or killed	TRAID
Total days of stay	Total days of stay in hospital by all persons in age group. When multiple admissions occurred for one individual, the sum of each of their lengths of stay were totalled.	HMRI
Total days in ICU	Total days spent in Intensive Care Units. When multiple admissions occurred for one individual, the sum of each of their days of stay in ICU'S were totalled.	HMRI

Rate I-1 calculated the incidence of (any degree of) injury in children 0-4 years in relation to persons of **all ages** who sustained any degree of injury in a MVTA:

I-1. Children 0-4 years injured or killed / 1,000 persons of all ages injured or killed

Calculation: $\dfrac{\text{Injured + killed (in age group)}}{\text{Injured + killed persons (all ages)}} \times 1{,}000$

Rate 1-2 calculated the incidence of (non-fatal) hospitalization in children 0-4 years among children 0-4 years who were involved in an injury-related MVTA (whether or not they were injured):

*** I-2. The non-fatal hospitalization rate in 0-4 year olds / 1,000 0-4 year olds involved in injury-related MVA's.**

Calculation: $\dfrac{\text{Non-fatal hospitalized admissions 0-4 year olds}}{\text{0-4 year olds involved in injury-related crashes}} \times 1{,}000$

Rate 1-3 examined the incidence of death from a MVTA in children 0-4 years among all children 0-4 years who were involved in an injury-related MVTA (whether or not they were injured):

*** I-3. The fatality rate of 0-4 year olds / 1,000 persons 0-4 involved in injury-related MVA's**

Calculation: $\frac{\text{Killed 0-4 year olds}}{\text{0-4 year olds involved in injury-related crashes}} \times 1{,}000$

In order to control for variations in the population of children in the 0-4 age group over the duration of the study period, rates **I-4 to I-5** were calculated using Ontario mid-year population figures as the denominators. Annual Ontario population estimates from Statistics Canada were used for each of the four quarters in each year:

I-4. The non-fatal hospitalization rate of childrens 0-4 years / 100,000 population 0-4

Calculation: $\frac{\text{Non-fatal hospital admissions, 0-4 years old}}{\text{Population of persons 0-4 years old}} \times 100{,}000$

I-5. The fatality rate of children 0-4 years of age / 100,000 population 0-4 years

Calculation: $\frac{\text{Killed 0-4 year olds}}{\text{Population 0-4 years old}} \times 100,000$

Rates **I-6 to I-9** controlled for fluctuations in two variables which pertain to the exposure to the risk of being injured or killed in a MVA. The first, the number of vehicles involved in injury-related crashes, could have been affected by, for example, improvements in the road construction and design, improvements in safety features in vehicles themselves, as well as the number of cars on the road and the number of kilometres driven.

*** I-6. The non-fatal hospitalization rate in children 0-4 years / 10,000 vehicles involved in injury-related crashes**

Calculation: $\frac{\text{Non-fatal hospital admissions, 0-4 years olds}}{\text{Total vehicles involved in injury-related crashes}} \times 10,000$

*** I-7. The fatality rate in persons 0-4 years of age per 10,000 vehicles involved in injury-related crashes.**

Calculation: $\frac{\text{Killed 0-4 year olds}}{\text{Total vehicles involved in injury-related crashes}} \times 10,000$

The second exposure-related variable, the number of cubic meters of motor gasoline sold (which is a proxy for the number of kilometres driven), could have been affected by, for example, the strength of the economy and the prices per litre of gasoline over the duration of the study period.

I-8. The non-fatal hospitalization rate in children 0-4 years / 1,000,000 cubic meters of motor gasoline sold

Calculation: $\frac{\text{Non-fatal hospital admissions, 0-4 years old}}{\text{Cubic meters of motor gasoline sold}} \times 1{,}000{,}000$

I-9. The fatality rate in children 0-4 years / 1,000,000 cubic meters of motor gasoline sold

Calculation: $\frac{\text{Killed 0-4 year olds}}{\text{Cubic meters of motor gasoline sold}} \times 1{,}000{,}000$

2.4.2 Indicators of severity

Since there is no severity-of-injury rating applied to injuries upon admission to hospital, rates **S-1 to S-3** were calculated to approximate severity of injury.

*** S-1. Fatalities in children 0-4 years / 1,000 severely injured children 0-4 years (Case Fatality Rate)**

Calculation:

$$\frac{\text{Killed 0-4 year olds}}{\text{Killed (0-4 years) + non-fatal hospital admissions (0-4 years)}} \times 1{,}000$$

*** S-2. Average Length of stay (non-fatal hospitalized injuries)**

Calculation:

$$\frac{\text{Total days of stay by 0-4 year olds}}{\text{Non-fatal hospital admissions, 0-4 years old}}$$

S-3. Average number days in Intensive Care Units (ICU)

Calculation:

$$\frac{\text{Total days in ICU's, 0-4 year olds}}{\text{Non-fatal hospital admissions, 0-4 yrs old}}$$

2.4.3 Patterns of injury

The most responsible diagnosis for each HMRI record was considered in determining the anatomical region of injury for each case.

Changes in the anatomical patterns of injury over the duration of the study period were assessed by calculating the two rates described below. Rate P-1 was calculated separately by 'nature of injury' category, as listed above:

P-1. The rates of admission for (Nature of Injury category) / 100 hospital admissions (fatal + non-fatal)

Calculation:

$$\frac{\text{Number of fatal and non-fatal admissions with (nature of injury category) as most responsible diagnosis}}{\text{Number of fatal + non-fatal hospital admissions}} \times 100$$

Rate P-2 was calculated separately by 'anatomical region', as listed above:

P-2. The rates of admission for injuries to (Anatomical Region) / 100 hospital admissions (fatal + non-fatal)

Calculation:

$$\frac{\text{Number of fatal and non-fatal admissions with (anatomical region category) in most responsible diagnosis}}{\text{Number of fatal + non-fatal hospital admissions}} \times 100$$

CHAPTER 3 - RESULTS

APPENDIX 6 contains tabular results of the numerators and denominators, as well as rates, which were studied.

3.1 RECORDS SELECTED - HMRI DATA

3.1.1 Age and gender distribution

Study group

Thirteen hundred and fifty records (1350, including four sets of twins) were selected from the HMRI data base according to the criteria outlined above in Section 2.2. Three duplicate records were excluded. Of the 1347 remaining records, 81 records were found to match at least one other record on OHIP number and birthdate. Thirty-five (35) individuals accounted for these 81 records. It was therefore assumed that these 35 persons had multiple admissions to hospital for injuries suffered in a single MV crash. One of the 1266 records for single admissions was deleted because the child had been admitted for the late effects of injuries which had occurred prior to the study period.

Of the 1300 (35 + 1265) remaining cases, 112 were excluded because the child did not reside in Ontario (even though the child had been admitted to an Ontario hospital). Therefore, a total of 1188 eligible cases remained in the study group. (Refer to APPENDIX 7 for illustration.)

Eleven hundred and sixty-one (97.7%) cases were discharged alive from hospital, while 27 (2.3%) died in hospital. Table 2 (below) illustrates the age and gender breakdown of all of the hospitalized cases.

TABLE 2
AGE AND GENDER DISTRIBUTION OF CHILDREN 0-4 HOSPITALIZED FOR INJURIES DUE TO MOTOR VEHICLE CRASHES

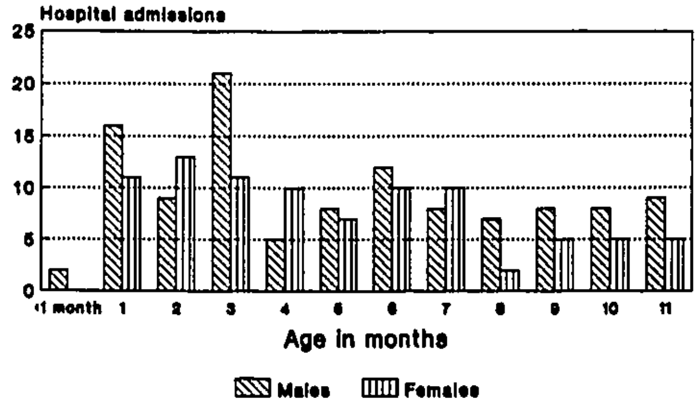
ADMISSIONS	MALES	%	FEMALES	%	TOTAL
NON-FATAL					
Infants	113	55.9	89	44.1	202 (17.4%)
					959 (82.6%)
Toddlers	538	56.1	420	43.8	1161+ (97.7% of total)
FATAL					
Infants *	1	20.0	4	80.0	5 (18.5%)
					22 (81.5%)
Toddlers **	11	50.0	11	50.0	27 (2.3% of total)
TOTAL INFANTS	114	55.1	93	44.9	207 (17.4%)
TOT. TODDLERS	549	56.0	431	43.9	981+ (82.6%)
GRAND TOTAL	663	55.8	524	44.1	1188

* Infants: < 1 year
** Toddlers: 1-4 years inclusive
\+ The gender of one toddler was unknown

<u>Age at admission- non-fatal injuries</u>: Nearly half of the infants (48.5%) were four months old or younger. For boys, three months of age was the most frequent age at admission, while for girls it was at two months of age (Figure 11). For toddlers, the frequency of non-fatal admissions was greatest at 3 years of age (30.9%), followed by four years of age (27.6%), two years of age (24%) and one year of age (17.5%). (Figure 12)

FIGURE 11

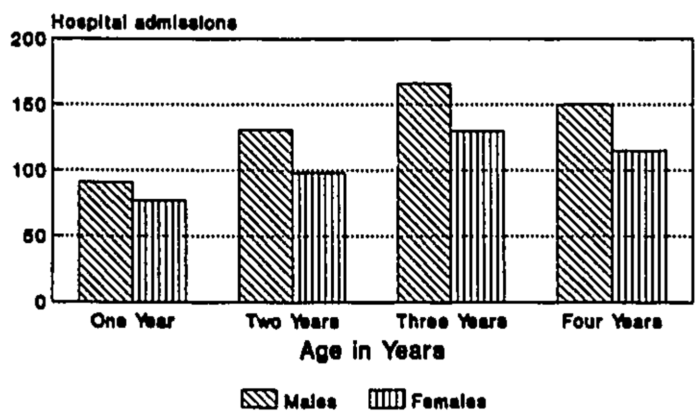
PASSENGER ADMISSIONS-NONFATAL INJURIES DUE TO MOTOR VEHICLE CRASHES 1979-1988 BY AGE AND GENDER ONTARIO AGE <1 YEAR



SOURCE: HMRI

FIGURE 12

PASSENGER ADMISSIONS-NONFATAL INJURIES DUE TO MOTOR VEHICLE CRASHES 1979-1988 BY AGE AND GENDER ONTARIO AGES 1-4 YRS

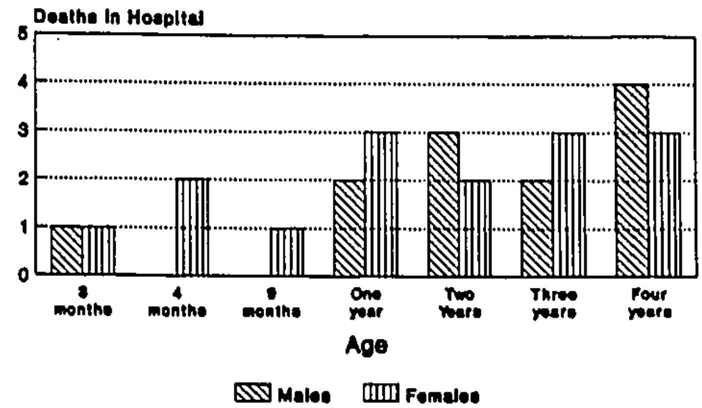


SOURCE:HMRI

Age at admission - fatal injuries: Five deaths occurred to infants, while 22 deaths occurred to toddlers. The frequency of admissions for (ultimately) fatal toddler injuries was greatest at four years of age (31.8%) and equal at one, two and three years of age (approximately 22.7% for each year). (Figure 13)

FIGURE 13

PASSENGER DEATHS IN HOSPITAL 1979-1988
DUE TO MOTOR VEHICLE CRASHES
BY AGE AND GENDER,ONTARIO AGE 0-4 YEARS



SOURCE:HMRI

Control group

Twelve thousand one hundred and forty-five (12,145) records were selected from the HMRI data base according to the criteria outlined above in Section 2.2. One duplicate record was excluded. Of the 12,144 remaining records, 782 were found to match at least one other record on both OHIP number and birthdate. Three hundred and fifty-seven (357) individuals accounted for these 782 records. It was therefore assumed that these 357 persons had multiple admissions to hospital for injuries suffered in a single MV crash. Ten of these were deleted because they had been admitted for the late effects of injury. Of the 11,362 single admissions, 56 were deleted because the person had been admitted for the late effects of an injury which had occurred prior to the study period.

Of the 11,653 (347 + 11,306) remaining cases, 910 were excluded because the person did not reside in Ontario (even though he or she had been admitted to an Ontario hospital). Therefore, a total of 10,743 eligible cases remained in the control group. Table 3 (below) illustrates the age and gender distribution of hospitalized adults 20-44 years.

TABLE 3
AGE AND GENDER DISTRIBUTION OF ADULTS 20-44 HOSPITALIZED FOR INJURIES DUE TO MOTOR VEHICLE CRASHES

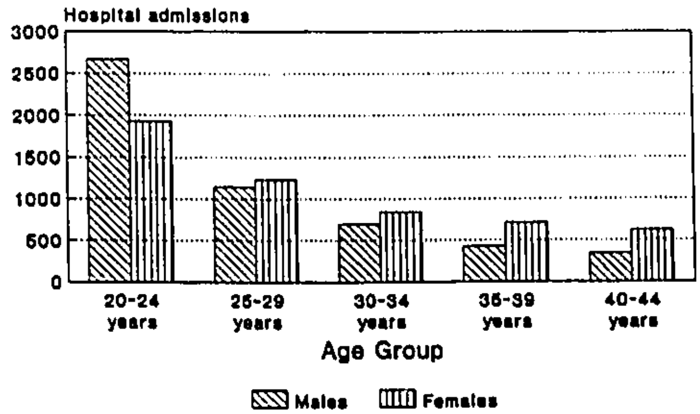
ADMISSIONS	MALES	%	FEMALES	%	TOTAL
NON-FATAL INJURIES	5281	49.7	5336	50.3	10617 (98.8%)
FATAL INJURIES	76	60.3	50	39.7	126 (1.2%)
TOTAL	5357	49.9	5386	50.1	10743

Age at admission- non-fatal injuries: The 20-24 year age group had the greatest frequency for both genders, accounting for 43.2% of all non-fatal admissions in the study period. The frequency decreased with each successive age group, i.e, 22.4% at 25-29 years, 14.5% at 30-34 years, 10.7% at 35-39 years, and 9.2% at 40-44 years. Females outnumbered males in all age groups except 20-24 years. (Figure 14)

Fatal injuries: The frequency of admissions for fatal injuries was also greatest in the 20-24 year age group (50.8%). The frequency decreased with age, from 22.2% (25-29), 9.6% (30-34), to 8.7% for each remaining group. (Figure 15)

FIGURE 14

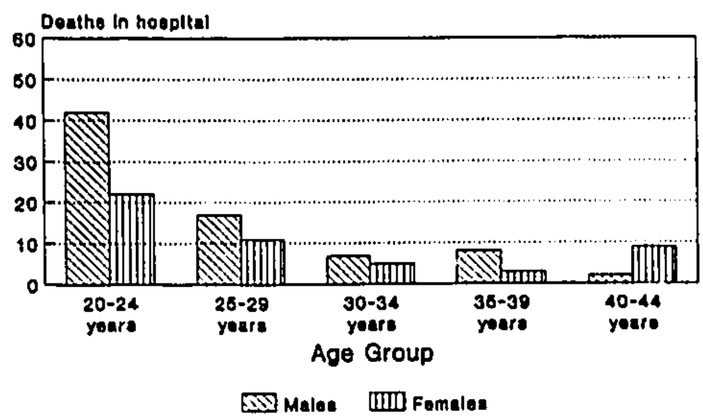
PASSENGER ADMISSIONS-NON-FATAL INJURIES
DUE TO MOTOR VEHICLE CRASHES 1979-1988
BY AGE AND GENDER ONTARIO 20-44 YEARS



SOURCE: HMRI

FIGURE 15

PASSENGER DEATHS IN HOSPITAL 1979-1988
DUE TO MOTOR VEHICLE CRASHES
BY AGE AND GENDER ONTARIO AGE 20-44 YRS



SOURCE: HMRI

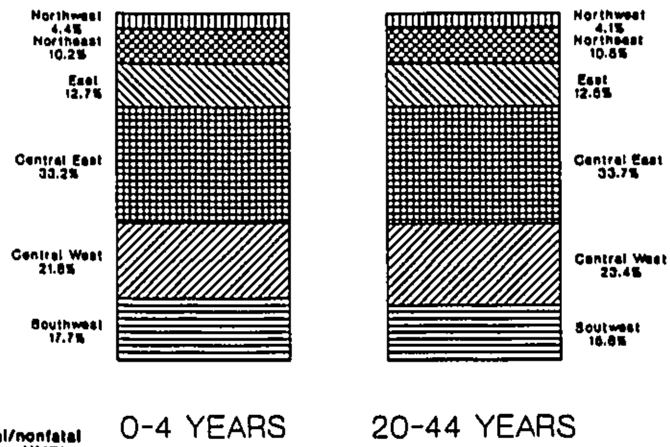
3.1.2 Region of residence

Study group

More than half of the admitted children resided in either the Central East (33.19%) or the Central West (21.81%). An additional 30.4% resided in either the Southwest (17.7%) or Eastern regions (12.7%). (Figure 16)

FIGURE 16

PASSENGER ADMISSIONS* DUE TO MV CRASHES
REGION OF RESIDENCE
ONTARIO 1979-1988 0-4 YRS, 20-44 YRS



*Fatal/nonfatal
Source:HMRI

Control group

More than half of the admitted adults resided in either the Central East (34%) or Central West (23%). Approximately one-quarter resided in either the Southwest (16%) or Eastern (12%) region. (Figure 16)

3.2 RECORDS SELECTED - TRAID DATA

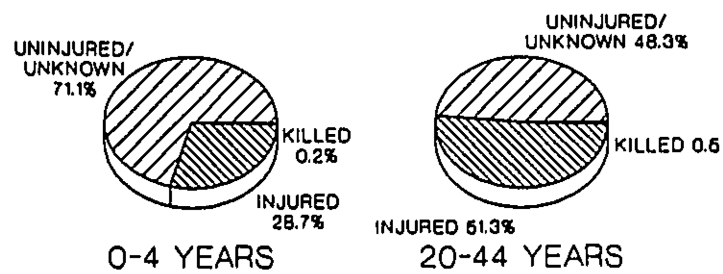
3.2.1 Personal injury outcome

Study group

Fifty-one thousand seven hundred and thirty-one (51,731) children under the age of five were involved in an injury-related MV crash during the study period. Of these, 36,757 (71.1%) were either uninjured or their injury status was unknown (these two categories were "lumped" together in the data base); 14,851 (28.7%) were non-fatally injured; and 123 (.2%) were fatally injured. (Figure 17)

FIGURE 17

PERSONAL INJURY OUTCOME - PASSENGERS IN INJURY-RELATED MOTOR VEHICLE CRASHES ONTARIO 1979-1988 0-4 YRS, 20-44 YRS



SOURCE: TRAID

Control group

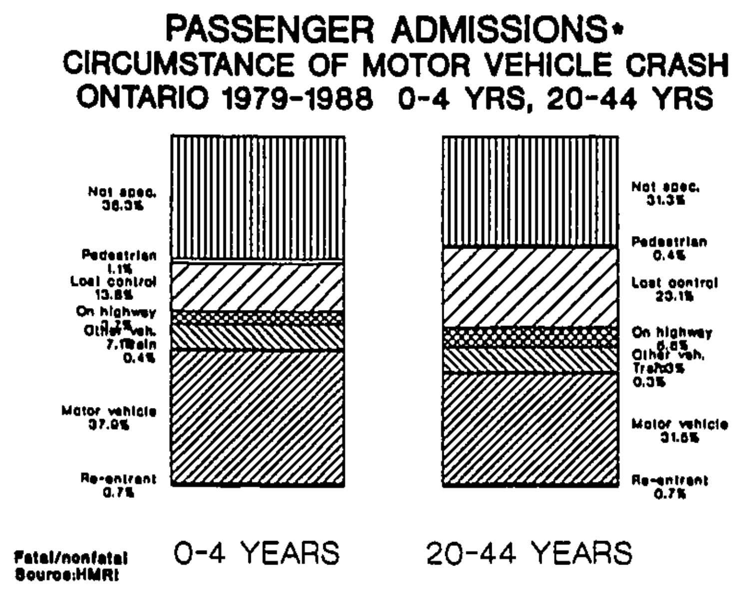
There were 286,794 people between the ages of 20 and 44 years who were involved in an injury-related MV crash during the study period. Of these, 138,454 (48.3%) were either uninjured or their injury status was unknown; 147,045 (51.3%) were non-fatally injured; and 1,295 (.4%) were fatally injured. (Figure 17)

3.2.2 Circumstance of crash

Study group

The greatest proportion (38.9%) of admitted children had been riding in a motor vehicle which collided with another motor vehicle. In 14% of cases, the driver of the car in which the child was a passenger lost control of the vehicle without colliding. (Figure 18)

FIGURE 18



Control group

Almost one-third of adult occupants admissions had been riding in a vehicle which collided with another motor vehicle. In an additional 23% of cases, the driver of the vehicle had lost control without collision. (Figure 18)

3.3 YEARLY AND QUARTERLY TRENDS IN VARIABLES

Trends in the variables comprising the numerators and denominators of the rates and indicators (i.e., admissions, gasoline sales, persons involved, vehicles involved) are discussed in APPENDIX 8.

3.4 ANALYSIS OF INCIDENCE RATES OF NON-FATAL ADMISSIONS

Only the results for the key incidence rates of non-fatal admissions are presented in this section. A detailed description of the other non-fatal admission rates, as well as the rate "injured or killed/1,000 all ages injured or killed" can be found in APPENDIX 8. A summary of the results of all non-fatal admission rates are found in Section 3.4.3.

3.4.1 Non-fatal admissions /10,000 involved vehicles

Rate I-6 calculated the number of non-fatal admissions, controlling for the number of vehicles involved in injury-related crashes.

Children: The lowest point in the **quarterly** rate series (Figure 19) occurred in first quarter of 1983. In the **yearly** rate series (Figure 20), after the high level of 1979, the rate dropped by 1981 to reach its lowest point in the series. The rate then rose, reaching a peak (and the second highest level in the ten-year period) in 1983. After a decline until 1985, the rate began to rise again slightly. No significant step* changes in level were detected.

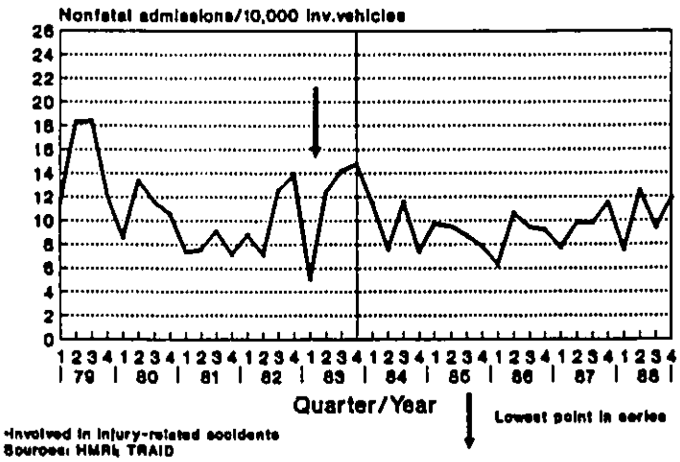
Controls: In the **quarterly** rate series (Figure 21) a step intervention was detected at 3/85, indicating a significant **downward** change in the level of the series after that point (*t* value = - 8.71). There was a marked decline in the **yearly** rate series between 1983 and 1986 (Figure 22).

---

* Note that only significant step interventions which signal changes in the level of a rate will be discussed in this and the following sections. Pulse, or temporary, interventions are noted in Tables 4 and 5 at the end of this chapter.

FIGURE 19

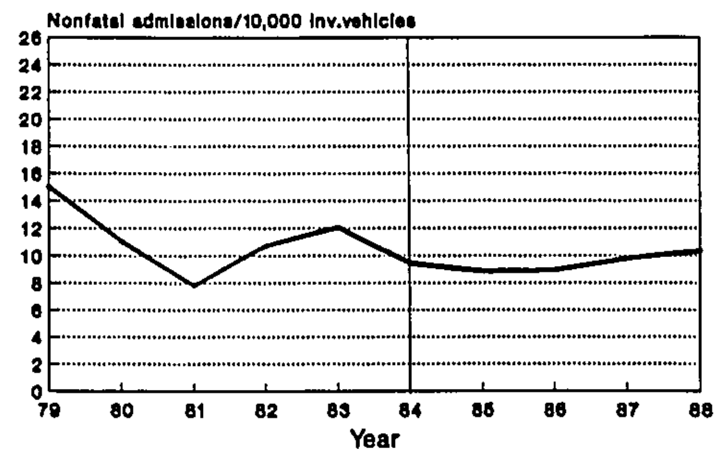
NON-FATAL ADMISSIONS/10,000 VEHICLES*
ONTARIO PASSENGERS 0-4 YEARS OLD 1979-88



*Involved in injury-related accidents
Sources: HMRI; TRAID

FIGURE 20

NON-FATAL ADMISSIONS/10,000 VEHICLES*
ONTARIO PASSENGERS 0-4 YEARS OLD 1979-88



*Involved in injury-related accidents
Sources: HMRI; TRAID

FIGURE 21

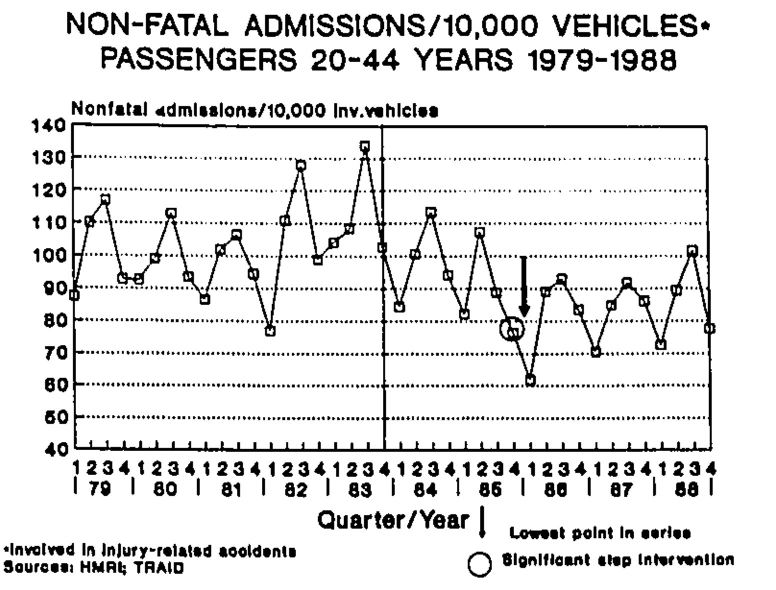
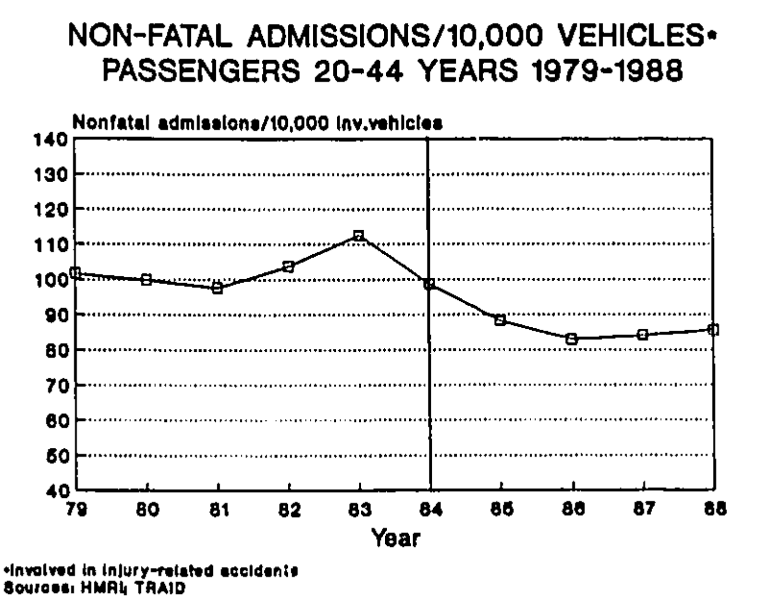


FIGURE 22



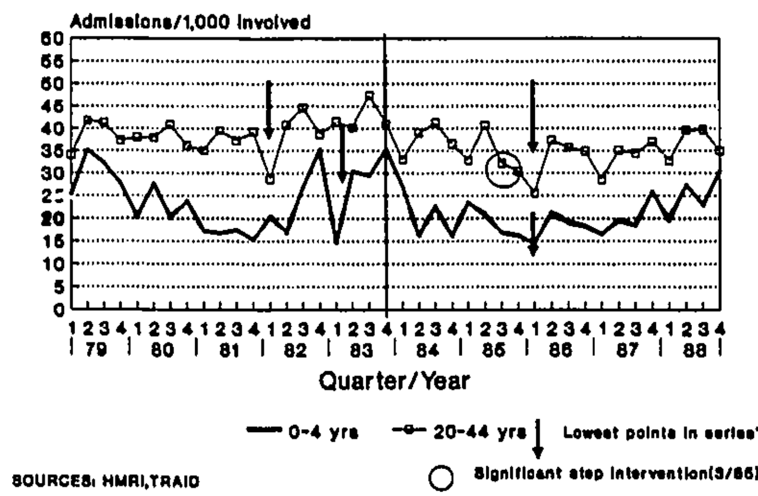
3.4.2 Non-fatal admissions per 1,000 involved persons

Rate I-2 calculated the number of non-fatal admissions, controlling for the number of persons (in the respective age group) involved in injury-related crashes.

Children: There was a decline in the yearly rate for children under 5 years 1979 from 1979 to 1981 (Figure 24), at which time it reached its lowest level in the ten-year period. However, a sharp increase followed immediately such that by 1983 the rate had nearly attained its '79 level (despite the fact that the first quarter of 1983 was the lowest in the quarterly series - see Figure 23). After 1983, the rate again fell until, in 1986, it had almost reached its '81 level. In 1987 the rate began to climb again. No significant step changes were detected.

FIGURE 23

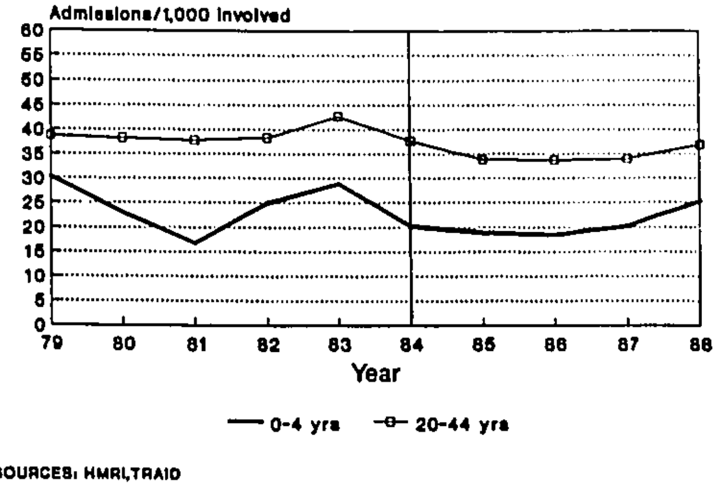
ADMISSIONS/1,000 INVOLVED PASSENGERS
0-4 YRS AND 20-44 YRS ONTARIO 1979-1988



Controls: Overall, the adult yearly rate series (Figure 24) followed a strikingly similar pattern to that of the study group (children). Although the period between 1979 and 1982 was remarkably stable, the highest level in the **quarterly** series (Figure 23) occurred in 1983 while the lowest level occurred in 1986. A significant **downward** change in level occurred at 3/85 (*t* value = -3.53).

FIGURE 24

ADMISSIONS/1,000 INVOLVED PASSENGERS
0-4 YRS AND 20-44 YRS ONTARIO 1979-1988



3.4.3 Summary of all incidence rates pertaining to non-fatal admissions (Refer also to APPENDIX 8.)

Both the yearly and quarterly series' for all incidence rates pertaining to non-fatal admissions of **children under 5** are remarkably similar to one another: in all cases, the rate fell between 1979 and 1981 and then rose by 1983, in some cases to levels approaching those of '79. In all cases, the rate fell again in 1984. Rates None of the series' experienced a step, or level change after 1983, even though 1984 was the first year of the full implementation of the child restraint legislation.

As was observed in the study group series', all of the incidence rates pertaining to non-fatal admissions in the **adult control group**, with the exception of rate I-4: "non-fatal admissions per 100,000 population", saw 1983 as the year with the highest level. In contrast to the results for children, significant downward changes in level beginning in the third quarter of 1985 were detected for the two key incidence rates pertaining to non-fatal admissions.

3.5 TIME SERIES ANALYSIS OF INCIDENCE RATES OF FATALITIES

Only the results for the key incidence rates of fatal injuries are presented in this section. A detailed description of the results for other fatal incidence rates can be found in APPENDIX 8.

A summary of the results of **all** fatal incidence rates are found in Section 3.5.3.

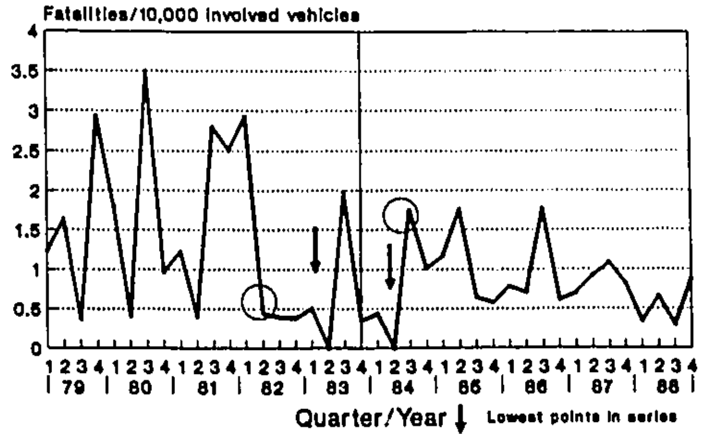
3.5.1 Fatalities /10,000 vehicles

Rate I-7 calculated the number of fatalities per quarter, controlling for the number of vehicles involved in injury-related crashes.

Children: Both the quarterly and yearly rate series' (Figures 25 and 26) are almost identical in shape to the fatality series' discussed in Appendix 8. Like rate I-5, the second quarter of 1982 was detected as the beginning of a significant **downward** change in level (*t* value = 6.28) and the third quarter of 1984 was detected as the beginning of a significant **upward** change in level (*t* value = -4.90). (Note that the signs of the *t* values are reversed since AUTOBOX chose to apply a negative lambda value (i.e., the inverse of each value) to the series).

FIGURE 25

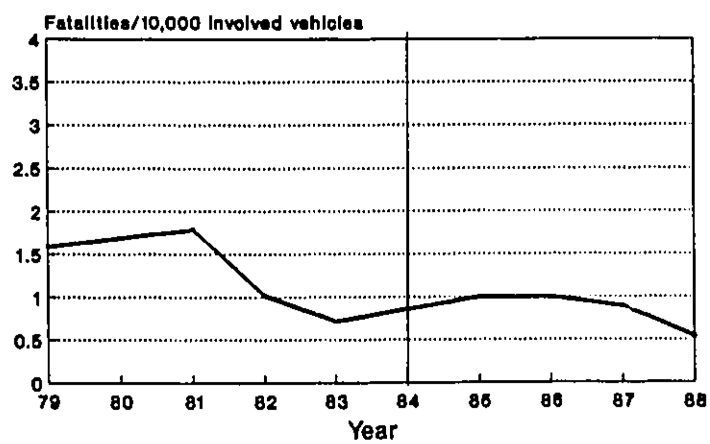
PASSENGER FATALITIES/10,000 VEHICLES*
ONTARIO 0-4 YEARS OLD 1979-1988



SOURCE: TRAID
*vehicles in injury-related accidents

FIGURE 26

PASSENGER FATALITIES/10,000 VEHICLES*
ONTARIO 0-4 YEARS OLD 1979-1988



SOURCE: TRAID
*vehicles in injury-related accidents

FIGURE 27

PASSENGER FATALITIES/10,000 VEHICLES*
ONTARIO 20-44 YEARS OLD 1979-1988

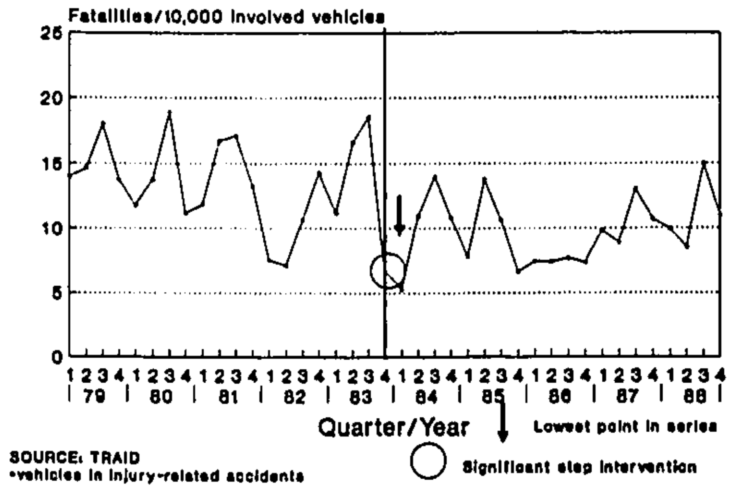
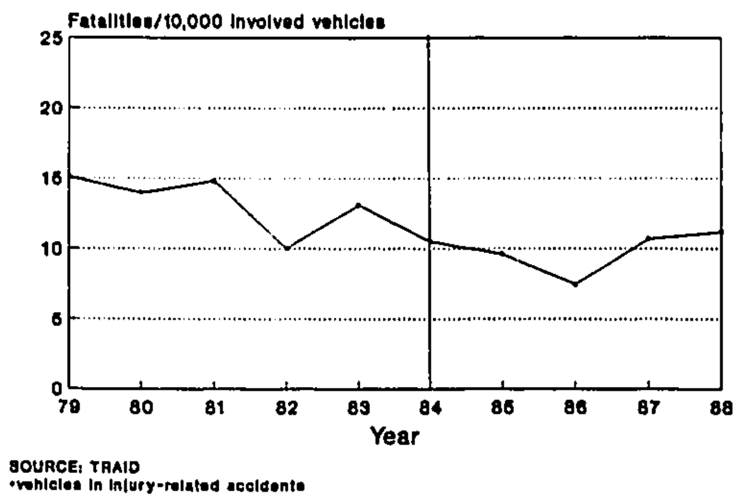


FIGURE 28

PASSENGER FATALITIES/10,000 VEHICLES*
ONTARIO 20-44 YEARS OLD 1979-1988



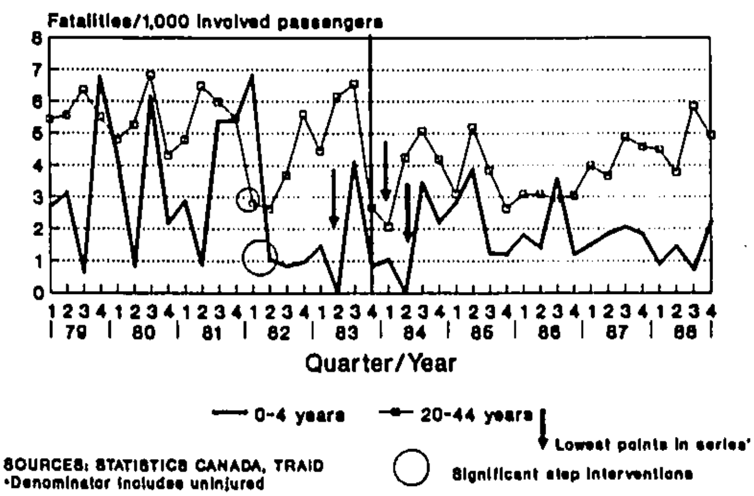
3.5.2 Fatalities per 1,000 involved persons

Rate I-3 calculated the number of fatalities per quarter, controlling for the number of involved persons.

<u>Children</u>: The patterns of the quarterly and yearly rate series' for children (Figures 29 and 30) are remarkably similar to those of the other rate series' pertaining to fatalities. As in rates I-5 and I-7, the second quarter of 1982 was detected as the beginning of a significant **downward** change in level (t value = -2.2).

FIGURE 29

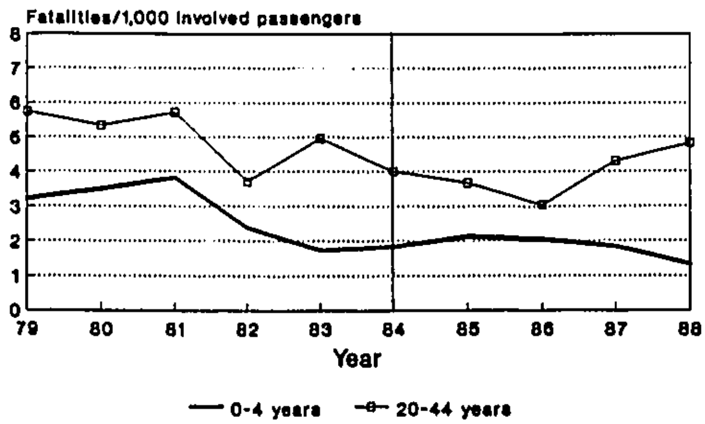
PASSENGER FATALITIES/1,000 INVOLVED*
ONTARIO 0-4 YEARS, 20-44 YEARS



<u>Controls</u>: Again, the patterns of the quarterly and yearly rate series' for adult controls (Figures 29 and 30) are remarkably similar to those of the other rate series' pertaining to fatalities. The first quarter of 1982 was detected as the beginning of a significant **downward** change in level (t value = -3.2).

FIGURE 30

PASSENGER FATALITIES/1,000 INVOLVED*
ONTARIO 0-4 YEARS, 20-44 YEARS



SOURCES: STATISTICS CANADA, TRAID
*Denominator includes uninjured

3.5.3 Summary of all incidence rates pertaining to fatalities (Refer also to APPENDIX 8.)

The yearly and quarterly patterns of all incidence rates pertaining to fatalities in **children under 5** are similar to one another. In all cases the post-legislation levels were lower overall than those prior to the full implementation of the legislation. However, it can be seen that the rates had been falling since 1981 to reach a low point in 1983, the year prior to full implementation of the legislation. In fact, for three of the four rates the second quarter of 1982 (this was more than one year preceding the full implementation of the legislation) was detected as the beginning of a significant **downward** change in level. However, after 1984 the fatality rates rose without exception to beyond the '83/'84 levels, falling only at the very end of the study period to approximately '83 levels. In two of the rates the third quarter of 1984 was detected as the beginning of a significant **upward** change in level.

The patterns of all incidence rates pertaining to fatalities in the **adult control group** are also remarkably similar to one another. The rates had a downward trend throughout the ten-year study period until 1986 when they began to rise again. In the two key incidence rates pertaining to fatalities, significant **downward** changes in level occurred at or before the point of full implementation of child restraint legislation.

3.6 TIME SERIES ANALYSIS OF SEVERITY OF INJURY INDICATORS

Only the results for the key severity of injury rates are presented in this section. See APPENDIX 8 for a detailed description of the results for other severity rates.

A summary of the results of all severity rates are found in Section 3.7.3.

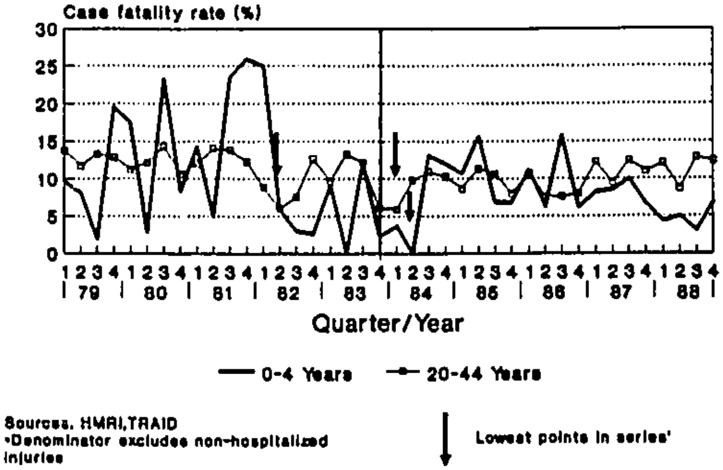
3.6.1 Case Fatality Rate

Rate S-1 calculated the percentage of severely injured persons (who were at least admitted to hospital) who died from their injuries.

Children: Both the quarterly and yearly patterns (Figures 31 and 32) of this rate bear a strong resemblance to those of incidence rates pertaining to child fatalities. Although the overall post-legislation level was lower, it is clear that this rate had been falling since 1981, three years prior to full implementation of the law. After it peaked in 1981, the rate fell below its '79 level; it then rose, peaking to approximately its '79 level in 1985; thereafter it began a gradual decline. The 1988 rate was marginally lower than the '83 rate. No significant step intervention points were detected.

FIGURE 31

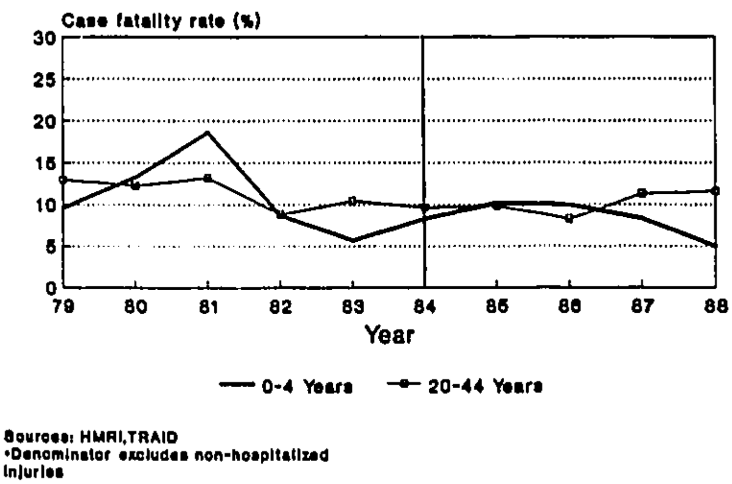
CASE FATALITY RATE* 1979-1988
PASSENGERS 0-4 YEARS, 20-44 YEARS



Controls: There was a downward trend in the yearly rate series (Figure 32) from 1979 until 1986, not unlike the trend observed in incidence rates pertaining to adult control fatalities. No significant step intervention points were detected.

FIGURE 32

CASE FATALITY RATE* 1979-1988
PASSENGERS 0-4 YEARS, 20-44 YEARS



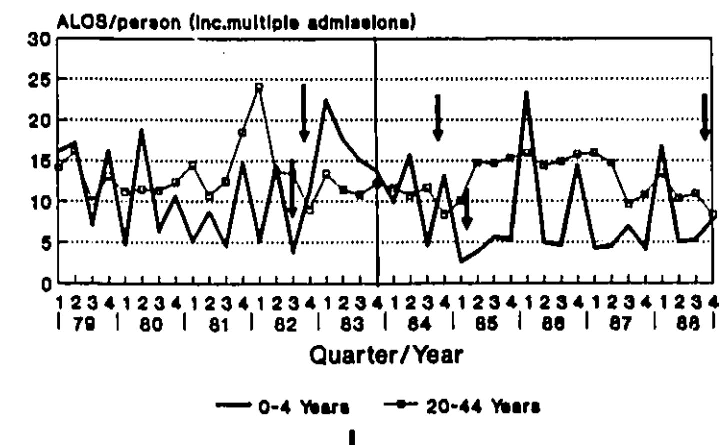
3.6.2 Average Length of Stay

Rate S-2 calculated the average length of stay per quarter for persons who were admitted for non-fatal injuries. When multiple admissions occurred for the same individual, the total of lengths of stay for all admissions were assigned to the quarter in which the first admission took place.

Children: When the yearly rate series (Figure 34) for average length of stay in children is compared with those for fatalities in children a very interesting pattern emerges. First, the increase in fatality rates from 1979 to 1981 is contrasted with a corresponding decline in average length of stay. Second, the dip in the 1983 fatality rates corresponds with the 1983 peak in the average length of stay. Third, the increase in fatality rates between 1983 and 1985 corresponds to a decrease in average length of stay over the same period. Although the post-legislation level appeared to be generally lower overall than the pre-legislation levels (Fig 33) no significant step intervention points were detected.

FIGURE 33

AVERAGE LENGTH OF STAY 1979-1988
PASSENGERS 0-4 YRS, 20-44 YRS

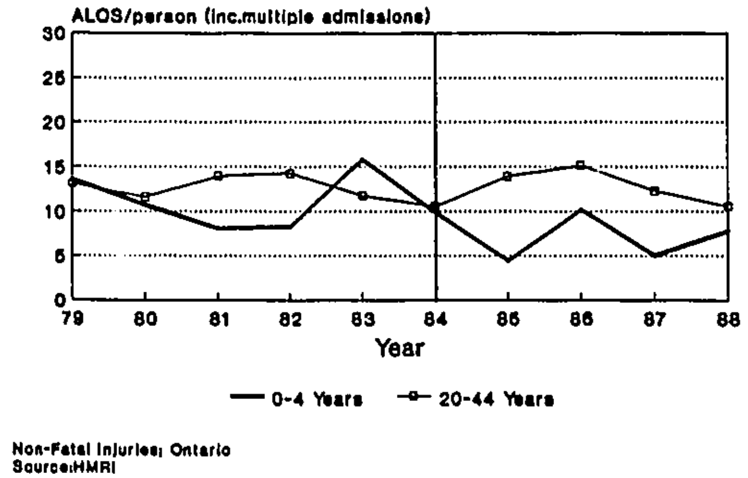


Non-Fatal Injuries; Ontario
Source:HMRI

Controls: Like the rate series' for children, it was observed that low levels in 1982 and 1986 in the fatality rate series' corresponded with high levels in those years in average length of stay. Whereas the first two quarters of 1982 were among the lowest points in all quarterly series' pertaining to fatalities, the highest quarterly average length of stay (by far) in this series occurred in 1/82. No significant step intervention points were detected.

FIGURE 34

AVERAGE LENGTH OF STAY 1979-1988
PASSENGERS 0-4 YRS, 20-44 YRS



3.6.3 Summary of indicators pertaining to severity of injury (Refer also to APPENDIX 8.)

For children under 5, the overall post-legislation levels appeared to be lower for "average length of stay" and "case fatality rate". However, the case fatality rate had been falling since 1981; in addition, the post-legislation case fatality rates exceeded the '83 rate in all years but 1988.

None of the four indicators had a detectable, significant downward change in level in the post-legislation period. In fact, the post-legislation level of "average days in special care units" actually appeared to have increased.

Similar patterns were observed in the adult control group, with the exception of "average length of stay", whose overall level did not appear to change after introduction of the legislation. None of the indicators had a detectable, significant change in the overall level in the post-legislation period.

3.7 TIME SERIES ANALYSIS OF NATURE OF INJURY/BODY PART RATES

Most of the "natures of injury" did not occur often enough in each quarter as the most responsible diagnosis to allow time series analysis, i.e., the values in many quarters were "0". The four "natures of injury" which occurred sufficiently often to permit analysis were: lower extremity fractures/100 admissions, open wound of the head/neck/trunk per 100 admissions, skull fractures per 100 admissions and intracranial injuries per 100 admissions. Only the results for the key nature/body part of injury rates are presented in this section. A detailed description of the results for other nature/body part rates can be found in APPENDIX 8. A summary of the results of all nature/body part rates are found in Section 3.8.4.

3.7.1 Skull Fractures per 100 admissions

Children: There was much variability in the quarterly rate series. (Figure 35) While there was a downward trend in the yearly series (Figure 36) from 1979 to 1982, the post-legislation level was higher overall. However, no significant step intervention points were detected.

Controls: The variability in the adult controls was negligible, and the level remained relatively constant throughout the study period. No significant step intervention points were detected.

FIGURE 35

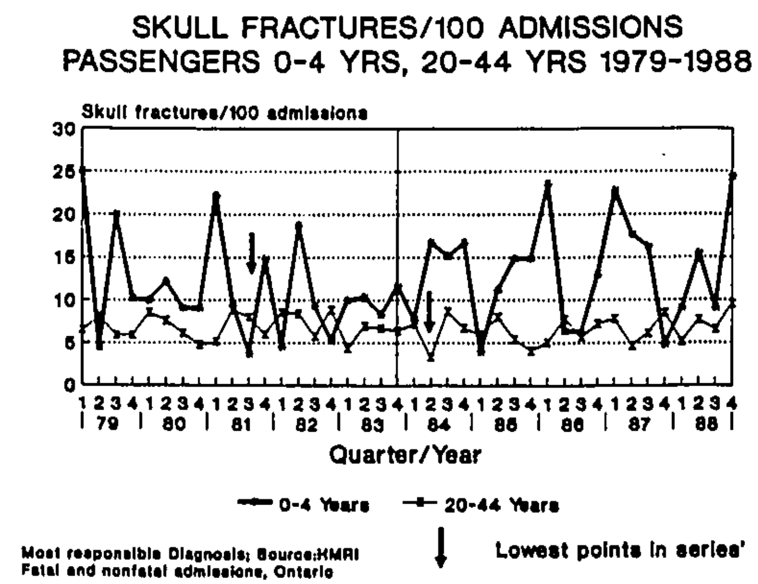
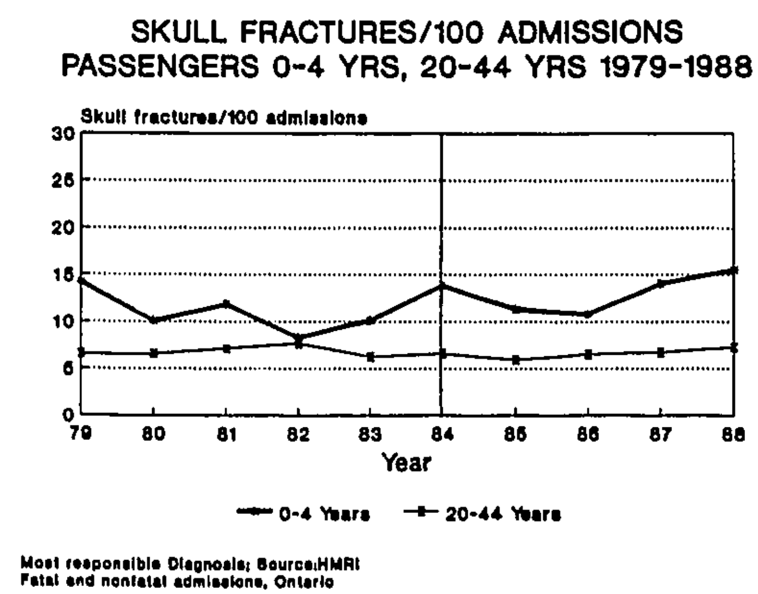


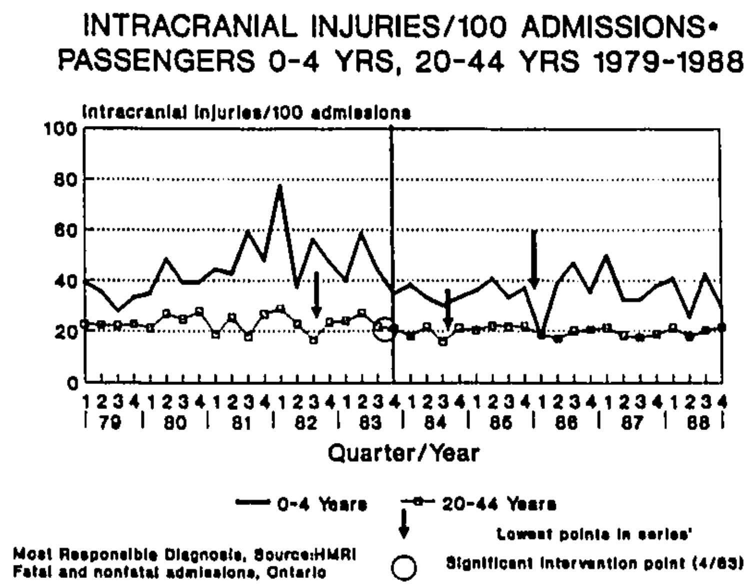
FIGURE 36



3.7.2 Intracranial Injuries per 100 admissions

Children: (Fig.37-38) Intracranial injuries reached their peak in 1982 (nearly 55 per 100 admissions) and their lowest points in 1984 and 1988 (less than 34 per 100 admissions. There was a noticeable, although insignificant, decrease the overall post-legislation level; however this rate had been dropping since early in 1982.

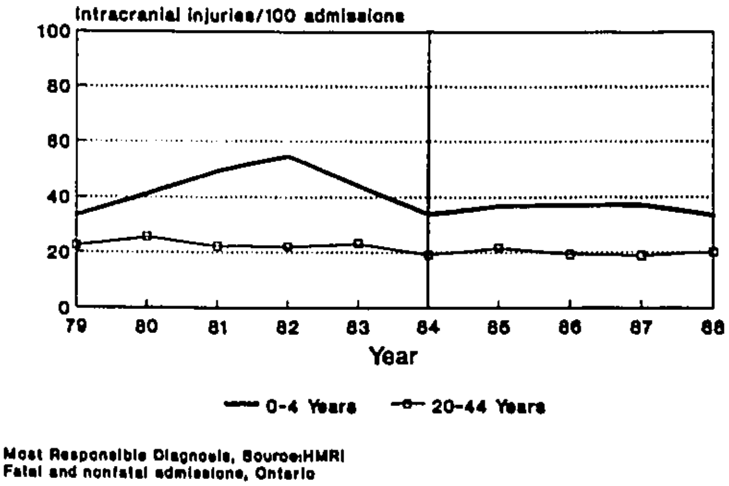
FIGURE 37



Controls: There was much less variability of the quarterly rate series compared with the study group. A step intervention was detected, indicating a significant **downward** change in the level of the rate beginning in 4/83 (*t* value = -4.05).

FIGURE 38

INTRACRANIAL INJURIES/100 ADMISSIONS•
PASSENGERS 0-4 YRS, 20-44 YRS 1979-1988



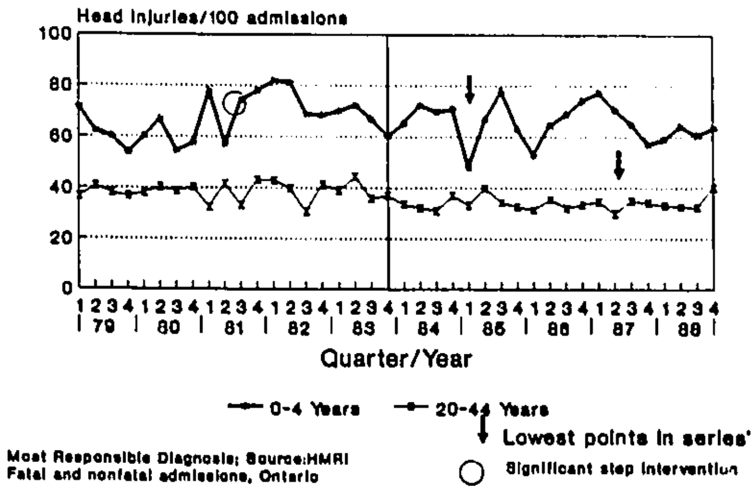
Injuries to most of the anatomical regions except "head and face" and "extremities" did not occur sufficiently frequently to allow time series analysis, i.e., the values in many quarters were "0". However, the rates "head and facial injuries per 100 admissions" and "extremity injuries per 100 admissions" were analyzed.

3.7.3 Head injuries/100 admissions

Children: Head and facial injuries as the most responsible diagnosis increased between 1979 and 1982 (Figures 39 and 40). Thereafter, it began a slow decline from 73.15 per 100 admissions to 62.22 per 100 admissions in 1988. The third quarter of 1981 signalled a significant **upward** change in level (*t* value = 2.73).

FIGURE 39

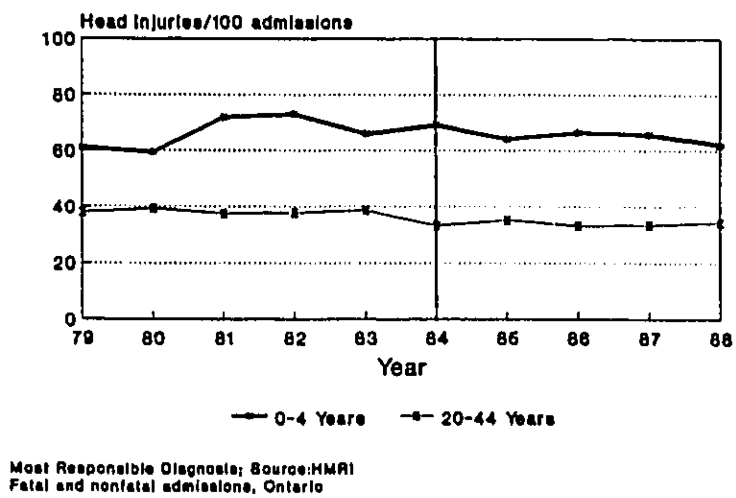
HEAD INJURIES/100 ADMISSIONS
PASSENGERS 0-4 YRS, 20-44 YRS



Controls: The post-legislation level of the yearly rate series is marginally lower. However, no significant step intervention points were detected.

FIGURE 40

HEAD INJURIES/100 ADMISSIONS
PASSENGERS 0-4 YRS, 20-44 YRS



3.7.4 Summary of patterns of injury rates (Refer also to APPENDIX 8)

There was no significant change in children under 5 in the level of skull fractures or intracranial injuries following introduction of the legislation. However, when all natures of injury to the head/face region were considered together there was a significant upward change in level beginning in 1981; this trend was not reversed following the legislation. There was a significant decrease in all natures of injury to upper and lower extremities considered together. However, this level shift preceded the implementation of the legislation by some three years. For the adult control group, there was a significant downward change in the level of intracranial injuries at the point of intervention, i.e., the fourth quarter of 1983.

Therefore, child restraint legislation does not appear to have had a significant impact on the severity of injuries to children under 5 years.

3.8 TABULAR SUMMARY OF RESULTS

Tables 3 and 4 illustrate the results of time series analyses performed by the AUTOBOX software, including any statistically significant points of intervention. In addition, the lowest point for the rates are indicated, even if they were not selected by the program as statistically significant points of intervention.

In the column entitled "Model Type" the type of ARIMA model for each rate is identified, i.e, autoregressive (AR), moving average (MA) or white noise. The "lag" denotes the specific prior quarter(s) which are correlated with the current one. For example, an AR model with lag 4 means that the value of the current observation may be predicted (to a degree indicated by the coefficient of the AR parameter) by the value of the observation one year, or four quarters, prior. Similarly, an (MA) model with lag 3 means that the effects of 'random shocks' persist for 9 months.

TABLE 3:RESULTS OF TIME SERIES ANALYSIS STUDY GROUP (0-4 YEARS)

	INCIDENCE RATES	MODEL TYPE	LOWEST POINT(S) QUARTER/YEAR	SIGNIFICANT INTERVENTION QUARTER/YEAR
I-1.	PASSENGERS INJURED AND KILLED PER 1,000 ALL AGES INJURED AND KILLED	1. AR MODEL WITH LAG 1 2. AR MODEL WITH LAG 2	1/83 (Steep drop);3/88	2/88 (Pulse)
I-2.	NON-FATAL ADMISSIONS PER 1,000 PASSENGERS INVOLVED IN INJURY-RELATED MV CRASH	1. MA MODEL WITH LAG 8 2. AR MODEL WITH LAG 2	1/86; 1/83 (steep drop)	NONE
I-3.	PASSENGER FATALITIES PER 1,000 PASSENGERS INVOLVED IN INJURY-RELATED MV CRASH	MA MODEL WITH LAG 12	2/83; 2/84	2/82 (Step)
I-4.	NON-FATAL ADMISSIONS PER 100,000 POPULATION	MA MODEL WITH LAG 4	1/83	NONE
I-5.	PASSENGER FATALITIES PER 100,000 POPULATION	NO MODEL IDENTIFIED - WHITE NOISE ONLY	2/83; 2/84	4/79 (Pulse) 3/80 (Pulse) 2/82 (Step) 3/83 (Pulse) 3/84 (Step)
I-6.	NON-FATAL ADMISSIONS PER 10,000 VEHICLES INVOLVED	NO MODEL IDENTIFIED - WHITE NOISE ONLY	1/83; 1/86	NONE
I-7.	FATALITIES PER 10,000 VEHICLES INVOLVED IN IRC	MA MODEL WITH LAG 12	2/83; 2/84	2/82 (Step) 3/84 (Step)

TABLE 3:RESULTS (CONT'D)
STUDY GROUP (0-4 YEARS)

INCIDENCE RATES (CONT'D)	MODEL TYPE	LOWEST POINT QUARTER/YEAR	SIGNIFICANT INTERVENTION QUARTER/YEAR
I-8. NON-FATAL ADMISSIONS PER MILLION CUBIC METRES GASOLINE SOLD	MA MODEL WITH LAG 4	1/83	1/83 (Pulse)
I-9. PASSENGER FATALITIES PER MILLION CUBIC METRES GASOLINE SOLD	NO ARIMA MODEL IDENTIFIED - WHITE NO!SE ONLY	2/83; 2/84	NONE
SEVERITY OF INJURY INDICATORS			
S-1. CASE FATALITY RATE	NO ARIMA MODEL IDENTIFIED - WHITE NOISE ONLY	2/83; 2/84	NONE
S-2. AVERAGE LENGTH OF STAY	AR MODEL WITH LAG 2	1/85	NONE
S-3. AVERAGE DAYS IN SPECIAL CARE UNITS	NO ARIMA MODEL IDENTIFIED - WHITE NOISE ONLY	1/83; 3/84; 4/84	NONE

TABLE 3:RESULTS (CONT'D)
STUDY GROUP (0-4 YRS)

NATURE OF INJURY RATES	MODEL TYPE	LOWEST POINT(S) QUARTER/YEAR	SIGNIFICANT INTERVENTION QUARTER/YEAR
P-1A. LOWER EXTREMITY FRACTURES PER 100 ADMISSIONS	MA MODEL WITH LAG 1	2/84; 3/84; 2/83	2/83 (Pulse)
P-1B. OPEN WOUND HEAD/NECK/TRUNK PER 100 ADMISSIONS	AR MODEL WITH LAG 2	2/81; 1/82; 2/83	NONE
P-1C. SKULL FRACTURES PER 100 ADMISSIONS	NO ARIMA MODEL IDENTIFIED - WHITE NOISE ONLY	3/81; 1/85	NONE
P-1D. INTRACRANIAL INJURIES PER 100 ADMISSIONS	AR MODEL WITH LAG 2	1/86	1/82 (Pulse) 1/86 (Pulse)
ANATOMICAL REGION OF INJURY RATES			
P-2A. HEAD INJURIES PER 100 ADMISSIONS	MA MODEL WITH LAG 1	1/85	1/81 (Pulse) 3/81 (Step) 1/85 (Pulse)
P-2B. EXTREMITY INJURIES PER 100 ADMISSIONS	NO ARIMA MODEL IDENTIFIED - WHITE NOISE ONLY	1/87; 1/81	1/81 (Step) 3/87 (Pulse)

TABLE 4:RESULTS OF TIME SERIES ANALYSIS CONTROL GROUP (20-44 YEARS)

	INCIDENCE RATES	MODEL TYPE	LOWEST POINT(S) QUARTER/YR	SIGNIFICANT INTERVENTION QUARTER/YEAR
I-1.	PASSENGERS INJURED AND KILLED PER 1,000 ALL AGES INJURED AND KILLED	1. MA MODEL WITH LAG 1 2. MA MODEL WITH LAG 4	3/79	NONE
I-2.	NON-FATAL ADMISSIONS PER 1,000 PASSENGERS INVOLVED IN INJURY-RELATED CRASHES	AR MODEL WITH LAG 4	1/86; 1/87; 1/82	1/82 (Pulse) 3/85 (Step)
I-3.	PASSENGER FATALITIES PER 1,000 PASSENGERS INVOLVED IN INJURY-RELATED CRASHES	MA MODEL WITH LAG 1	1/84; 2/82; 4/85; 4/83	1/82 (Step)
I-4.	NON-FATAL ADMISSIONS PER 100,000 POPULATION	1. MA MODEL WITH LAG 4 2. MA MODEL WITH LAG 1	1/86	3/85 (Pulse)
I-5.	PASSENGER FATALITIES PER 100,000 POPULATION	1. AR MODEL WITH LAG 4 2. MA MODEL WITH LAG 1	1/84; 2/82	NONE
I-6.	NON-FATAL ADMISSIONS PER 10,000 VEHICLES INVOLVED IN INJURY-RELATED CRASHES	MA MODEL WITH LAG 8	1/86	1/83 (Pulse) 3/85 (Step)
I-7.	FATALITIES PER 10,000 VEHICLES INVOLVED IN IRC	1. MA MODEL WITH LAG 1 2. MA MODEL WITH LAG 4	1/84; 4/85; 4/83; 2/82	4/83 (Step)

TABLE 4:RESULTS (CONT'D)
CONTROL GROUP (20-44 YRS)

INCIDENCE RATES (CONT'D)	MODEL TYPE	LOWEST POINT(S) QUARTER/YEAR	SIGNIFICANT INTERVENTION QUARTER/YEAR
I-8. NON-FATAL ADMISSIONS PER MILLION CUBIC METRES GASOLINE SOLD	MA MODEL WITH LAG 4	1/86	1/86 (Pulse)
I-9. PASSENGER FATALITIES PER MILLION CUBIC METRES GASOLINE SOLD	1. AR MODEL WITH LAG 1 2. AR MODEL WITH LAG 2	1/84; 2/82	NONE
SEVERITY OF INJURY INDICATORS			
S-1. CASE FATALITY RATE	AR MODEL WITH LAG 1	1/84; 2/82; 4/83	NONE
S-2. AVERAGE LENGTH OF STAY	1. AR MODEL WITH LAG 1 2. MA MODEL WITH LAG 12	4/88; 4/84; 4/82	NONE
S-3. AVERAGE DAYS IN SPECIAL CARE UNITS	1. AR MODEL WITH LAG 1 2. AR MODEL WITH LAG 3	2/79; 2/81	NONE

TABLE 4:RESULTS (CONT'D)
CONTROL GROUP (20-44 YRS)

NATURE OF INJURY RATES	MODEL TYPE	LOWEST POINT(S) QUARTER/YEAR	SIGNIFICANT INTERVENTION QUARTER/YEAR
P-1A. LOWER EXTREMITY FRACTURES PER 100 ADMISSIONS	NO ARIMA MODEL IDENTIFIED - WHITE NOISE ONLY	3/79; 2/86; 2/83	NONE
P-1B. OPEN WOUND HEAD/NECK/TRUNK PER 100 ADMISSIONS	NO ARIMA MODEL IDENTIFIED - WHITE NOISE ONLY	1/82; 1/80	NONE
P-1C. SKULL FRACTURES PER 100 ADMISSIONS	NO ARIMA MODEL IDENTIFIED - WHITE NOISE ONLY	2/84; 4/85	NONE
P-1D. INTRACRANIAL INJURIES PER 100 ADMISSIONS	NO ARIMA MODEL IDENTIFIED - WHITE NOISE ONLY	3/84; 3/82	4/83 (Step)
ANATOMICAL REGION OF INJURY			
P-2A. HEAD INJURIES PER 100 ADMISSIONS	AR MODEL WITH LAG 2	2/87; 3/82	NONE
P-2B. EXTREMITY INJURIES PER 100 ADMISSIONS	MA MODEL WITH LAG 12	1/82; 1/83; 4/88	3/84 (Pulse) 2/87 (Pulse) 3/88 (Pulse)

CHAPTER 4 - DISCUSSION

4.1 COMPARISON OF RESULTS WITH THOSE OF OTHER STUDIES

The results reported above seem somewhat disheartening, especially in light of the results of other (American) studies of the impact of child restraint legislation. However, the differences are likely accounted for in large part by variations between this and other studies in such factors as the sources of data, study designs, the length of the study periods, data analysis techniques and ages of the control groups studied, as described below. In addition, Section 4.2 (below) outlines the possible factors contributing to the lack of a greater impact of Ontario's law.

Wagenaar, using time series analysis, found a significant decline in the total number of crash-related casualties in children under 4 years, using a very short (8 months) post-law period.[34] However, he also found such a trend among 25-34 year olds. He did not control for changes in population, exposure to the risk (e.g., vehicle miles driven), or the number of crash-involved children or vehicles. In a followup study one year later by Wagenaar and Webster[35], the investigators controlled for vehicle-miles driven and the number of crashed vehicles and found a significant reduction in the casualty (injuries + fatalities) rates for children under 4 years, as well as a less dramatic but significant decline for 18-24 year olds. They concluded that the compulsory use of child restraints had significantly reduced injuries among young children. Nevertheless, the length of the post-law period was short in the second study (1.5 years) compared with the 5-year post-law period in the present study.

Guerin and MacKinnon[37] found no significant reduction in the number of fatalities in children under 4 years, but did find a significant reduction in the number of injuries. However, they did not control for changes in population, vehicle miles, the number of crash-involved vehicles or the number of crash-involved children. Furthermore, the length of the post-law period was limited to one year.

The study by Margolis *et al*[40] also employed time series analysis; however the study focused only on the clinical effects of child-restraint legislation. The authors found a significant decline in hospitalization rates following the introduction of the legislation, especially for head and extremity injuries, as well as in lengths of stay. The post-law period was relatively long (almost three years), and the investigators controlled for population, vehicle miles and the number of crashes. The data was limited to 9% of all discharges in the state, although the authors provided convincing evidence of the internal validity and generalizability of the sample.

When Agran *et al*[39] examined the effects of the California Child Passenger Safety Law on the trauma patterns of crash-involved children who were subsequently evaluated in an emergency room, they found a significant decrease in the number of non-fatal injuries, especially to the head and face, of children under 4. Several aspects of this study are notable. First, the pre- and post-law periods were limited to 2 years each. Second, data collection was limited to 9 hospitals in a single county which were participating in an ongoing monitoring system. Third, no adjustment was made for population, vehicle miles, or the number of vehicles or children involved in crashes. In addition, one half of the children who had been killed in the county in a traffic crash during the study period had died prior to reaching the hospital; those children were not counted among the fatalities. Finally, the data were analyzed using the chi-squared tests of association between summaries of pre-law and post-law frequencies of injury. The application of time series analysis would have been more appropriate to test the differences between pre- and post- law frequencies of injury.

While Sewell *et al* found a 33% reduction in MV fatality rates and an overall 12.6% reduction in non-fatal MV injury rates after the New Mexico restraint law became effective,[38] their analysis consisted of calculating the percentage change between the mean pre-law and post-law rates per 10,000 reported crashes. A simple comparison of the means of monthly rates erroneously assumes that each monthly rate is completely independent of the rates in all other months. Furthermore, no test of significance was applied to the findings.

Hall found no decrease in the percentage of fatal and serious injuries among crash-involved children under 4 following implementation of North Carolina's child restraint legislation.[62] The pre-law period was limited to only 4 months, and no formal analysis of the time series was done. In addition, no adjustment was made for population, exposure or the number of crash-involved children or vehicles.

It is interesting to note that none of the American studies analyzed state-wide hospitalization data.

4.2 FACTORS CONTRIBUTING TO THE LACK OF A GREATER IMPACT

Several factors might have contributed to the lack of a greater impact on casualties of the Ontario child restraint legislation, including voluntary wearing of restraints prior to legislation; barriers to the use, or correct use of child restraint devices, including misuse of such restraint systems; risk-taking behaviour on the part of drivers, including non-compliance with the legislation; lack of adequate enforcement of the legislation; exemptions to the legislation; restraint usage in crash-involved children, and long-term trends in traffic fatalities. Each of these factors are discussed below.

4.2.1 Wearing rates of child restraint systems before and after legislation

The effects of Ontario child restraint legislation may have been attenuated by the fact that child restraints had been used by safety-conscious parents prior to the passage of the law. Child restraints had been available since the mid-1970's; furthermore, there had been extensive publicity during the year preceding the first phase of the legislation.

Pre-legislation surveys: A national vehicle occupant restraint survey (based on interviews) conducted by Transport Canada in 1981 found that 68% of the parents of children under 5 years indicated that they possessed a child restraint (child seat or infant carrier), and that they placed their children in them 73% of the time.[63] (Improper installation of infant and child restraints systems was common among those surveyed.)

Surveys conducted by the Ontario Ministry of Transportation and Communication in 1978 and 1981 (based on roadside observation) showed that the number of restrained children between 0-5 years old increased from 37.8% to 47.1% over the three year period.[14] This reflected an increased use of child restraints (from 21% to 33.1%) as well as seat belts. Amazingly, 55.8% of all drivers surveyed in 1981 believed that there was legislation mandating the use of child restraint systems by children under 5, while the remaining 44.2% believed that children under 5 were required to wear seat belts.

Post-legislation Transport Canada Surveys: Transport Canada has conducted three roadside surveys (based on direct observation of drivers and passengers) since 1985 to determine the extent of proper child restraint use in Canada.[55 64 65] (An earlier survey conducted in 1984 will not be considered here on the advice of one of its authors - there were methodological difficulties with that study.) The criteria used for appropriate restraint use were: Children less than one year to be in infant carrier or child seat; Children 1 to 4 years of age to be in child seat, booster seat or seat belt. The extent of satisfactory child restraint use in children 0-4 years was determined as follows:

1. The percentage of **all** children 0-4 surveyed who were using a restraint system which was appropriate to their age (i.e., infants in infant seats, toddlers in child seats, booster seats or seat belts).

2. The percentage of **appropriately restrained** children 0-4 who were **properly** attached to that appropriate system.

3. The percentage of **all** children 0-4 for whom there was proper use of an appropriate restraint system (i.e., those for whom the restraint was appropriate to their weight **and** the restraint was attached correctly). This was calculated by multiplying the percent obtained in #1 by the percent obtained in #2 above.

Proper use of infant carriers was determined by observing whether the harness was fastened and whether the car seat belt was fastened around the carrier. (Information about whether the carriers were installed in the correct rear-facing direction was collected only for the 1989 survey; therefore, the results for children under one year and for the total of children under 5 years cannot be compared with the results of previous surveys.) Proper use of child seats was determined by observing whether the harness and seat belt were fastened, and whether the tether strap was in use.

APPENDIX 9 summarizes the results of the three surveys, for Ontario and for Canada as a whole. It can be seen that, in Ontario, the percentage of infants who were restrained in an appropriate system (column 1) was very high, although it declined slightly from 1985 to 1989 (from 91.8% to 87.2%). However, when overall proper use of these restraints was taken into consideration (column 3) this percentage dropped dramatically to approximately 50% in 1985 and 1987, and to

29.5% in 1989 (this percentage was very low compared with the other two years because of the additional criterion for proper use being considered, i.e., rear-facing infant carriers.)

For children 1-4 years, the use of appropriate restraints (column 1) increased from 45.9% in 1985 to 76.7% in 1989. However, when overall proper use of these systems was taken into consideration (column 3), this rate dropped dramatically (18.5% in 1985 to approximately 46% in the other two years).

The overall proper usage rate for children under 5 almost doubled between 1985 and 1987, but has remained at less than 44% in 1989.

It is interesting to note that the percentages of overall proper use in Ontario exceeded those of Canada as a whole in all categories for all three years, except for infants in 1989.

Post-legislation Ontario Ministry of Transportation and Communication Survey:

A roadside survey conducted by the Ontario Ministry of Transportation in 1984, one year following the implementation of the child restraint legislation, found that 55% of children under one year of age were restrained, and in less than half of those was the method of restraint proper. For children aged 1-4 years old, 79% were restrained, but at least 41% of those were in an inappropriate device.[66]

4.2.2 Barriers to the (correct) use of child restraints

Mechanical difficulties in installing and using child restraints: Unlike adult restraints (i.e., seat belts), child restraints are not an integral part of the vehicle, nor are they supplied with the vehicle when sold.[67] Therefore, the onus is on the parent to purchase and correctly install such a system for their child.

There are several components to the proper installation and use of child restraint systems. Infant seats (used from birth-9 kg) must be installed facing the rear of the vehicle, and the infant must be harnessed snugly into the seat. Child seats (9-18 kg) must have an anchor bolt secured to the frame of the vehicle and a tether strap attached to the anchor bolt. In addition, the lap belt must be routed through the frame of the child seat according to the manufacturer's instructions. The harness adjusted to the child's height and fastened snugly over the shoulders, with the chest clip positioned at the underarm level. For booster seats, the lap belt must be worn firmly over the hips or over the abdominal shield, according to the manufacturer's instructions. In cars in which the lap/shoulder belts are of the continuous loop type, a locking clip must be purchased and attached to the seat belt to prevent the loosening of the belt as the car turns or swerves around a corner.[68 69 70 71 72]

One important barrier to the widespread and proper use of child restraints has been that they are frequently difficult to install correctly. Although the use of the tether strap is mandatory according to all Canadian child restraint laws, cars sold in Canada before 1989 did not have to provide a convenient anchor point for the attachment of this strap. Special holes have to be drilled in those cars by a person skilled in making such a modification to the vehicle, at the expense of the parent. Automobile manufacturers are still not obligated to provide this feature in the new breed of passenger mini-vans which are so popular with parents of small children.

Weber and Melvin noted that certain misuse configurations, such as failing to anchoring the tether or incorrectly routing the lap belt, can degrade crash protection and have serious consequences for child occupants.[73 74] In an experimental study of the effects of improper installation of child restraints on larger children, Kelleher et al found that, in addition to the inherent protective design of a child restraint system, the mode of installation is a major determinant of its performance.[75]

Baker and Karwacki reported that one important barrier to widespread and proper use of child restraints is the fact that most of them are inconvenient to use correctly, requiring extra effort on the part of adults each time they are used.[76] The lack of product-knowledge on the part of sales-persons was another barrier cited by the authors.

Socio-economic factors: Pless *et al* found that child restraint use tends to be lower among persons with less education and/or lower socio-economic status.[77] Hletko *et al* correlated demographic family data obtained from mothers exposed to an inpatient post-partum child restraint device (CRD) education program (after which all were offered the free use of a car seat) with the results of direct observations of how the infant was restrained at a two-week well-baby visit.[78] Children who were correctly restrained were more likely to come from a family in which: both parents were high school or college graduates; neither parent smoked; the family income was higher; and both parents reported using seat belts.

Undoubtedly, the cost of purchasing child restraint systems is a deterrent to use for many parents. Over the last decade there has been a proliferation of agencies, such as the Junior Safety League, which rent child seats for a nominal fee.

Defective Child Safety Seats: The Canadian Automobile Association coordinates the National Child Restraint Information Program in association with Transport Canada. The Program is responsible for issuing press releases and public notices regarding recalls of, or adjustments required to, certain brands of child restraints.[79] Unfortunately, no data are available on the number of injuries which may have been caused by defective child restraint systems.

4.2.3 Non-compliance/risk-taking behaviour of drivers

Even the most comprehensive child restraint legislation cannot be effective if parents choose not to buckle up their children. Non-compliance behaviour may occur in two very different groups of drivers. The first group mistakenly believes that if they are good drivers then their children will be safe. In fact, the majority of motor vehicle crash victims under 10 years of age die in multiple-vehicle crashes in which other vehicles initiated the crash by failing to yield the right of way or by crossing into the wrong lane.[7] Another popular misconception is that young children are protected when they are held by adults. In fact, a child travelling in the arms or lap of another person cannot be protected in a crash and is susceptible to being crushed by the holder.[76] Decker *et al* found that children who were being held in a passenger's arms at the time of a crash suffered injuries and death at a rate approaching that of entirely unrestrained children.[11] Furthermore, there was no significant difference in the rate of ejection from the vehicle between these two groups of children.

The second group of non-compliers are risk-takers, i.e., they comprise the group which is less likely than others to obey traffic laws. It has been estimated that in Canada, this group comprises 5-10% of drivers, but accounts for 40-75% of the fatalities.[80]

Hall[62] found that unrestrained children tended to be in more severe crashes, and hypothesized that drivers who are less likely to obey traffic laws in general and/or take more risks (eg. speeding, unsafe manoeuvres) are also less likely to obey child restraint legislation, and are more likely to become involved in a crash. Jonah and Lawson postulated that the impact of seat belt legislation in three of the provinces fell short of expectations because it was mainly the safe drivers who buckled up in response to the laws.[30] Baker and Karwacki noted that even in jurisdictions where adult seat belt legislation has resulted in large increases in belt use (to 70%-80% among front seat occupants), the overall reduction in fatality rates have only been 10% to 20%.[76] They concluded that this is partly due to the fact that the people who are most likely to crash are least likely to buckle up in response to legislation.

Decker *et al*[11] found that children under 4 years travelling with drivers who were not wearing their seat belts were more than four times as likely to be left entirely unrestrained as compared with children travelling with belted drivers. Wagenaar *et al*[36] noted that children who are killed in traffic crashes after mandatory restraint laws are in force are typically unrestrained and that parents who continue non-use of restraints after their use is required by law are at higher risk for crash involvement than those who comply with the law. In a prior study, Wagenaar and Webster[35] had found that after Michigan's child restraint law went into effect the decrease in the number of children injured in high-damage vehicles was smaller than the decrease for children injured in low-damage vehicles. They partially attributed the difference to the fact that the post-law increase in restraint use was more dramatic among children in less severe crashes.

Adams[27] hypothesized that so-called "risk compensation" was one reason for the apparent general overall ineffectiveness of seat belt legislation worldwide despite increased wearing rates. Drivers who are protected by seat belts drive in more dangerously than they would if they were unrestrained. Wilde, an American psychologist, similarly argued that "risk homeostasis" may explain the lack of impact of seat belt laws.[81] However, Jonah and Lawson[30] reviewed the literature on risk compensation and found very little experimental support for this theory.

4.2.4 Enforcement of child restraint legislation

The rigour of a law has much to do with the stringency of its sanctions. In Canada, the probability of a non-complier being apprehended is relatively low, and penalties, when they are imposed, are mild, especially when compared to those imposed for other violations (such as parking infractions) which have less serious consequences[80] .

Hall stated that the problems associated with enforcement, particularly at the municipal level, may include the time required for police to learn how to enforce the new law (including understanding the components of correct restraint use) and the specific provisions of the law (including restriction, exemptions).[62] He noted that the stronger sanctions of the enforcement phase, beginning in the third year of the North Carolina Child Passenger Protection Law, appeared to have some effect on restraint usage rates. Hall concluded that if parents perceive that there is a significant risk of receiving a ticket for violating the law, the likelihood that they will comply will be increased.

Decker et al found that the reduction in motor vehicle fatalities among children younger than four years old following implementation of the Tennessee Child Passenger Protection Act was strongly correlated with number of citations issued for non-compliance with the Act.[11]

Jonah and Lawson hypothesized that one reason why the magnitude of the reduction in occupant casualties was less than expected was that belt wearing rates dropped once motorists realized that the legislation was not being enforced by police.[30]

It has been estimated that only 4% of Ontario drivers who do not wear seat belts are convicted of this offence every year.[82]

A summary of Ontario enforcement statistics for seat belt legislation as it applies to children under 16 years of age appears in APPENDIX 11 (separate data for 0-4 year olds is unavailable). Considering the age range represented in these enforcement statistics, coupled with the known rate of non-use and misuse of child restraints, the numbers appear low. However, since we do not know the number of car trips taken by young children, it is difficult to put these numbers into any context.

4.2.5 Exemptions to the legislation

There are several exemptions to the Ontario child restraint legislation through which young children are not required to be restrained, as follows:[20 21 22]

1. Child safety seats need not be installed for child passengers under 18 kg riding in vehicles registered in other jurisdictions or which have been leased on a short-term basis.

2. Children weighing less than 23 kg who hold a signed certificate from a medical practitioner, and who, for medical reasons, or because of their size, build or other characteristics (such as physical disability) are unable to wear seat belts, are exempt.

3. Drivers of taxicabs, buses or public vehicles transporting passengers for-hire are exempt from the requirement to restrain an infant or toddler under 18 kg.

4. Passengers weighing between 9-18 kg riding in a vehicle other than that used by their parent or legal guardian can use the pelvic restraint system of the seat belt assembly (i.e., a safety seat need not be installed).

5. There is a so-called "silent" exemption through which, if no seating positions for which there is a seat belt assembly provided is available, a child may ride on the lap of another passenger.

According to the Canadian Council of Motor Transport Administrators, "the existence of legislative exemptions undermines the credibility of the law by enabling offenders to find loopholes or to put forward personal excuses which are perceived as valid arguments. In addition, the inconsistency of the law weakens the social consensus surrounding the value of restraint systems." Research has shown that the more uniformly a law is applied, the more it is respected.[80]

4.2.6 Reported child restraint usage in crash-involved children

Between 1980 and 1987 police officers who investigated a personal-injury crash had to note whether or not a child seat was installed and whether it had been used. Proper versus improper use of child restraints has been recorded since 1988. APPENDIX 10 illustrates the reported usage of child restraints between 1980 and 1989.[3]

Investigations of children under 5 who were fatally injured in Ontario have shown that those who were restrained were in vehicles in which other occupants were also killed (i.e., the crash may not have been survivable). However in the majority of cases where children were unrestrained, they were the only ones killed in that vehicle. Unrestrained children suffered a proportionately higher incidence of severe and fatal injuries. [87]

Dalmotas *et al* noted that information on reported seat belt use in Ontario police reports of crashes was "clearly unreliable", especially in cases of non-fatal injuries.[14] (The authors believed that reported restraint use was probably valid in cases of fatal injury because of the extensive police investigation which invariably follows a fatal-injury crash.) They noted significant discrepancies between the wearing rates of seat belts reported in police reports of 1978-1980 traffic crashes and the wearing rates observed in roadside surveys conducted in 1978 and 1981 by the Ontario Ministry of Transportation and Communication. Restraint use rates attributed to crash victims of all ages were well in excess of those which would have been expected on the basis of the roadside surveys. The authors concluded that those findings reflect one of the more inevitable consequences associated with the passage of any legislation which mandates the compulsory use of restraints, i.e,, the misrepresentation of restraint use by individuals involved in crashes. When an individual is faced with the possibility of incurring a fine for non-compliance with the law, there is no incentive to admitting to not having used one.

Webb et al found that while parents were accurate in their self-reports of children who were travelling restrained, they were inaccurate in reporting restraint use with children who were travelling unrestrained.[83] They concluded that strong social sanctions against failing to provide adequate care for children and that pressure to provide socially acceptable answers to questions of this nature is so strong that parents would rather lie than admit their failure to restrain their children.

Similarly, Reinfurt et al found that, with the onset of North Carolina's occupant restraint law, police-reported belt use in crashes increased dramatically, even among persons who were not covered by the law.[32] Furthermore, reported belt use in crashes considerably exceeded the level simultaneously observed in roadside surveys, even though previous experience had shown that belt use in crashes is less than in the population at risk. The authors hypothesized that a large part of the observed increase was due to crash-involved persons falsely stating that they had been restrained.

Wagenaar hypothesized that one possible effect of the child restraint law in Michigan may have been to increase the number of crashed drivers who falsely report to police (when the usage of a restraint was not obvious to the police officer investigating the crash) that their children had been restrained.[35]

Guerin and MacKinnon wondered whether the reduction that they observed in reported crash-induced injuries following the passage of the California Child Passenger Restraint Law could not have been due to an under-reporting (to police) of crashes in which the child had not been properly restrained.[37]

4.2.7 Long-term Canadian trends in traffic casualties

Motor vehicle-related casualty rates had been declining during the 60 months preceding the Ontario child restraint law. In fact, casualty rates have been declining sharply since the early 1970's.

Lawson found that there was a decline in the trend for all-age fatalities per 10,000 registered motor vehicles between 1950 and 1973 (all classes of road user were considered together, i.e., drivers, passengers, pedestrians, etc.).[84] Since 1973 the decline in the average rate has been much steeper; in fact, that decline was hardly interrupted at all between 1973 and 1988. The author attributed part of that reduction to depressed economic activity, with the sharpest reductions in the fatality rates occurring between 1974 and 1982. However, because sustained growth in economic activity between 1982 and 1988 produced no increase in the fatality rate, the author concluded that a fundamental improvement in safety has occurred since 1973. The author also noted that there had been a much larger reduction in fatalities in Canada since 1973 than in the United States as well as in a combined group of 19 countries of the European Conference of Ministers of Transport.

When Lawson looked at Canadian trends in all-age fatalities by road user type he found that both driver and passenger fatalities dropped by approximately one-third 1979 and 1982. Furthermore, an examination of trends for all road users by age group showed that fatalities per million Canadian children under 5 fell by approximately 40% between 1979 and 1982. In Ontario, the fatality rate during that period for all road users per 10,000 registered motor vehicles dropped by nearly one-third.

The sharpest drop in fatalities and injuries during the period between 1974 and 1985 occurred in 1982 (22.6% and 13.4% decreases respectively), i.e., prior to the full implementation of child restraint legislation.[85]

Millar and Last examined trends in motor vehicle traffic (MVT) mortality for all road user types in Canada from 1921 to 1984 and found a reduction in MVT fatalities after 1975 which affected all age groups and both genders.[86] When the average of mortality rates 1966-1970 was compared to the 1984 rate, a relative reduction of 77% was found for the age group 0-4 years. Percentage decreases for other 5-year age groups ranged from 25.9% (15-19 year olds) to 64.8% (65-69 year olds). The authors postulated that because the decrease in MVT mortality between 1975 and 1984 occurred in all age and sex groups, a plausible factor was the impact of higher oil and gasoline prices which may have reduced the exposure to risk by contributing to a decrease in the vehicle-kilometres travelled per year. They also cited safer cars, improved roads and greater use of safety belts as factors contributing to the decline.

In the present study, no significant intervention points were detected for either non-fatal injury or fatalities when adjustments were made for volume of gasoline sales. Lawson noted that while fuel consumption has often been used as a surrogate for the measure of vehicle-kilometres driven, fuel efficiency had improved so dramatically between 1978 and 1988 that the trend in fuel consumption had departed from that of vehicle-kilometres driven. Nevertheless, it is probable that, due to the occurrence in the early 1980's of the worst economic recession since World War II, reductions in fuel sales did reflect decreases in distances driven.[84]

The evidence in the two key mortality indicators of a significant intervention effect (for both the child and adult control groups) **which temporally preceded the full implementation of the legislation** suggests that any reduction in mortality may have been attributable to improvements over time in such factors as road design, safety features of the vehicles themselves (eg. improved interior design, improved braking systems, crumple zones), surveillance for drunk drivers and slower driving speeds and voluntary use of restraints.

Gradual improvements in emergency response time and better medical care in the immediate after-crash hours may have also contributed to these reductions. An overall decline in the case-fatality rate after 1981 and for both adults and children lends credence to this postulate.

4.3 LIMITATIONS OF THE STUDY

4.3.1 Limitations of information contained in the TRAID data base

Under-representation of the number of persons and vehicles

The number of involved and injured persons, as well as the number of involved vehicles in the TRAID data base, was undoubtedly under-represented, for two reasons. First, not all injury-related crashes are reported to police. The Ontario Ministry of Transportation has estimated that 20% of injuries to young are unreported as they do not occur in crash situations, but as a result of sudden stops or swerves.[87] In a large-scale trauma epidemiology study in northeastern Ohio hospitals, Barancik *et al* found that the injury incidence rate from motor vehicle crashes was 1.4 times higher than the official statistics.[88]

A study by Stutts et al which compared hospital records and police reports for North Carolina's bicycle-related injuries found that a substantial percentage of bicycle-motor vehicle crashes did not appear on police files.[89] Virtually no non-motor vehicle bicycle crashes appear on the files, even though many of these do occur on public roads and result in injuries serious enough to require emergency room treatment and, in some cases, hospitalization.

A study by Pless *et al* showed that police reports were a useful adjunct to information collected by a monitoring system set up at ten Montreal hospitals in the identification of cases, but were not accurate in the classification of severity in that only 745 of 1152 injuries recorded by the police were seen at one of the hospitals.[90] In addition, almost 30% of cases not found in police files had serious injuries.

Second, if, in the subjective assessment of the investigating officer, there are no injuries associated with a motor vehicle crash, the crash would be recorded as a "property-damage only" crash. However, persons with no "observable" injury may indeed be injured and seek medical help after leaving the scene. Hence, the persons and vehicles involved in such crashes would have been excluded from the study, since only injury-related crashes were selected for this study.

If the number of persons who were actually involved in injury-related crashes, as well as the number of vehicles that were involved, were indeed under-estimated, the values for rates I-2, I-3, I-6 and I-7 would have been **over-estimated**. However, it is not possible to determine whether the extent of this probable bias had changed over the ten-year study period.

Possible under-reporting of fatalities

It is most unlikely that the number of fatalities was greatly under-represented, since serious crashes would most certainly be reported. However, even with fatalities there is room for under-reporting by police.[91] It is also important to note that a death may have been misclassified as an injury in the TRAID data base if the death occurred more than 30 days after the crash; or if a person was injured before March 31 of any given year and subsequently died **after** March 31 of the same year, regardless of whether 30 days had elapsed. This would have had the effect of underestimating the incidence rates pertaining to fatalities. However, it is not known whether the strength of this bias changed over the ten-year period.

4.3.2 Limitations of information contained in the HMRI data base

Accuracy of "Most Responsible Diagnosis" (HMRI)

It is possible that there was some error regarding the value of rates pertaining to patterns of injury, insofar as the Most Responsible Diagnosis (MRP) may not have reflected the true MRP of all admitted persons. The 1990 Ontario Data Quality Re-abstracting Study undertaken by HMRI sought to validate the assignment of "Most Responsible Diagnosis" in Ontario discharge abstracts. A sample of charts was re-abstracted and the percentage agreement between the original abstract and re-abstract was calculated. The MRP's matched 81% of the time.[92]

Matching of records

It is possible that persons whose records were matched were involved in more than one motor vehicle crash; this would have had the effect of deflating the number of hospital admissions. On the other hand, there were undoubtedly some persons who were admitted more than once for the treatment of injuries resulting from a single motor vehicle crash, but whose records could not be "matched" because of missing OHIP numbers (between 33% and 39% of records did not have an OHIP number). This would have had the effect of inflating the number of non-fatal admissions, although it is not known to what extent this two effects may have offset one another.

Possible changes in admissions policies over ten years

It is possible that, due to financial restraints and changes in medical care, admission criteria became more stringent over the ten-year study period. This could have had the effect of masking an intervention effect of the Case Fatality Rate. On the other hand, the significant reduction in the two key non-fatal admission rates for the control group could have been partially attributable to this factor.

4.3.3 Limitations of combining information from HMRI and TRAID data bases

There are three limitations associated with the combined use of the two data sources, HMRI and TRAID. First, whereas the selected TRAID records pertained to crashes involving only passenger cars and light vans, it is more than likely that persons injured in other types of motor vehicles such as buses or trucks would have been included in the HMRI data base. Second, as described in Section 4.4.1, persons who were injured in crashes which were not reported to police would not have been included in the TRAID data base. However, persons who were severely injured in these circumstance would likely have been included in the HMRI data base. The effect of these two factors might have been to bias (inflate) the number of severely injured persons (vis-a-vis TRAID) who were hospitalized.

Third, out-of-province residents were excluded from the search of the HMRI data base, whereas the jurisdiction of residence of crash victims in the TRAID data base could not be determined. This would have had the effect of deflating the number of severely injured persons (vis-a-vis TRAID) who were hospitalized. However, it is unlikely that this effect would have offset the combined effect of the two factors noted above.

4.3.4 Multiple Tests of Significance

The intervention detection procedure involved testing each time period in the series' for significant intervention effects. It is therefore possible that one or more of the significant results were spurious, since the greater the number of hypotheses tested, the greater is the likelihood that one or more will prove statistically significant on the basis of chance alone.[93 94] However, there were temporally coincident intervention effects in **both** key fatality rates for **both** the study and control groups, as well as for the **both** key non-fatal admission rates for the control group, which suggests that these results were not spurious.

4.4 CONCLUSIONS

The results of time series intervention analysis, which compared the injury experience of children under 5 for five years before and five years after full implementation of Ontario's child restraint legislation suggest that there was no significant or sustained reduction in either the incidence of serious or fatal injuries, in the overall severity of injuries or in the anatomical patterns of injury.

There are two possible explanations for the apparent lack of an intervention effect. The first is that the pre- to post-legislation change in (proper) usage rates was not sufficiently large to have resulted in significantly reduced incidence of severely injured or killed children. The second is that there were positive effects of the legislation, but that they were too gradual be detected. These conclusions are supported by evidence that there was a relatively high level of usage of child restraints (between 37% and 47%) in the years prior to the legislation, due to the wide availability of these devices since the late 1970's, as well as the extensive publicity about the restraint legislation for one year prior to the implementation of the first phase of the law in November 1982. Thus, pre-law usage levels of child restraints may have masked an intervention effect.

In addition, surveys conducted after the full implementation of the law indicated that less than half of Ontario's children under 5 are not adequately protected when they travel in cars, due to a combination of non-use and misuse of child restraints. The reasons for this low level of protection include socio-economic factors, non-compliance with the law by high-risk drivers, difficult installation procedures, lack of adequate enforcement and the number of children who are legally exempt from complying with the law.

Furthermore, trends in vehicle and traffic safety both before and during the study period may have attenuated any effect of the legislation. Significant reductions in the key mortality rates prior to full implementation of the legislation were detected in both the study group and the control group, suggesting that factors in addition to restraint use may have also been responsible.

Child restraint laws cannot achieve their objective without a higher level of sustained compliance. This goal is currently being addressed jointly by the provincial and territorial Ministries of Transportation, as described below.

4.5 THE NATIONAL OCCUPANT RESTRAINT PROGRAM (NORP)

In 1988, the Montreal Symposium on Road Safety identified increasing the use of occupant restraints (for all ages) as a top priority. The next year, the Canadian Council of Motor Transport Administrators (CCMTA), a body comprising representatives from each provincial/territorial Ministry of Transportation, presented to the federal and provincial ministers responsible for road safety a proposal for a National Occupant Restraint Program (NORP). Approval has been granted by the ministers to proceed with the so-called "95 by 95 program" whose aim it is to increase the wearing rate of restraints in all age groups across Canada to 80% by 1990 (Phase 1) and to 95% by 1995 (Phase 2).

The strategies to be incorporated into the NORP address many of the factors discussed above: education, enforcement, legislative exemptions and attention to high-risk groups, as discussed below.

4.5.1 Public Education and Awareness

Public education efforts will be accomplished through the use of the mass media (advertising) and the news media. In addition, community-based programs will be implemented at the workplace and in the school setting. Programs aimed at the community as a whole would include, for example, the posting of signs indicating changes in wearing rates in the community.[95] Other programs would encourage the purchasing and proper use of restraints (for example, 48-hour warnings by police and installation "clinics").[80]

4.5.2 Enforcement

Lawless and Siani stated that education of the law-enforcement community is the first step toward securing their active involvement in child passenger safety. Officers must be thoroughly familiar with the provisions of the law, and the correct ways to install and use child safety seats.[96] In addition, they must be trained in the correct procedures (other than issuing citations) in dealing with violators, such as handing out brochures and referral to appropriate agencies.

Police officer training is an integral component of NORP, and consists of convincing officers about the merits of restraint use as well as training on how to conduct Selective Traffic Enforcement Programs (STEP's) as effectively as possible. The overt support of police efforts by the community, including local politicians, is considered to be essential to the success of NORP. With respect to child restraint legislation, enforcement efforts will be directed at identifying vehicles with children standing or moving around freely in the vehicle.

4.5.3 Legislative Exemptions

The CCMTA has recommended that all Canadian jurisdictions work toward removing all exemptions to child restraint legislation, with the exception of persons occupying vehicle seating positions which were/are not required to be equipped with seat belts at the time of manufacture; and vehicle occupants for whom belts are not available as a result of all available belted seating positions being occupied.[97]

4.5.4 Targeting high-risk groups

Modification of the behaviour of high-risk drivers will be the greatest challenge of the NORP program, but it is the one which will result in the greatest benefit.[80] The strategy will consist of specific enforcement efforts aimed at impaired drivers, speed limit violators, night-time drivers and regions in which seat belt use is known to be low.[98]

4.6 RECOMMENDATIONS

4.6.1 Pre-natal education of parents

Ideally, parental education regarding child safety seats should begin pre-natally. A number of studies which evaluated educational interventions in **medical** settings (either pre- or post-natally) have shown that while such interventions may make significant short-term improvements in parental use of child seats, these differences usually do not continue beyond a few months, even when persons are given free restraints.[19 99 100 101 102]

Polen and Friedman recommended that, because of the enormous burden caused by motor vehicle crashes, high priority be given to research that will determine the most effective types of medically-based programs to promote the use of restraint systems by automobile occupants of all ages.[18] Specifically, they recommended studies that address the issues of counselling by physicians compared with counselling by other health professionals; the optimal timing, frequency, and duration of such interventions.

4.6.2 Targeting non-compliers

Research must focus on the best way to target the education of persons at high risk for non-compliance, i.e., the lower socio-economic groups and the risk-takers. Traditional public information programs are more geared to the middle class, and that unless ways are found to reach the low socio-economic status drivers, casualty reductions will not be as favourable as hoped.[32 78]

The modification of risk-taking behaviour is a complex task. It is encouraging to witness the emergence of such programs as "HEROES" in Alberta (a multi-media show which is aimed at educating teen-agers about the perils of drinking and driving and the importance of buckling up), whose objective is the prevention of high-risk behaviours, or the modification of such behaviours at an early age. Follow-up studies should be conducted at a later date to compare the extent to which adolescents exposed to programs such as "HEROES" properly use restraint systems for their future children.

4.6.3 Loaner programs

"Buckle-up-baby" car seat rental programs are typically geared to infants under one year of age, since long-term rentals of toddler car seats would be quite expensive. Robitaille *et al* evaluated an infant car seat loan program in a low-income community in Montreal to see whether the program had a long-term effect, i.e., if, after having returned the borrowed seat at 9 months, parents in the experimental community bought a child car seat. No significant difference between the experimental and control communities was found between the rate of car seat utilization at 13 months of age.[103]

It is recommended that the feasibility of implementing low-cost rental, loan or cost-sharing programs to needy families of toddlers be investigated.

4.6.4 Incentives to compliance

The effects of non-punitive incentives to compliance with the law should be evaluated. In Tennessee, for example, persons cited for violation of the Child Passenger Protection Act are offered the loan of a child restraint device. The device is reclaimed at the court hearing, and all charges and costs are dropped if the defendant shows proof of having acquired a child restraint device.[11] Almost every state in the U.S.A allows for a waiver of the fine for non-compliance upon proof of purchase (or rental) of a child safety seat.[104]

4.6.5 Simplification of design and installation requirements

Manufacturers of child safety seat should be encouraged to simplify the design and installation requirements of child car seats in order to reduce the negative impact of improper restraint use. Furthermore, automobile manufacturers must be encouraged to provide "integrated car restraints" such as those currently available in Chrysler mini-vans. These would address some of the important barriers to (proper) use, namely accessibility, transferability between vehicles and difficulty with installation.

4.6.6 Utilization of the CHIRPP national childhood injury database

The availability of a national childhood injury surveillance program, the Children's Hospitals Injury Research and Prevention Program (CHIRPP), will provide valuable data through which: trends and patterns of motor vehicle injuries may be monitored; follow-up studies (such as studies of the long-term consequences of injuries caused to motor vehicle passengers) may be undertaken; and interventions relevant to motor vehicle passenger protection may be planned and evaluated.[105]

4.6.7 Evaluation of the National Occupant Restraint Program

Finally, an evaluation, similar to the present study of the success of the National Occupant Restraint Program should be undertaken several years after the target date of 1995, in order to determine further measures required to achieve compliance with restraint legislation.

REFERENCES

1.Avard D, Hanvey L. The Health of Canada's Children: A CICH Profile. Canadian Institute of Child Health,1 1989.

2. Statistics Canada Mortality and Morbidity Data Bases, as accessed by MORTCON software developed by Robert Semenciw, Laboratory Centre for Disease Control, Health and Welfare Canada

3. Ontario Ministry of Transportation and Communication. Motor Vehicle Accident Facts (Annual), 1979-1984. Ontario Road Safety Annual Reports, 1985-1989.

4.Rodriguez JG. Childhood Injuries in the United States. AJDC 1990;144:627-646.

5.Rice DP, MacKenzie EJ, and associates. Cost of Injury in the United States: A Report to Congress. San Francisco, CA: Institute for Health and Aging, University of California and Injury Prevention Center, The Johns Hopkins University, 1989.

6.Wigle DT,Mao Y,Wong T, Lane R. Economic Burden of Illness in Canada, 1986. Supplement to Chronic Diseases in Canada 1991; Vol 12: Bureau of Chronic Disease Epidemiology, Laboratory Centre for Disease Control, Health Protection Branch, Health and Welfare Canada.

7.Berger LR. Childhood injuries: Recognition and prevention. Clin Probl Pediatr 1981;12:6-59.

8.Aldman, B. Prospectives for and Problems Related to Protection of Children in Child Restraints. SAE Technical Paper #840524, 1984; 363-368.

9.Canadian Automobile Association. Transporting Small Children. Information (newsletter). Reprinted with the permission of the Ontario Ministry of Transportation and Communication. (Not dated)

10.Wheatley J, Cass DT. Traumatic deaths in children: the importance of prevention. Med J Aust 1989;150:72-8.

11.Decker, M.D., Dewey, M.J, Hutcheson, R.H.Jr. and Schaffner, W. The use and efficacy of child restraint devices: the Tennessee experience, 1982 and 1983. JAMA 1984; 252:2571-2575.

12.Transport Canada. The human collision; how injuries occur.... how seat belts prevent them. 2nd edition. Department of Supply and Services (Canada) 1986. Cat No. T46-13/1976E

13.Radovich VG. Development of infant and child restraint regulations and their application. SAE Technical Paper # 831655. 1985;101-111.

14.Dalmotas DJ, Dance DM, Gardner WT, Gutoskie PA, Smith GA. Current Activities in Canada Relating to the Protection of Children in Automobile Accidents. SAE Technical Paper Series #840529 1984;405-426.

15.Kahane CJ, Kossar J, Chi GY. Evaluation of the effectiveness of child safety seats in actual use. SAE Technical Paper #831656. 1983:113-123.

16.Scherz RG. Fatal motor vehicle accidents of child passengers from birth through 4 years of age in Washington State. Pediatrics 1981;68:572-575.

17.Agran PF, Dunkle DE, Winn DG. Restraint usage patterns of children less than four years of age evaluated in a medical setting after a motor vehicle accident. Am Ass.of Automotive Medicine 28th annual proceed. 1984:373-382.

18.Polen MR, Friedman GD. Automobile injury - selected risk factors and prevention in the health care setting. JAMA 1988;259:77-80.

19.Christopherson ER. Preventing injuries to children: a behavioral approach to child passenger safety. In: Matarazzo JD, Weiss SM, Herd JA, Miller NE, Weiss, SM, eds. Behavioral Health; A Handbook of Health Enhancement and Disease Prevention. New York:John Wiley and Sons,1984:990-1002.

20. 1980 Revised Regulations of Ontario, Regulation 485 under the Highway Traffic Act.

21.Ontario Regulation 545 of 1982 to amend Regulation 485 of Revised Regulations of Ontario,1980 made under the Highway Traffic Act.

22.Ontario Regulation 629 of 1983 to amend Regulation 485 of Revised Regulations of Ontario, 1980 made under the Highway Traffic Act.

23.Foldvary LA, Lane JC. The effectiveness of compulsory wearing of seat-belts in casualty reduction (with an appendix on chi-square partitioning-tests of complex contingency tables). Accident Analysis and Prevention 1974;6:59-81.

24.Crinion JD, Foldvary LA, Lane JC. The effect on casualties of a compulsory seat belt wearing law in South Australia. Accident Analysis and Prevention 1975; 7:81-89.

25.Trinca GW, Dooley BJ. The effects of seat belt legislation on road traffic injuries. Aust.N.Z.J.Surg. 1977;47:150-155.

26.McDermott FT, Hough DE. Reduction in road fatalities and injuries after legislation for compulsory wearing of seat belts:experience in Victoria and the rest of Australia. British Journal of Surgery 1979;66:518-521.

27.Adams JGU. The efficacy of seat belt legislation. SAE Technical Paper #820819. 1982;1-15.

28.Pierce JA. Safety benefits of the seat belt legislation and speed limit reduction in Ontario. Proceedings of the 1979 American Association for Automotive Medicine, 1979;243-253.

29.Bergan AT, Watson LG, Rivett DE, Shiels AC. The effect on injury and fatality rates due to seatbelt usage in Saskatchewan. Proceedings of the 1979 American Association for Automotive Medicine 1979;412-425.

30.Jonah BA, Lawson JJ. The effectiveness of the Canadian mandatory seat belt use laws. Accident Analysis and Prevention 1984;16:433-450.

31.McCarthy, M. The benefit of seat belt legislation in the United Kingdom. Journal of Epidemiology and Community Health 1989;43:218-222.

32.Reinfurt DW, Campbell BJ, Hunter WW, Stutts JC. An evaluation of North Carolina's occupant restraint law. Proceedings of the American Association of Automotive Medicine 1987;237-253.

33.Budd JS. Effect of seat belt legislation on the incidence of sternal fractures seen in the accident department. British Medical Journal 1985;291:785.

34.Wagenaar AC. Effectiveness of Mandatory Child Restraint Laws. Proceedings of the 28th American Association of Automotive Medicine 1984;319-330.

35.Wagenaar AC, Webster DW. Preventing Injuries to Children Through Compulsory Automobile Safety Seat Use. Pediatrics 1986;78:662-863.

36.Wagenaar AC, Webster DW, Maybee RG. Effects of Child Restraint Laws on Traffic Fatalities in Eleven States. The Journal of Trauma 1987;27:726-732.

37.Guerin D, MacKinnon DP. An Assessment of the California Child Passenger Restraint Requirement. AJPH 1985;75:142-144.

38.Sewell CM, Hull HF, Fenner J, Graff H, Pine J. Child Restraint Law Effects on Motor Vehicle Accident Fatalities and Injuries: The New Mexico Experience. Pediatrics 1986;78:1079-1084.

39.Agran PF, Dunkle DE, Winn DG. Effects of Legislation on Motor Vehicle Injuries to Children. AJDC 1987;141:959-964.

40.Margolis LH, Wagenaar AC, Liu W. The Effects of a Mandatory Child Restraint Law on Injuries Requiring Hospitalization. AJDC 1988;142:1099-1103.

41.Campbell DT. From description to experimentation: interpreting trends as quasi-experiments. In Harris CW ed., Problems of Measuring Change. Madison:University of Wisconsin Press 1963, (revised in 1967).

42.Ross HL, McCleary R. Methods for studying the impact of drunk driving laws. Accident Analysis and Prevention 1983;15:415-428.

43.Campbell DT, Ross HL. The Connecticut crackdown on speeding: Time-series data in quasi-experimental analysis. Law and Society Review 1968;3:33-53.

44.Deutch SJ, Alt FB. The effect of Massachusetts' gun control law on gun-related crimes in the city of Boston. Evaluation Quarterly 1977;1:543-568.

45.Loftin C,McDowall D, Wiersema B, Cottey TJ. Effects of restrictive licensing of handguns on homicide and suicide in the District of Columbia. New England Journal of Medicine 1991; 325:1615-1620.

46.Box GEP, Tiao GC. Intervention analysis with applications to economic and environmental problems. Journal of the American Statistical Association 1975;70:70-79.

47.Chambers LW, Roberts RS, Voelker CA. The epidemiology of traffic accidents and the effect of the 1969 breathalyser amendment in Canada. Accident Analysis and Prevention 1976;8:201-206.

48.McKinlay JB, McKinlay SM. The questionable contribution of medical measures to the decline of mortality in the United States in the twentieth century. Milbank Memorial Fund Quarterly, Summer 1977;405-428.

49.Tsouros AG, Young RJ. Applications of time-series analysis: a case study on the impact of computer tomography. Statistics in Medicine 1986;5:593-606.

50.Catalano R, Serxner S. Time series designs of potential interest to epidemiologists. American Journal of Epidemiology 1987;126:724-731.

51.Martinez-Schnell B, Zaidi A. Time series analysis of injuries. Statistics in Medicine 1989;8:1497-1508.

52.Last JM. ed. A Dictionary of Epidemiology 2nd ed. 1988. Oxford University Press:New York.

53.Morgenstern H. Uses of ecologic analysis in epidemiologic research. American Journal of Public Health 1982;72:1336-1344.

54.McDowall D, McCleary R, Meidinger EE, Hay RA. Interrupted time series analysis. 1980.Sage Publications: Beverly Hills.

55.Dawson NE, Jonah BA, Arora HR, Moore A, Deforest DW. The 1985 National Child Restraint Use Survey. Proceedings of the 30th Annual American Association for Automotive Medicine. 1986;371-384.

56.Verreault R,Stulginskas J, Keyl P, Read J, Pless, IB. Use of automobile seat restraints by children in two Canadian cities. Canadian Medical Association Journal 1982;126:1163-1167.

57.McCain LJ, MCCleary R. The statistical analysis of the simple interrupted time-series quasi-experiment. In Cook TD, Campbell DT. Quasi-Experimentation: Design and analysis issues for field settings. Chicago:Rand McNally College Publishing Co.; 1979.

58.Armitage P, Berry G. Statistical Methods in Medical Research 2nd ed. 1987. Blackwell Scientific Publications.

59. Autobox Plus: User's Guide, Version 2.0. Automatic Forecasting Systems, Inc. Statistical Consultants. P.P. Box 563, Hatboro, Pennsylvania 19040. Tel (215) 675-0652.

60.Personal communication with Ms. Shelagh Maloney, HMRI, Toronto.

61. Tape containing data on motor gasoline sales 1980-1988, made available to the Laboratory Centre for Disease Control. 1979 data obtained via personal communication with Mr. Jerry O'Conner, Statistics Canada.

62.Hall WL. Evaluation of the effects of the North Carolina Passenger Protection Law. Am Ass.of Automotive Medicine 29th annual proceed. 1985:137-151.

63.Jonah BA, Dawson NE. The National Vehicle Occupant Restraint Survey: Attitudes Toward and Use of Restraints by Canadians. Transport Canada 1982.

64.Road Safety Directorate,Transport Canada. Child restraint use in Canada: 1987 Survey Data. Transport Canada Leaflet #TP2436; Catalog # CL 8806(E).

65.Road Safety Directorate, Transport Canada. Child restraint use in Canada: 1989 survey data. Transport Canada. Leaflet #TP2436; Catalog # CL 9006 (E)

66.Hemsley G, Duncan D. Seat belt usage and driver attitude survey, May/June 1984. Strategic Policy Secretariat, Ontario Ministry of Transportation and Communications, July 1985.

67.Melvin JW, Stalnaker RL, Mohan D. Protection of Child Occupants in Automobile Crashes. Proceedings of the Twenty-second STAPP Car Crash Conference 1978:673-694.

68.Canadian Automobile Association. Installing your child restraint: solving seat belt problems. **Information.** (Not dated)

69.Insurance Corporation of British Columbia. Child safety seat check points (Pocket card issued to police officers). ID# TSC-46A (07-90)

70.The Infant and Toddler Safety Association. Carseat Safety Checklist (Guidelines for Ontario Residents). July 1989.

71.Ministry of Transportation and Communications. Life is Precious: Choosing and Using Child Safety Seats. Ministry of Transportation and Communication. 8/86:ISBN 0-7743-9564-8.

72.Insurance Corporation of British Columbia. Do it up right- for your family. Insurance Corporation of British Columbia. 1990: Publication #TS-244A

73.Weber K, Melvin JW. Injury Potential with Misused Child Restraint Systems. SAE Technical Paper Series #831604 1983:53-59.

74.Williams AF. Restraint use legislation:its prospect for increasing the protection of children in cars. Accident Analysis and Prevention 1979;11:255-260.

75.Kelleher BJ, Walsh MJ, Dance DM, Gardner WT. An Experimental Study of the Effects of Child Restraint Improper Installation and Crash Protection for Larger Size Children. SAE Technical Paper # 831602 1983:31-51.

76.Baker SP, Karwacki JJ Jr. Children killed in crashes. Am Ass.of Automotive Medicine Proceedings 1979:335-347.

77.Pless IB, Roghmann KJ. Safety restraints for children in automobiles: who uses them? Canadian Journal of Public Health 1978;69:289-292.

78.Hletko PJ, Hletko JD, Shelness AM, Robin SS. Demographic Predictors of Infant Car Seat Use. Am J Dis Child 1983;137: 1061-1063.

79.National Child Restraint Information Program. Public notices for infant restraints, combination child/infant restraints and booster cushions. Canadian Automobile Association 1990.

80.Canadian Council of Motor Transport Administrators. National Occupant Restraint Program: Phase II Proposal. August 1990.

81.Wilde GJS. The theory of risk homeostasis:implications for safety and health. Risk Analysis 1982;2:209-225. Cited in McCarthy M. The benefit of seat belt legislation in the United Kingdom. Journal of Epidemiology and Community Health 1989;43:218-222.

82.Personal Communication with Ms. Barbara Bisgrove, Acting Manager, Public Education, Communications and Public Education Branch, Ontario Ministry of Transportation.

83.Webb GR, Bowman JA, Sanson-Fisher RW. Studies of child safety restraint use in motor vehicles - some methodological considerations. Accid Anal & Prev 1988;20:109-115.

84.Lawson J. Long-term Trends in Road Safety. Road Safety and Motor Vehicle Regulation Directorate, Transport Canada, July 1988.

85.Road Safety and Motor Vehicle Regulation Directorate. Background Paper on Motor Vehicle Occupant Protection in Canada. Transport Canada, 1986.

86.Millar WJ, Last JM. Motor Vehicle Traffic Accident Mortality in Canada, 1921-1984. American Journal of Preventive Medicine 1988; 4:220-230.

87.Ontario Ministry of Transportation and Communications. Ontario Road Safety Annual Report, 1986.

88.Barancik JI, Chatterjee BF, Greene YC, et al. Northeastern Ohio Trauma Study: 1. Magnitude of the Problem. American Journal of Public Health 1983;73:746-751.

89.Stutts JC, Williamson JE, Whitley T, Sheldon FC. Hospital records and police accident reports: two sources of information on bicycle-related injuries and accidents. Am Ass.of Automotive Medicine 30th annual proceedings 1986:127-144.

90.Pless IB, Verreault R, Arsenault L, Frappier J-Y, Stulginskas J. The epidemiology of road accidents in childhood. Am J Pub Health 1987;77:358-360.

91.Chipman ML. Motor vehicle accident fatality statistics: an investigation of reliability. Canadian Journal of Public Health 1983; 74:381-384.

92.Hospital Medical Records Institute. 1990 Ontario Data Quality Re-abstracting Study. HMRI 1990.

93.Hulley SB, Cummings SR. eds. Designing Clinical Research: An Epidemiologic Approach 1988. Williams and Wilkins:Baltimore.

94.Colton T. Statistics in Medicine 1974. Little, Brown and Company:Boston.

95.Directorate Working Group for the National Occupant Restraint Program. Program Plan January 12, 1990.

96.Lawless EW, Siani TA. Child Passenger Safety Legislation: Implementation and Enforcement. SAE Technical Paper Series #840521. 1984:353-361.

97.Canadian Council of Motor Transport Administrators. National Occupant Restraint Program: Exemption Discussion Paper. June 1990.

98.Communication Plan - National Occupant Restraint Program. Canadian Council of Motor Transport Authorities. February 1991.

99.Reisinger KS, Williams AF, Wells JK, et al. Effect of pediatricians' counselling on infant restraint use. Pediatrics 1981;67:201-206.

100.Reisinger KS, Williams AF. Evaluation of programs to increase the protection of infants in cars. Pediatrics 1978;62:280-287.

101.Miller JR, Pless IB. Child automobile restraints:Evaluation of health education. Pediatrics 1977;59:907-911.

102.Christpherson ER, Sullivan MA. Increasing the protection of newborn infants in cars. Pediatrics 1982;70:21-25.

103.Robitaille Y, Legault J, Abbey H, Pless IB. Evaluation of an infant car seat program in low-income community. AJDC 1990;144:74-78.

104.Lawless EW, Siani TA. The state of the art of child passenger safety legislation in North America. SAE Technical Paper No. 831650,1983:229-242.

105. Senzilet LD, Allegakone M. Children's Hospital Injury Research and Prevention Program (CHIRPP): Technical Report #2. Laboratory Centre for Disease Control, Health and Welfare Canada. October 1991.

APPENDICES

SUMMARY OF CANADIAN STANDARDS FOR CHILD RESTRAINTS

INFANT RESTRAINT SYSTEMS

- Effective September 1, 1982
- From birth to 9 kg (20 pounds)
- Dynamic requirements
- Static requirements
- Labelling requirements

INFANT RESTRAINT SYSTEMS
- CMVSS 213.1
- effective September 1, 1982
- from birth to 9 kg (20 pounds)

- also applies to a convertible restraint used in infant mode

- *dynamic testing*
  - explain that restraint first goes forward then rebounds - SHOW FILM
  - explain containment in forward direction i.e.: limitation of forward tipping to prevent the head from hitting objects within the interior and helps prevent ejection in case of misuse and in rearward direction i.e.: prevents hitting rear window or frame
  - separation of structural elements of restraint not allowed during dynamic testing

- *static requirements*
  - must face rear of vehicle to offer continuous protection to head and neck in all modes of collisions
  - must be able to be attached to vehicle by a lap or a lap and shoulder belt
  - sets minimum restraint back height dimensions
  - sets minimum restraint back and sides surface area
  - requires at least a 3-point harness
  - requires provision for adequate adjustment for size of child
  - specifies breaking strength under new and accelerated aging conditions
  - sets maximum requirements for flame propagation of materials
  - sets minimum height of surface protrusions
  - sets optimum requirements for the energy absorption of the padding
  - buckle requirements before and after dynamic testing

CHILD RESTRAINT SYSTEM

- Effective May 11, 1984
- For children from 9 kg (20 pounds) to 22 kg (48 pounds)
- Dynamic requirements
- Static requirements
- Labelling requirements

CHILD RESTRAINT SYSTEM

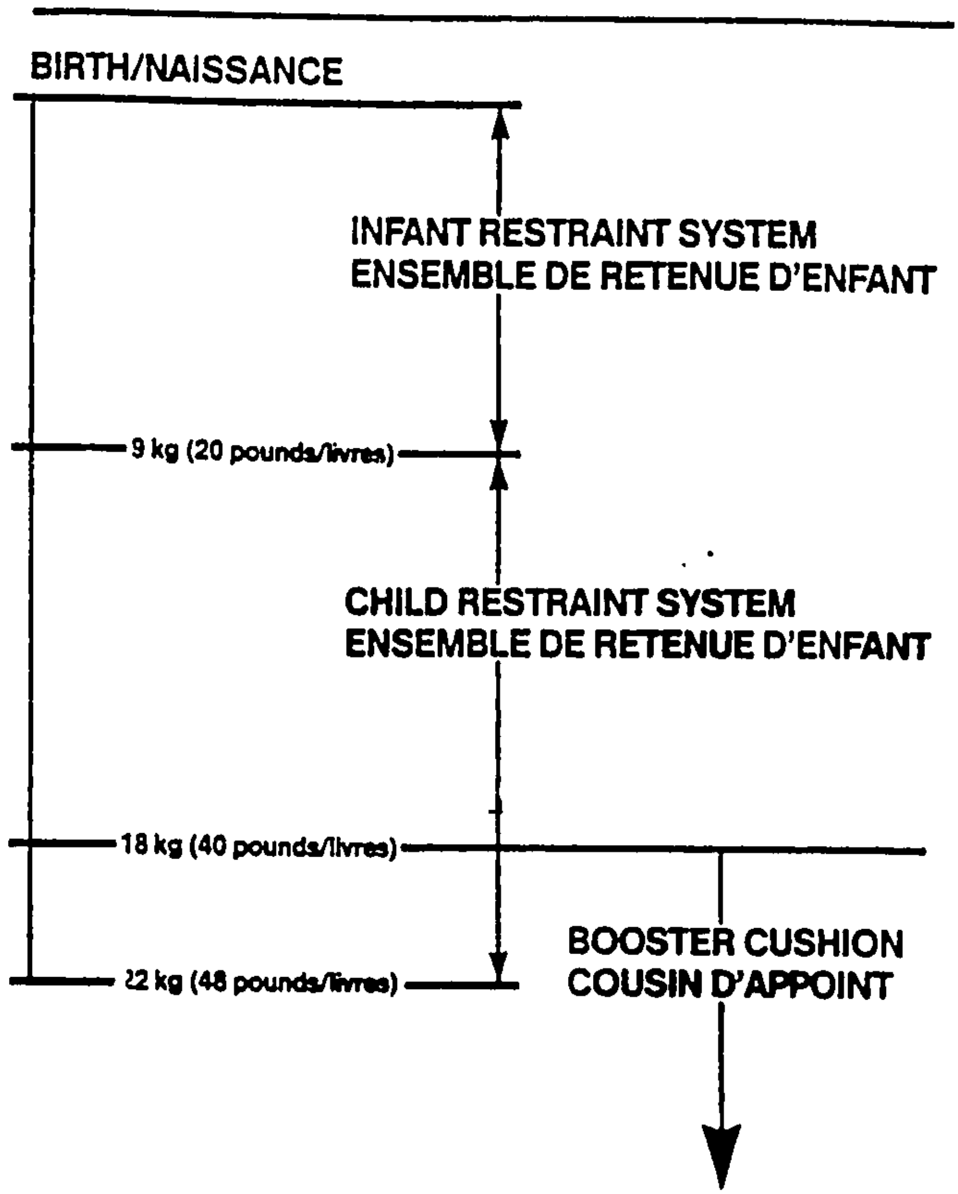
- CMVSS 213
- effective May 11, 1984
- for children from 9 kg (20 pounds) to 22 kg (48 pounds)
- explain that regulation is performance oriented and that tether strap is not required to pass head excursion requirement

- *dynamic testing*
  - limits head excursion to 720 mm (28.4 inches)
  - limits chest acceleration to 60 *g*'s for not more than 3 msec
  - must remain in same adjustment position after testing as it was before
  - separation of structural elements of restraint not allowed during dynamic testing

- *static requirements*
  - must be able to be attached to vehicle by a lap or a lap and shoulder belt and only additional top tether strap
  - sets minimum restraint back height dimensions
  - sets minimum restraint back and sides surface area
  - requires the equivalent of a 5-point harness in a combination of webbing and or shields
  - only restraining shields are allowed, trays or tables are not permitted
  - sets a minimum radius or curvature for restraining shield and edges
  - requires provision for adequate adjustment for size of child
  - specifies breaking strength under new and accelerated aging conditions
  - sets maximum requirements for flame propagation of materials

- sets minimum height of surface protrusions
- sets optimum requirements for the energy absorption of the padding
- buckle requirements before and after dynamic testing
- sets anchorage dimension range for tether belt hook top be compatible with the tether anchorage regulation

APPENDIX 2
FIGURE A-1: APPROPRIATE CHILD RESTRAINTS



CHAPTER 14

An Act to amend The Highway Traffic Act

Assented to December 18th, 1975

HER MAJESTY, by and with the advice and consent of the Legislative Assembly of the Province of Ontario, enacts as follows:

1. *The Highway Traffic Act*, being chapter 202 of the Revised Statutes of Ontario, 1970, is amended by adding thereto the following section: s. 63a, enacted

Definition

63*a*.—(1) In this section, "seat belt assembly" means a device or assembly composed of straps, webbing or similar material that restrains the movement of a person in order to prevent or mitigate injury to the person and includes a pelvic restraint or an upper torso restraint or both of them.

Seat belt assembly R.S.C 1970, c. 26, (1st Supp.)

(2) No person shall drive on a highway a motor vehicle in which a seat belt assembly required under the provisions of the *Motor Vehicle Safety Act* (Canada) at the time that the vehicle was manufactured or imported into Canada has been removed, rendered partly or wholly inoperative or modified so as to reduce its effectiveness.

Use of seat belt assembly by driver

(3) Subject to subsection 5, every person who drives on a highway a motor vehicle in which a seat belt assembly is provided for the driver shall wear the complete seat belt assembly in a properly adjusted and securely fastened manner.

Use of seat belt assembly by passenger

(4) Subject to subsection 5, every person who is a passenger on a highway in a motor vehicle in which a seat belt assembly is provided for the seating position occupied by the passenger shall wear the complete seat belt assembly in a properly adjusted and securely fastened manner.

Exemption

(5) Subsections 3 and 4 do not apply to a person,

(*a*) driving a motor vehicle in reverse;

(*b*) who holds a certificate signed by a legally qualified medical practitioner certifying that the person is,

(i) for the period stated in the certificate, unable for medical reasons to wear a seat belt assembly, or

(ii) because of the person's size, build or other physical characteristic, unable to wear a seat belt assembly;

(*c*) who is actually engaged in work which requires him to alight from and re-enter a motor vehicle at frequent intervals and who, while engaged in such work, does not drive or travel in that vehicle at a speed exceeding 25 miles per hour; or

(*d*) under the age of sixteen years.

Driver to ensure passenger uses seat belt assembly

(6) No person shall drive on a highway a motor vehicle in which there is a passenger who has attained the age of two years and is under sixteen years of age and occupies a seating position for which a seat belt assembly has been provided unless that passenger is wearing the complete seat belt assembly and it is properly adjusted and securely fastened.

Exception

(7) Subsection 6 does not apply where the passenger,

(*a*) is the holder of a certificate signed by a legally qualified medical practitioner certifying that the passenger is,

(i) for the period stated in the certificate, unable for medical reasons to wear a seat belt assembly, or

(ii) because of the passenger's size, build or other physical characteristic, unable to wear a seat belt assembly;

(*b*) is actually engaged in work which requires him to alight from and re-enter the motor vehicle at frequent intervals and the motor vehicle does not travel at a speed exceeding 25 miles per hour; or

(c) is occupying and properly secured in child seating and restraint systems prescribed under the regulations.

Regulations

(8) The Lieutenant Governor in Council may make regulations,

(a) requiring the use of child seating and restraint systems in motor vehicles on highways and prescribing the specifications thereof;

(b) providing for the exemption from any of the provisions of this section of,

(i) any type or class of motor vehicles,

(ii) any class of drivers or passengers in motor vehicles.

s. 147 (2), re-enacted

2. Subsection 2 of section 147 of the said Act, as amended by the Statutes of Ontario, 1974, chapter 123, section 34 and 1975, chapter 78, section 11, is repealed and the following substituted therefor:

Owner when not driver not liable for penalties

(2) The owner of a motor vehicle except when he is also the driver shall not incur the penalties provided for any contravention of any of the provisions of subsection 3 or 6 of section 63*a* or of sections 82 to 114, 117, 120, 125 and 139 or any regulation or by-law made or passed thereunder or under subsection 8 of section 63*a* or of any of the provisions of any by-law passed under any Act regulating or prohibiting turns on a highway.

Commencement

3. This Act comes into force on the 1st day of January, 1976.

Short title

4. This Act may be cited as *The Highway Traffic Amendment Act, 1975 (2nd Session) (No. 2)*.

Definition **90.**—(1) In this section, "seat belt assembly" means a device or assembly composed of straps, webbing or similar material that restrains the movement of a person in order to prevent or mitigate injury to the person and includes a pelvic restraint or an upper torso restraint or both of them.

(2) No person shall drive on a highway a motor vehicle in which a seat belt assembly required under the provisions of the *Motor Vehicle Safety Act* (Canada) at the time that the vehicle was manufactured or imported into Canada has been removed, rendered partly or wholly inoperative or modified so as to reduce its effectiveness. Seat belt assembly R.S.C. 1970, c. 26 (1st Supp.)

(3) Subject to subsection (5), every person who drives on a highway a motor vehicle in which a seat belt assembly is provided for the driver shall wear the complete seat belt assembly in a properly adjusted and securely fastened manner. Use of seat belt assembly by driver

(4) Subject to subsection (5), every person who is a passenger on a highway in a motor vehicle in which a seat belt assembly is provided for the seating position occupied by the passenger shall wear the complete seat belt assembly in a properly adjusted and securely fastened manner. 1975 (2nd Sess.), c. 14, s. 1, *part.* Use of seat belt assembly by passenger

(5) Subsections (3) and (4) do not apply to a person, Exemption

(*a*) driving a motor vehicle in reverse;

(*b*) who holds a certificate signed by a legally qualified medical practitioner certifying that the person is,

(i) for the period stated in the certificate, unable for medical reasons to wear a seat belt assembly, or

(ii) because of the person's size, build or other physical characteristic, unable to wear a seat belt assembly;

(*c*) who is actually engaged in work which requires him to alight from and re-enter a motor vehicle at frequent intervals and who, while engaged in such work, does not drive or travel in that vehicle at a speed exceeding 40 kilometres per hour; or

(*d*) under the age of sixteen years. 1975 (2nd Sess.), c. 14, s. 1, *part*; 1977, c. 19, s. 2 (1).

SECTION 90, HIGHWAY TRAFFIC ACT, ONTARIO 1980

Driver to ensure passenger uses seat belt assembly

(6) No person shall drive on a highway a motor vehicle in which there is a passenger who has attained the age of two years and is under sixteen years of age and occupies a seating position for which a seat belt assembly has been provided unless that passenger is wearing the complete seat belt assembly and it is properly adjusted and securely fastened. 1975 (2nd Sess.), c. 14, s. 1, *part*.

Exception

(7) Subsection (6) does not apply where the passenger,

(*a*) is the holder of a certificate signed by a legally qualified medical practitioner certifying that the passenger is,

(i) for the period stated in the certificate, unable for medical reasons to wear a seat belt assembly, or

(ii) because of the passenger's size, build or other physical characteristic, unable to wear a seat belt assembly;

(*b*) is actually engaged in work which requires him to alight from and re-enter the motor vehicle at frequent intervals and the motor vehicle does not travel at a speed exceeding 40 kilometres per hour; or

(*c*) is occupying and properly secured in child seating and restraint systems prescribed under the regulations. 1975 (2nd Sess.), c. 14, s. 1, *part*; 1977, c. 19, s. 2 (2).

Regulations

(8) The Lieutenant Governor in Council may make regulations,

(*a*) requiring the use of child seating and restraint systems in motor vehicles on highways and prescribing the specifications thereof;

(*b*) providing for the exemption from any of the provisions of this section of,

(i) any type or class of motor vehicles,

(ii) any class of drivers or passengers in motor vehicles. 1975 (2nd Sess.), c. 14, s. 1, *part*.

1982 AMENDMENT TO SECTION 90, HIGHWAY TRAFFIC ACT, ONTARIO

s. 90 (2), re-enacted

3.—(1) Subsection 90 (2) of the said Act is repealed and the following substituted therefor:

Seat belt assembly

R.S.C. 1970, c. 26, (1st Supp.)

(2) No person shall drive on a highway a motor vehicle in which a seat belt assembly required under the provisions of the *Motor Vehicle Safety Act* (Canada) at the time that the vehicle was manufactured or imported into Canada has been removed, rendered partly or wholly inoperative, modified so as to reduce its effectiveness or is not operating properly through lack of maintenance.

s. 90 (6), amended

(2) Subsection 90 (6) of the said Act is amended by striking out "has attained the age of two years and" in the second and third lines.

s. 90 (7) (c), re-enacted

(3) Clause 90 (7) (*c*) of the said Act is repealed and the following substituted therefor:

(*c*) is secured in the manner prescribed by the regulations.

s. 90 (8) (b), re-enacted

(4) Clause 90 (8) (*b*) of the said Act is repealed and the following substituted therefor:

(*b*) governing the use of different child seating and restraint systems based on the birth date, age, height or weight of a child or the relationship of a child to the driver or owner of the motor vehicle and prescribing, or adopting by reference manufacturer's recommendations concerning, the manner in which a child is to be secured therein;

(*c*) prescribing classes of motor vehicles, drivers and passengers;

(*d*) adopting by reference, in part or in whole, any code, standards or specifications concerning child restraint systems;

(*e*) exempting from any of the provisions of this section or the regulations made under this section,

(i) any class of motor vehicle,

(ii) any class of driver or passenger, or

(iii) drivers carrying any prescribed class of passenger,

and prescribing conditions for any such exemption.

APPENDIX 3B

REGULATION 485

under the Highway Traffic Act

SEAT BELT ASSEMBLIES

1. Correctional service of Canada vehicles that are modified to facilitate the transportation of persons held in custody and police department vehicles are exempt from the requirement that,

(*a*) upper torso restraints,

(*b*) seat belt assemblies in the centre front seat seating position, and

(*c*) seat belt assemblies in the rear seat seating positions,

not be removed, rendered partly or wholly inoperative or modified so as to reduce their effectiveness.
O. Reg. 1087/80, s. 1.

2. A police officer, constable or peace officer who in the lawful performance of his duty is transporting a person in his custody is exempt from subsections 90 (3) and (6) of the Act. O. Reg. 1087/80, s. 2, *part*.

3. A person who is in the custody of a police officer, constable or peace officer is exempt from subsection 90 (3) of the Act. O. Reg. 1087/80, s. 2, *part*.

4. An employee or agent of the Canada Post Office while engaged in rural mail delivery is exempt from subsection 90 (3) of the Act. O. Reg. 34/76, s. 4.

5.—(1) In this Regulation "taxicab" means,

(*a*) a motor vehicle licensed as a cab by a municipality, or

(*b*) a motor vehicle designed for carrying less than ten passengers and operated under the authority of an operating licence issued under the *Public Vehicles Act*.

(2) Taxicabs are exempt from the requirement that,

(*a*) upper torso restraints for drivers' seating positions, and

(*b*) seat belt assemblies in the centre front seat seating positions,

not be removed, rendered partly or wholly inoperative or modified so as to reduce their effectiveness.

(3) The driver of a taxicab while transporting for hire a passenger is exempt from subsection 90 (3) of the Act. O. Reg. 192/76, s. 1, *part*.

6. The driver of a motor vehicle is exempt from the provisions of subsection 90 (6) of the Act in respect of a passenger under the age of five years or weighing less than 22.7 kilograms. O. Reg. 192/76, s. 1, *part*; O. Reg. 571/78, s. 1.

7. Where a motor vehicle that was manufactured in or imported into Canada prior to the 1st day of January, 1974 is driven on a highway,

(*a*) the driver and passengers are exempt from the requirement to wear the upper torso restraint component of a seat belt assembly; and

(*b*) the driver is exempt from the provisions of subsection 90 (6) of the Act with respect to the requirement that passengers wear upper torso restraint components. O. Reg. 192/76, s. 1, *part*.

1982 AMENDMENT TO REGULATION 485 OF THE HIGHWAY TRAFFIC ACT

HIGHWAY TRAFFIC ACT

O. Reg. 545/82.
Seat Belt Assemblies
[illegible]
[illegible]

REGULATION TO AMEND REGULATION 485 OF REVISED REGULATIONS OF ONTARIO, 1980 MADE UNDER THE HIGHWAY TRAFFIC ACT

1. Section 6 of Regulation 485 of Revised Regulations of Ontario, 1980 is revoked and the following substituted therefor:

6.—(1) The following classes of passengers are prescribed for the purposes of clause 90 (7) (c) of the Act:

1. Children weighing less than nine kilograms are classified as infants.

2. Children weighing nine kilograms or more but less than eighteen kilograms are classified as toddlers.

3. Children weighing eighteen kilograms or more but less than twenty-three kilograms are classified as pre-schoolers.

(2) For the purposes of clause 90 (7) (c) of the Act, an infant born after the 31st day of October, 1982, shall be secured in a rearward-facing child restraint system that,

(a) conforms to the requirements of Standard 213.1 under the *Motor Vehicle Safety Act* (Canada);

(b) is secured by the pelvic restraint of a seat belt assembly in the manner recommended by the manufacturer of the child restraint system; and

(c) has all harnesses, straps and buckles designed to secure the child in the child restraint system properly adjusted and securely fastened.

(3) For the purposes of clause [illegible] of the Act, [illegible] a toddler born after [illegible] the [illegible] 1982, shall be secured,

(a) in a child restraint system that,

(i) conforms to the requirements of the Children's Car Seats and Harness Regulations made under the *Hazardous Products Act* (Canada),

(ii) is secured by the pelvic restraint system of a seat belt assembly in the manner recommended by the manufacturer of the child restraint system and, where practicable, by all other anchorage straps and devices recommended by the manufacturer, and

(iii) has all harnesses, straps and buckles designed to secure the child in the child restraint system properly adjusted and securely fastened; or

(b) by the pelvic restraint of a seat belt assembly.

(4) A toddler born after the 31st day of October, 1982, who is being transported in a motor vehicle that is owned, leased or regularly used by his parent or legal guardian, shall be secured in a child restraint system that complies with the requirements set out in clause (3) (a).

(5) For the purposes of clause 90 (7) (c) of the Act, a pre-schooler shall be secured by the pelvic restraint of a seat belt assembly.

(6) The driver of,

(a) a taxicab, bus or public vehicle, while transporting a passenger for hire; or

(b) a motor vehicle that is leased on a short-term basis or registered in another jurisdiction,

is exempt from subsection 90 (6) of the Act in respect of a passenger who is an infant or toddler.

(7) The driver of a motor vehicle is exempt from subsection 90 (6) of the Act in respect of a passenger born before the 1st day of November, 1982 who is an infant or toddler. O. Reg. 545/82, s. 1.

2. This Regulation comes into force on the 1st day of November, [illegible]

1983 AMENDMENT TO REGULATION 485 OF THE HIGHWAY TRAFFIC ACT

HIGHWAY TRAFFIC ACT

O. Reg. 629/83.
Seat Belt Assemblies
Made—September 2[illegible] 1983
Filed—September [illegible]th 1983

REGULATION TO AMEND REGULATION 485 OF REVISED REGULATIONS OF ONTARIO, [illegible] MADE UNDER THE HIGHWAY TRAFFIC ACT

1. Subsections 6 (2), (3), (4) and (7) of Regulation 485 of Revised Regulations of Ontario, [illegible] as made by section 1 of Ontario Regulation 545/82, are revoked and the following substituted therefor:

(2) For the purposes of clause 90 (7) (c) of the Act, an infant shall be secured in a rearward-facing [illegible] restraint system that,

(a) conforms to the requirements of Standard 213.1 under the *Motor Vehicle Safety Act* (Canada);

(b) is secured by the pelvic restraint system of a seat belt assembly in the manner recommended by the manufacturer of the [illegible] restraint system, and

(c) has all harnesses, straps and buckles designed to secure the child in the [illegible] restraint system properly adjusted [illegible] securely fastened.

(3) For the purposes of clause [illegible] [illegible]

(a) in a child restraint system that,

(i) conforms to the requirements of the Children's Car Seats and Harnesses Regulations made under the *Hazardous Products Act* (Canada), or [illegible] the requirements of Standard [illegible] under the *Motor Vehicle Safety Act* (Canada),

(ii) is secured by the pelvic restraint system of a seat belt assembly in the manner recommended by the manufacturer of the child restraint system and, where practicable, by all other anchorage straps and devices recommended by the manufacturer, and

(iii) has all harnesses, straps and buckles designed to secure the child in the child restraint system properly adjusted and securely fastened; or

(b) by the pelvic restraint system of a seat belt assembly.

(4) For the purposes of clause 90 (7) (c) of the Act, a toddler, who is being transported in a motor vehicle that is owned, leased or regularly used by his parent or legal guardian, shall be secured in a child restraint system that complies with the requirements set out in clause (3) (a). O. Reg. 629/83, s. 1.

2. This Regulation comes into force on the 1st day of November, 1983.

APPENDIX 4
TABLE A-1: ONTARIO REGIONS/COUNTIES

	COUNTY NAMES		COUNTY NAMES
REGION 1	BRUCE; ELGIN; ESSEX; GREY; HURON; KENT; LAMBTON; MIDDLESEX; OXFORD; PERTH	REGION 2	BRANT; DUFFERIN; HALDIMAND-NORFOLK R.M.; HALTON R.M.; NIAGARA R.M.; WATERLOO R.M.; WELLINGTON; HAMILTON-WENTWORTH R.M.
REGION 3	HALIBURTON; METROPOLITAN TORONTO; NORTHUMBERLAND; DURHAM R.M.; PEEL R.M.; PETERBOROUGH; SIMCOE; VICTORIA; YORK R.M.	REGION 4	FRONTENAC; HASTINGS; LANARK; LEEDS & GRENVILLE; LENNOX & ADDINTON; OTTAWA-CARLETON R.M.; PRESCOTT & RUSSELL; PRINCE EDWARD; RENFREW; STORMONT, DUNDAS & GLENGARRY
REGION 5	MUSKOKA, D.M.; ALGOMA; COCHRANE; MANITOULIN; NIPISSING; PARRY SOUND; SUDBURY, R.M.; SUDBURY, D.; TIMISKAMING	REGION 6	KENORA &KENORA P.P; RAINY RIVER; THUNDER BAY
REGION 7	CANADA EXCL. ONTARIO	REGION 8	UNITED STATES
REGION 9	OTHER WORLD REMAINING	REGION 10	NOT KNOWN

TABLE A-2: NATURE OF INJURY CATEGORIES/N CODES

SKULL FRACTURES	800(.0)-804(.9)
NECK AND TRUNK FRACTURES	805(.0)-809(.9)
UPPER LIMB FRACTURES	810(.0)-819(.9)
LOWER LIMB FRACTURES	820(.0)-829(.9)
DISLOCATIONS	830(.0)-839(.9)
SPRAINS AND STRAINS	840(.0)-848(.9)
INTRACRANIAL INJURY	850(.0)-854(.0)
INTERNAL INJURIES OF THE CHEST/ABDOMEN/PELVIS	860(.0)-869(.9)
OPEN WOUND OF HEAD/NECK/TRUNK	870(.0)-879(.9)
OPEN WOUND OF UPPER LIMB	880(.0)-887(.9)
OPEN WOUND OF LOWER LIMB	890(.0)-897(.9)
INJURY TO BLOOD VESSELS	900(.0)-904(.9)
SUPERFICIAL INJURY	910(.0)-919(.9)
CONTUSION WITH INTACT SKIN	920(.0)-924(.9)
CRUSHING INJURY	925(.0)-929(.9)
EFFECTS OF FOREIGN BODY ENTERING THROUGH ORIFICE	930(.0)-939(.9)
BURNS	940(.0)-949(.9)
INJURY TO NERVES AND SPINAL CORD	950(.0)-957(.9)
CERTAIN TRAUMATIC COMPLICATIONS AND UNSPECIFIED INJURIES	958(.0)-959(.9)
ALL OTHER (Disease Classifications as per Chapters 1-16 of ICD-9)	001(.0)-799(.9); V010-V709; V720-V829

TABLE A-3: ANATOMICAL REGIONS/N CODES

ANATOMICAL REGION	ICD-9 N CODES
HEAD	8000-8049; 8300-8301; 8480-8141; 8500-8541; 8700-8739; 9100-9109; 920; 850; 9210-9219; 925; 9300-9309; 931-932; 9350; 9500-9519; 9180-9189; 9570; 9200; 9590
NECK	8050-8051; 8060-8061; 8075-8076; 8390-8391; 8470; 8482; 8740-8749; 9000-9009; 9330-9340; 9520; 9530; 9540
BACK	8052-8059; 8062-8069; 8392-8395; 8471-8479; 8760-8771; 9261;9521-9529; 9531-9535; 9541-9549; 8460-8469; 846
THORAX	8070-8074; 8090-8091; 8483-8489; 8600-8629; 8750-8751; 8790-8791; 9010-9019; 9220-9221; 9268-9269; 9341-9349; 9351
ABDOMEN	8630-8691; 8780-8789; 8792-8796; 9020-9029; 9222-9229; 9260; 9352;936-938; 9390-9399
EXTREMITIES	8080-8089; 8100-8291; 8310-8381; 8400-8451; 9120-9129; 9130-9139; 9140-9149; 9150-9159; 9160-9169; 9170-9179; 8485; 8800-8977; 9030-9049; 9230-9249; 9270-9299; 9550-9569; 9592-9597; 840
OTHER LOCATIONS	8398; 8488; 8499; 8797-8799; 9538-9539; 9571-9579; 9110-9119; 9580-9588; 9591; 9598-9599; 9261; 8396-8397

APPENDIX 6
TABULAR RESULTS OF NUMERATORS/DENOMINATORS/RATES

TABLE A-4
CHILDREN 0-4 YEARS - HOSPITAL ADMISSIONS

QUARTER	FEMALE NONFATAL ADMISS.	MALE NONFATAL ADMISS.	TOTAL NONFATAL ADMISS.	FEMALE FATAL ADMISS.	MALE FATAL ADMISS.	TOTAL FATAL ADMISS.	HMRI CHILD ADMISS.
1	10	17	28	0	0	0	28
2	17	28	45	0	0	0	45
3	29	21	50	0	0	0	50
4	21	16	37	1	1	2	39
SUBTOTAL	77	82	160	1	1	2	162
5	9	10	19	0	1	1	20
6	14	19	33	0	0	0	33
7	14	19	33	0	0	0	33
8	16	17	33	0	0	0	33
SUBTOTAL	53	65	118	0	1	1	119
9	3	15	18	0	0	0	18
10	8	11	19	1	1	2	21
11	14	12	26	0	1	1	27
12	12	8	20	6	1	7	27
SUBTOTAL	37	46	83	7	3	10	93
13	10	11	21	0	1	1	22
14	11	5	16	0	0	0	16
15	8	24	32	0	0	0	32
16	15	21	36	1	1	2	38
SUBTOTAL	44	61	105	1	2	3	108
17	4	6	10	0	0	0	10
18	11	18	29	0	0	0	29
19	15	21	36	0	0	0	36
20	22	20	42	1	0	1	43
SUBTOTAL	52	65	117	1	0	1	118
21	17	9	26	0	0	0	26
22	6	12	18	0	0	0	18
23	11	22	33	0	0	0	33
24	9	13	22	2	0	2	24
SUBTOTAL	43	56	99	2	0	2	101
25	13	12	25	0	0	0	25
26	7	20	27	0	0	0	27
27	12	15	27	0	0	0	27
28	14	13	27	0	0	0	27
SUBTOTAL	46	60	106	0	0	0	106
29	7	9	16	0	1	1	17
30	13	17	30	0	1	1	31
31	11	21	32	0	0	0	32
32	18	12	30	1	0	1	31
SUBTOTAL	49	59	108	1	2	3	111
33	13	9	22	0	0	0	22
34	8	24	32	0	2	2	34
35	14	22	36	1	0	1	37
36	21	21	42	0	0	0	42
SUBTOTAL	56	76	132	1	2	3	135
37	10	12	22	0	0	0	22
38	15	23	38	1	0	1	39
39	13	19	32	0	1	1	33
40	14	27	41	0	0	0	41
SUBTOTAL	52	81	133	1	1	2	135

TABLE A-5
ADULT CONTROLS 20-44 YEARS - HOSPITAL ADMISSIONS

QUARTER	FEMALE NONFATAL ADMISS.	MALE NONFATAL ADMISS.	TOTAL NONFATAL ADMISS.	FEMALE FATAL ADMISS.	MALE FATAL ADMISS.	TOTAL FATAL ADMISS.	HMRI CONTROL ADMISS.
1	115	98	213	1	2	3	216
2	145	125	270	1	0	1	271
3	161	157	318	1	2	3	321
4	150	134	284	1	1	2	286
SUBTOTAL	571	514	1085	4	5	9	1094
5	106	99	205	1	4	5	210
6	129	116	245	0	4	4	249
7	162	161	323	1	2	3	326
8	158	135	293	0	1	1	294
SUBTOTAL	555	511	1066	2	11	13	1079
9	105	107	212	0	1	1	213
10	119	137	256	1	3	4	260
11	172	133	305	1	5	6	311
12	124	140	264	2	2	4	268
SUBTOTAL	520	517	1037	4	11	15	1052
13	105	79	184	2	1	3	187
14	106	143	249	0	0	0	249
15	142	184	326	4	1	5	331
16	140	116	256	2	1	3	259
SUBTOTAL	493	522	1015	8	3	11	1026
17	108	97	205	1	2	3	208
18	117	138	255	0	2	2	257
19	166	174	340	1	2	3	343
20	160	132	292	1	2	3	295
SUBTOTAL	551	541	1092	3	8	11	1103
21	108	83	191	3	0	3	194
22	108	131	239	1	3	4	243
23	148	177	325	4	4	8	333
24	144	135	279	3	2	5	284
SUBTOTAL	508	526	1034	11	9	20	1054
25	119	92	211	1	3	4	215
26	134	171	305	2	4	6	311
27	146	130	276	0	2	2	278
28	152	112	264	2	4	6	270
SUBTOTAL	551	505	1056	5	13	18	1074
29	96	62	158	1	1	2	160
30	121	132	253	3	1	4	257
31	150	165	315	2	0	2	317
32	148	125	273	1	1	2	275
SUBTOTAL	515	484	999	7	3	10	1009
33	106	95	201	1	3	4	205
34	120	157	277	0	1	1	278
35	148	191	339	0	2	2	341
36	149	166	315	1	1	2	317
SUBTOTAL	523	609	1132	2	7	9	1141
37	118	94	212	0	3	3	215
38	125	148	273	1	0	1	274
39	165	182	347	1	2	3	350
40	141	128	269	2	1	3	272
SUBTOTAL	549	552	1101	4	6	10	1111

TABLE A-6
CHILDREN 0-4 YEARS INVOLVED IN INJURY-RELATED CRASHES
(SOURCE:TRAID)

QUARTER	KILLED	INJURED	UNINJURED/ UNKNOWN	INVOLVED
1	3	366	742	1111
2	4	394	884	1282
3	1	507	1042	1550
4	9	413	910	1332
SUBTOTAL	17	1680	3578	5275
5	4	311	619	934
6	1	404	790	1195
7	10	504	1107	1621
8	3	440	941	1384
SUBTOTAL	18	1659	3457	5134
9	3	343	700	1046
10	1	362	767	1130
11	8	448	1027	1483
12	7	409	880	1296
SUBTOTAL	19	1562	3374	4955
13	7	299	721	1027
14	1	321	627	949
15	1	365	831	1197
16	1	306	716	1023
SUBTOTAL	10	1291	2895	4196
17	1	198	483	682
18	0	274	679	953
19	5	295	924	1224
20	1	343	845	1189
SUBTOTAL	7	1110	2931	4048
21	1	253	708	962
22	0	294	818	1112
23	5	359	1090	1454
24	3	342	1019	1364
SUBTOTAL	9	1248	3635	4892
25	3	295	769	1067
26	5	359	935	1299
27	2	394	1202	1598
28	2	409	1241	1652
SUBTOTAL	12	1457	4147	5616
29	2	307	800	1109
30	2	362	1054	1418
31	6	450	1215	1671
32	2	427	1215	1644
SUBTOTAL	12	1546	4284	5842
33	2	364	958	1324
34	3	430	1187	1620
35	4	491	1451	1946
36	3	440	1182	1625
SUBTOTAL	12	1725	4778	6515
37	1	335	789	1125
38	2	428	956	1386
39	1	402	996	1399
40	3	408	937	1348
SUBTOTAL	7	1573	3678	5258

TABLE A-7
ADULTS 20-44 YEARS INVOLVED IN INJURY-RELATED CRASHES
(SOURCE:TRAID)

QUARTER	KILLED	INJURED	UNINJURED/ UNKNOWN	INVOLVED
1	34	3161	3069	6264
2	36	3148	3286	6470
3	49	3728	3926	7703
4	42	4009	3555	7606
SUBTOTAL	161	14046	13836	28043
5	26	2812	2565	5403
6	34	3248	3169	6451
7	54	3893	3959	7906
8	35	4155	3921	8111
SUBTOTAL	149	14108	13614	27871
9	29	3122	2894	6045
10	42	3233	3207	6482
11	49	4019	4111	8179
12	37	3502	3197	6736
SUBTOTAL	157	13876	13409	27442
13	18	3289	3105	6412
14	16	2984	3091	6091
15	27	3544	3752	7323
16	37	3424	3151	6612
SUBTOTAL	98	13241	13099	26438
17	22	2642	2278	4942
18	39	3127	3178	6344
19	47	3474	3652	7173
20	19	3737	3360	7116
SUBTOTAL	127	12980	12468	25575
21	12	2980	2805	5797
22	26	2975	3130	6131
23	40	3845	3998	7883
24	32	4043	3566	7641
SUBTOTAL	110	13843	13499	27452
25	20	3317	3093	6430
26	39	3780	3692	7511
27	33	4152	4394	8579
28	23	4558	4112	8693
SUBTOTAL	115	15807	15291	31213
29	19	3274	2876	6169
30	21	3519	3260	6800
31	26	4347	4441	8814
32	24	4110	3708	7842
SUBTOTAL	90	15250	14285	29625
33	28	3645	3362	7035
34	29	4025	3857	7911
35	48	4955	4845	9848
36	39	4628	3852	8519
SUBTOTAL	144	17253	15916	33313
37	29	3672	2769	6470
38	26	3848	3020	6894
39	51	4746	3949	8746
40	38	4375	3299	7712
SUBTOTAL	144	16641	13037	29822

TABLE A-8
PERSONS ALL AGES INVOLVED IN INJURY-RELATED CRASHES
(SOURCE:TRAID)

QUARTER	KILLED	INJURED	UNINJURED/ UNKNOWN	INVOLVED
1	85	7260	8798	16143
2	99	7878	9892	17869
3	143	9863	12106	22112
4	126	9858	10846	20830
SUBTOTAL	453	34859	41642	76954
5	68	6571	7596	14235
6	80	8166	9735	17981
7	153	10090	12735	22978
8	90	9941	11335	21366
SUBTOTAL	391	34768	41401	76560
9	72	7026	8015	15113
10	102	7785	9586	17473
11	123	9939	12494	22556
12	87	8327	9414	17828
SUBTOTAL	384	33077	39509	72970
13	45	7017	8360	15422
14	63	6876	8646	15585
15	88	8623	11296	20007
16	87	7833	8971	16891
SUBTOTAL	283	30349	37273	67905
17	56	5729	6234	12019
18	79	7119	8881	16079
19	101	8152	10731	18984
20	58	8216	9658	17932
SUBTOTAL	294	29216	35504	65014
21	46	6303	7417	13766
22	53	6732	8949	15734
23	98	9032	11838	20968
24	81	8677	9884	18642
SUBTOTAL	278	30744	38088	69110
25	52	6937	8228	15217
26	81	8170	10230	18481
27	99	9464	12743	22306
28	95	9870	11413	21378
SUBTOTAL	327	34441	42614	77382
29	51	6777	7864	14692
30	69	7736	9757	17562
31	97	9999	12689	22785
32	70	9111	10344	19525
SUBTOTAL	287	33623	40654	74564
33	64	7746	9149	16959
34	73	8917	10960	19950
35	99	11437	14181	25717
36	77	10211	11117	21405
SUBTOTAL	313	38311	45407	84031
37	64	7956	8166	16186
38	56	8593	9436	18085
39	131	11056	12189	23376
40	79	9851	9999	19929
SUBTOTAL	330	37456	39790	77576

APPENDIX 6 (CONT'D)

TABLE A-9
INCIDENCE RATES I-1 TO I-5
CHILDREN 0-4 YEARS

QUARTER	RATE I-1 INJURED + KILLED 0-4/ALL AGES	RATE I-2 ADMISSIONS/ 1,000 INV 0-4 YEARS	RATE I-3 FATALITIES/ 1,000 INV 0-4 YRS	RATE I-4 NON-FATAL ADMISSIONS/ 100,000 POP.	RATE I-5 FATALITIES/ 100,000 POP 0-4 YRS
1	50.24	25.20	2.70	4.66	0.50
2	49.89	35.10	3.12	7.49	0.67
3	50.77	32.26	0.65	8.32	0.17
4	42.27	27.78	6.76	6.16	1.50
SUBTOTAL	48.06	30.33	3.22	26.64	2.83
5	47.45	20.34	4.28	3.19	0.67
6	49.11	27.62	0.84	5.53	0.17
7	50.18	20.36	6.17	5.53	1.68
8	44.16	23.84	2.17	5.53	0.50
SUBTOTAL	47.70	22.98	3.51	19.79	3.02
9	48.75	17.21	2.87	3.04	0.51
10	46.03	16.81	0.88	3.20	0.17
11	45.32	17.53	5.39	4.38	1.35
12	49.44	15.43	5.40	3.37	1.18
SUBTOTAL	47.25	16.75	3.83	14.00	3.20
13	43.33	20.45	6.82	3.51	1.17
14	46.40	16.86	1.05	2.67	0.17
15	42.02	26.73	0.84	5.35	0.17
16	38.76	35.19	0.98	6.02	0.17
SUBTOTAL	42.47	25.02	2.38	17.55	1.67
17	34.40	14.66	1.47	1.64	0.16
18	38.07	30.43	0.00	4.77	0.00
19	36.35	29.41	4.08	5.92	0.82
20	41.58	35.32	0.84	6.91	0.16
SUBTOTAL	37.85	28.90	1.73	19.24	1.15
21	40.01	27.03	1.04	4.21	0.16
22	43.33	16.19	0.00	2.91	0.00
23	39.87	22.70	3.44	5.34	0.81
24	39.39	16.13	2.20	3.56	0.49
SUBTOTAL	40.52	20.24	1.84	16.03	1.46
25	42.64	23.43	2.81	3.99	0.48
26	44.12	20.79	3.85	4.31	0.80
27	41.41	16.90	1.25	4.31	0.32
28	41.24	16.34	1.21	4.31	0.32
SUBTOTAL	42.25	18.87	2.14	16.91	1.91
29	45.25	14.43	1.80	2.53	0.32
30	46.64	21.16	1.41	4.74	0.32
31	45.17	19.15	3.59	5.06	0.95
32	46.73	18.25	1.22	4.74	0.32
SUBTOTAL	45.95	18.49	2.05	17.07	1.90
33	46.86	16.62	1.51	3.39	0.31
34	48.16	19.75	1.85	4.94	0.46
35	42.91	18.50	2.06	5.55	0.62
36	43.06	25.85	1.85	6.48	0.46
SUBTOTAL	44.97	20.26	1.84	20.37	1.85
37	41.90	19.56	0.89	3.33	0.15
38	49.72	27.42	1.44	5.74	0.30
39	36.02	22.87	0.71	4.84	0.15
40	41.39	30.42	2.23	6.20	0.45
SUBTOTAL	41.81	25.29	1.33	20.10	1.06

TABLE A-10
INCIDENCE RATES I-6 TO I-9
CHILDREN 0-4 YEARS

QUARTER	RATE I-6 ADMISSIONS PER 10,000 VEHICLES	RATE I-7 FATALITIES PER 10,000 VEHICLES	RATE I-8 NONFAT ADM/ 1,000,000 m3 GAS SOLD	RATE I-9 FATALITIES/ 1,000,000 m3 GAS SOLD
1	11.50	1.23	9.31	1.00
2	18.34	1.63	13.41	1.19
3	18.37	0.37	13.96	0.28
4	12.09	2.94	10.99	2.67
SUBTOTAL	15.00	1.59	12.02	1.28
5	8.58	1.81	7.26	1.53
6	13.35	0.40	11.51	0.35
7	11.55	3.50	10.45	3.17
8	10.54	0.96	11.45	1.04
SUBTOTAL	11.05	1.69	10.24	1.56
9	7.36	1.23	6.72	1.12
10	7.57	0.40	6.54	0.34
11	9.08	2.79	8.74	2.69
12	7.16	2.51	7.56	2.65
SUBTOTAL	7.82	1.79	7.41	1.70
13	8.79	2.93	8.52	2.84
14	7.13	0.45	6.11	0.38
15	12.56	0.39	11.34	0.35
16	13.90	0.39	14.01	0.39
SUBTOTAL	10.74	1.02	10.03	0.95
17	5.08	0.51	4.27	0.43
18	12.34	0.00	11.14	0.00
19	14.19	1.97	12.79	1.78
20	14.78	0.35	15.78	0.38
SUBTOTAL	12.07	0.72	11.23	0.67
21	11.49	0.44	10.68	0.41
22	7.57	0.00	6.81	0.00
23	11.52	1.75	11.82	1.79
24	7.43	1.01	8.13	1.11
SUBTOTAL	9.46	0.86	9.36	0.85
25	9.74	1.17	10.39	1.25
26	9.51	1.76	9.88	1.83
27	8.69	0.64	9.30	0.69
28	7.81	0.58	10.03	0.74
SUBTOTAL	8.86	1.00	9.88	1.12
29	6.27	0.78	6.51	0.81
30	10.58	0.71	10.61	0.71
31	9.44	1.77	10.90	2.04
32	9.18	0.61	11.03	0.74
SUBTOTAL	8.96	1.00	9.87	1.10
33	7.72	0.70	8.69	0.79
34	9.81	0.92	11.21	1.05
35	9.75	1.08	11.99	1.33
36	11.49	0.82	14.74	1.05
SUBTOTAL	9.81	0.89	11.74	1.07
37	7.52	0.34	8.31	0.38
38	12.46	0.66	13.29	0.70
39	9.37	0.29	10.16	0.32
40	11.84	0.87	13.48	0.99
SUBTOTAL	10.35	0.54	11.37	0.60

TABLE A-11
INCIDENCE RATES I-1 TO I-5
ADULTS 20-44 YEARS

QUARTER	RATE I-1 INJURED + KILLED20-44/ALL AGES	RATE I-2 ADMISSIONS/ 1,000 INV 20-44 YEAR	RATE I-3 FATALITIES/ 1,000 INV 20-44 YRS	RATE I-4 NON-FATAL ADMISSIONS/ 100,000 POP.20-44 YRS	RATE I-5 FATALITIES/ 100,000 POP 20-44 YRS
1	434.99	34.00	5.43	6.65	1.06
2	399.15	41.73	5.56	8.43	1.12
3	377.47	41.28	6.36	9.93	1.53
4	405.75	37.34	5.52	8.87	1.31
SUBTOT	402.33	38.69	5.74	33.89	5.03
5	427.47	37.94	4.81	6.28	0.80
6	398.01	37.98	5.27	7.51	1.04
7	385.34	40.86	6.83	9.90	1.66
8	417.71	36.12	4.32	8.98	1.07
SUBTOT	405.50	38.25	5.35	32.68	4.57
9	443.93	35.07	4.80	6.39	0.87
10	415.24	39.49	6.48	7.71	1.27
11	404.29	37.29	5.99	9.19	1.48
12	420.61	39.19	5.49	7.95	1.11
SUBTOT	419.38	37.79	5.72	31.25	4.73
13	468.28	28.70	2.81	5.42	0.53
14	432.34	40.88	2.63	7.34	0.47
15	409.94	44.52	3.69	9.61	0.80
16	436.99	38.72	5.60	7.55	1.09
SUBTOT	435.46	38.39	3.71	29.92	2.89
17	460.50	41.48	4.45	5.89	0.63
18	439.84	40.20	6.15	7.33	1.12
19	426.63	47.40	6.55	9.77	1.35
20	453.95	41.03	2.67	8.39	0.55
SUBTOT	444.15	42.70	4.97	31.38	3.65
21	471.26	32.95	2.07	5.35	0.34
22	442.30	38.98	4.24	6.70	0.73
23	425.52	41.23	5.07	9.11	1.12
24	465.29	36.51	4.19	7.82	0.90
SUBTOT	449.78	37.67	4.01	28.98	3.08
25	477.46	32.81	3.11	5.78	0.55
26	462.85	40.61	5.19	8.36	1.07
27	437.62	32.17	3.85	7.56	0.90
28	459.71	30.37	2.65	7.23	0.63
SUBTOT	457.95	33.83	3.68	28.93	3.15
29	482.28	25.61	3.08	4.25	0.51
30	453.56	37.21	3.09	6.80	0.56
31	433.14	35.74	2.95	8.47	0.70
32	450.28	34.81	3.06	7.34	0.65
SUBTOT	452.37	33.72	3.04	26.87	2.42
33	470.29	28.57	3.98	5.29	0.74
34	450.95	35.01	3.67	7.29	0.76
35	433.69	34.42	4.87	8.92	1.26
36	453.64	36.98	4.58	8.29	1.03
SUBTOT	450.42	33.98	4.32	29.80	3.79
37	461.47	32.77	4.48	5.48	0.75
38	447.91	39.60	3.77	7.06	0.67
39	428.80	39.68	5.83	8.97	1.32
40	444.41	34.88	4.93	6.95	0.98
SUBTOT	444.21	36.92	4.83	28.46	3.72

TABLE A-12
INCIDENCE RATES I-6 TO I-9
ADULTS 20-44 YEARS

QUARTER	RATE I-6 ADMISSIONS PER 10,000 VEHICLES	RATE I-7 FATALITIES PER 10,000 VEHICLES	RATE I-8 NONFAT ADM/ 1,000,000 m3 GAS SOLD	RATE I-9 FATALITIES/ 1,000,000 m3 GAS SOLD
1	87.50	13.97	70.84	11.31
2	110.04	14.67	80.45	10.73
3	116.86	18.01	88.77	13.68
4	92.78	13.72	84.36	12.48
SUBTOTAL	101.69	15.09	81.51	12.09
5	92.58	11.74	78.33	9.93
6	99.10	13.75	85.47	11.86
7	113.04	18.90	102.30	17.10
8	93.59	11.18	101.64	12.14
SUBTOTAL	99.86	13.96	92.50	12.93
9	86.64	11.85	79.18	10.83
10	101.93	16.72	88.09	14.45
11	106.49	17.11	102.53	16.47
12	94.49	13.24	99.78	13.98
SUBTOTAL	97.68	14.79	92.56	14.01
13	77.00	7.53	74.69	7.31
14	110.93	7.13	95.11	6.11
15	127.91	10.59	115.50	9.57
16	98.82	14.28	99.64	14.40
SUBTOTAL	103.85	10.03	96.91	9.36
17	104.17	11.18	87.50	9.39
18	108.53	16.60	97.96	14.98
19	134.03	18.53	120.77	16.70
20	102.73	6.68	109.70	7.14
SUBTOTAL	112.61	13.10	104.77	12.18
21	84.41	5.30	78.45	4.93
22	100.55	10.94	90.45	9.84
23	113.49	13.97	116.41	14.33
24	94.18	10.80	103.12	11.83
SUBTOTAL	98.80	10.51	97.78	10.40
25	82.20	7.79	87.72	8.31
26	107.41	13.73	111.61	14.27
27	88.81	10.62	95.07	11.37
28	76.41	6.66	98.04	8.54
SUBTOTAL	88.23	9.61	98.38	10.71
29	61.91	7.44	64.29	7.73
30	89.19	7.40	89.44	7.42
31	92.95	7.67	107.29	8.86
32	83.49	7.34	100.42	8.83
SUBTOTAL	82.92	7.47	91.31	8.23
33	70.51	9.82	79.38	11.06
34	84.88	8.89	97.03	10.16
35	91.83	13.00	112.88	15.98
36	86.20	10.67	110.56	13.69
SUBTOTAL	84.10	10.70	100.72	12.81
37	72.47	9.91	80.03	10.95
38	89.50	8.52	95.47	9.09
39	101.64	14.94	110.18	16.19
40	77.66	10.97	88.47	12.50
SUBTOTAL	85.66	11.20	94.11	12.31

TABLE A-13
SEVERITY OF INJURY RATES
CHILDREN 0-4 YEARS

QUARTER	RATE S-1 CASE FATALITY	RATE S-2 AVERAGE LOS	RATE S-3 AVERAGE ICU DAYS
1	9.68	16.11	0.64
2	8.16	17.13	0.04
3	1.96	7.16	0.72
4	19.57	16.11	0.60
SUBTOTAL	9.60	13.60	0.49
5	17.39	4.79	0.11
6	2.94	18.76	0.18
7	23.26	6.36	0.21
8	8.33	10.61	0.45
SUBTOTAL	13.24	10.76	0.25
9	14.29	5.17	0.83
10	5.00	8.68	0.05
11	23.53	4.58	0.31
12	25.93	14.75	0.05
SUBTOTAL	18.63	8.10	0.30
13	25.00	5.19	0.05
14	5.88	14.38	0.13
15	3.03	3.91	0.22
16	2.70	11.31	2.00
SUBTOTAL	8.70	8.30	0.78
17	9.09	22.40	0.00
18	0.00	17.62	0.10
19	12.20	15.08	0.06
20	2.33	13.69	0.50
SUBTOTAL	5.65	15.84	0.22
21	3.70	9.92	0.16
22	0.00	15.61	2.00
23	13.16	4.64	0.00
24	12.00	13.09	0.00
SUBTOTAL	8.33	9.90	0.39
25	10.71	2.64	0.08
26	15.63	3.93	0.11
27	6.90	5.59	0.33
28	6.90	5.37	0.15
SUBTOTAL	10.17	4.42	0.17
29	11.11	23.31	1.19
30	6.25	4.97	0.90
31	15.79	4.66	0.28
32	6.25	14.37	1.10
SUBTOTAL	10.00	10.20	0.81
33	8.33	4.32	1.00
34	8.57	4.50	0.78
35	10.00	6.86	0.17
36	6.67	4.17	0.48
SUBTOTAL	8.33	5.01	0.55
37	4.35	16.68	0.14
38	5.00	5.00	0.55
39	3.03	5.22	0.63
40	6.82	7.73	1.66
SUBTOTAL	5.00	7.83	0.84

TABLE A-14
SEVERITY OF INJURY RATES
ADULTS 20-44 YEARS

QUARTER	RATE S-1 CASE FATALITY	RATE S-2 AVERAGE LOS	RATE S-3 AVERAGE ICU DAYS
1	13.77	14.09	0.32
2	11.76	16.15	0.29
3	13.35	10.05	0.74
4	12.88	13.07	0.52
SUBTOTAL	12.92	13.15	0.49
5	11.26	11.21	0.53
6	12.19	11.47	0.43
7	14.32	11.36	0.43
8	10.67	12.30	0.99
SUBTOTAL	12.26	11.62	0.60
9	12.03	14.43	0.49
10	14.09	10.75	0.30
11	13.84	12.48	0.97
12	12.29	18.50	0.53
SUBTOTAL	13.15	13.98	0.60
13	8.91	24.10	0.59
14	6.04	13.63	0.53
15	7.65	13.39	0.49
16	12.63	9.04	0.54
SUBTOTAL	8.81	14.29	0.53
17	9.69	13.31	0.42
18	13.27	11.43	0.82
19	12.14	10.81	0.61
20	6.11	12.18	0.73
SUBTOTAL	10.42	11.80	0.66
21	5.91	11.62	0.75
22	9.81	10.74	0.97
23	10.96	11.68	0.86
24	10.29	8.36	0.89
SUBTOTAL	9.62	10.56	0.87
25	8.66	10.08	0.88
26	11.34	14.74	0.76
27	10.68	14.69	0.94
28	8.01	15.28	0.94
SUBTOTAL	9.82	13.94	0.87
29	10.73	15.92	0.81
30	7.66	14.38	0.80
31	7.62	14.91	1.00
32	8.08	15.73	0.91
SUBTOTAL	8.26	15.16	0.90
33	12.23	15.87	1.30
34	9.48	14.65	1.20
35	12.40	9.67	1.20
36	11.02	10.81	1.30
SUBTOTAL	11.29	12.31	1.25
37	12.03	13.37	1.20
38	8.70	10.33	0.63
39	12.81	10.90	0.75
40	12.38	8.31	1.20
SUBTOTAL	11.57	10.60	0.92

TABLE A-15
NATURE OF INJURY/BODY PART RATES
CHILDREN 0-4 YEARS

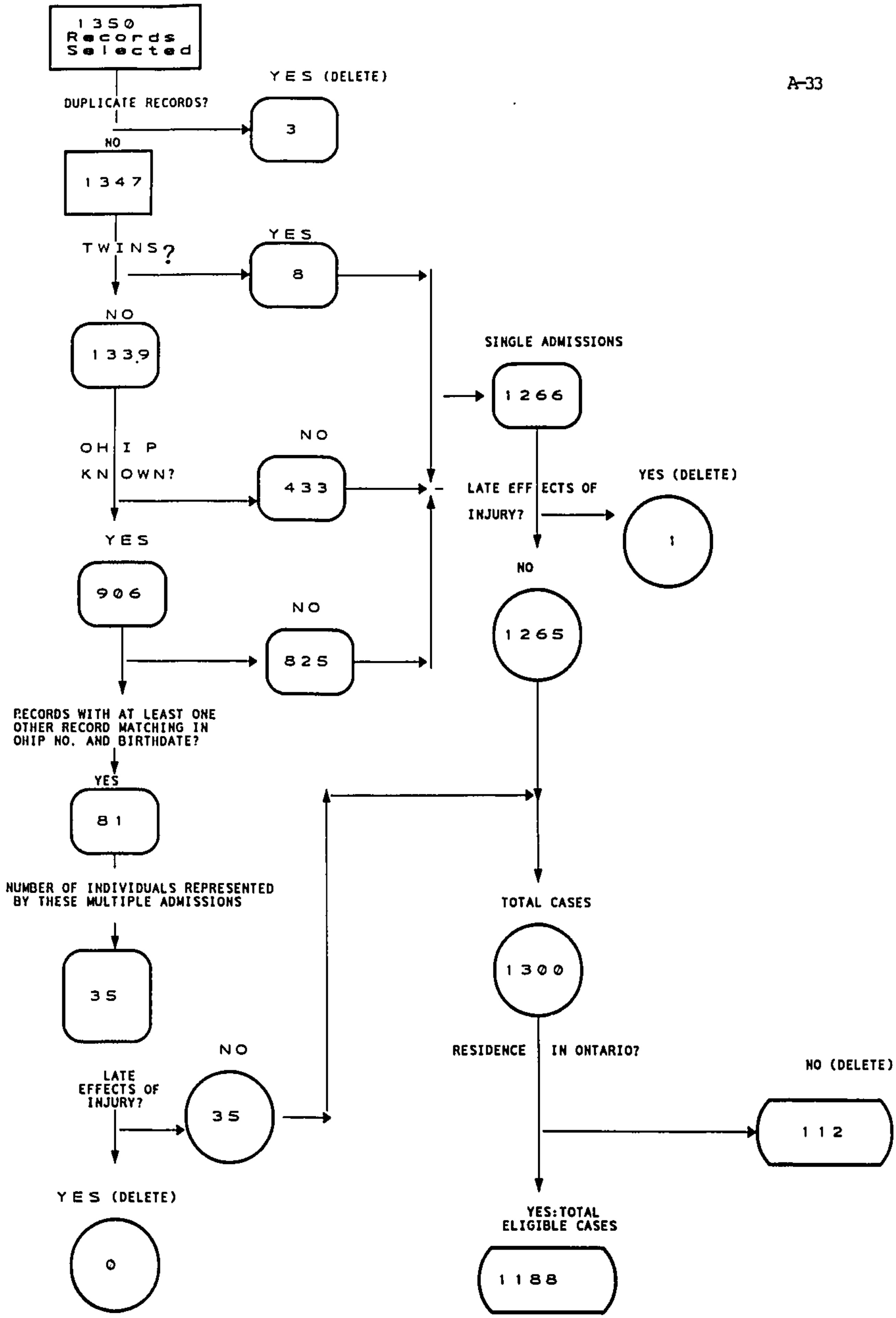
QUARTER	RATE P-1C SKULL FRACT	RATE P-1D INTRACRANIAL INJURY	RATE P-1A LOWER LIMB FRACTURE	RATE P-1B OPEN WOUND HEAD/NECK/TRUNK	RATE P-2A HEAD INJURIES	RATE P-2B EXTREMITY INJURIES
1	25.00	39.29	14.29	3.57	71.43	17.86
2	4.44	35.56	22.22	17.78	62.22	26.67
3	20.00	28.00	20.00	6.00	60.00	28.00
4	10.26	33.33	15.38	7.69	53.85	25.64
SUBTOTAL	14.20	33.33	18.52	9.26	61.11	25.31
5	10.00	35.00	20.00	10.00	60.00	25.00
6	12.12	48.48	18.18	3.03	66.67	27.27
7	9.09	39.39	21.21	9.09	54.55	24.24
8	9.09	39.39	12.12	9.09	57.58	24.24
SUBTOTAL	10.08	41.18	17.65	7.56	59.66	25.21
9	22.22	44.44	5.56	5.56	77.78	5.56
10	9.52	42.86	4.76	0.00	57.14	19.05
11	3.70	59.26	7.41	3.70	74.07	18.52
12	14.81	48.15	7.41	11.11	77.78	18.52
SUBTOTAL	11.83	49.46	6.45	5.38	72.04	16.13
13	4.55	77.27	4.55	0.00	81.82	9.09
14	18.75	37.50	6.25	12.50	81.25	12.50
15	9.38	56.25	6.25	3.13	68.75	15.63
16	5.26	47.37	10.53	10.53	68.42	13.16
SUBTOTAL	8.33	54.63	7.41	6.48	73.15	12.96
17	10.00	40.00	20.00	10.00	70.00	30.00
18	10.34	58.62	3.45	0.00	72.41	13.79
19	8.33	44.44	22.22	5.56	66.67	22.22
20	11.63	34.88	27.91	9.30	60.47	30.23
SUBTOTAL	10.17	44.07	19.49	5.93	66.10	23.73
21	7.69	38.46	11.54	15.38	65.38	15.38
22	16.67	33.33	0.00	16.67	72.22	16.67
23	15.15	30.30	3.03	12.12	69.70	12.12
24	16.67	33.33	12.50	16.67	70.83	20.83
SUBTOTAL	13.86	33.66	6.93	14.85	69.31	15.84
25	4.00	36.00	4.00	8.00	48.00	28.00
26	11.11	40.74	11.11	14.81	66.67	11.11
27	14.81	33.33	14.81	22.22	77.78	18.52
28	14.81	37.04	14.81	11.11	62.96	22.22
SUBTOTAL	11.32	36.79	11.32	14.15	64.15	19.81
29	23.53	17.65	23.53	11.76	52.94	29.41
30	6.45	38.71	6.45	12.90	64.52	19.35
31	6.25	46.88	9.38	6.25	68.75	21.88
32	12.90	35.48	6.45	19.35	74.19	9.68
SUBTOTAL	10.81	36.94	9.91	12.61	66.67	18.92
33	22.73	50.00	4.55	4.55	77.27	4.55
34	17.65	32.35	11.76	11.76	70.59	17.65
35	16.22	32.43	18.92	2.70	64.86	27.03
36	4.76	38.10	19.05	14.29	57.14	26.19
SUBTOTAL	14.07	37.04	14.81	8.89	65.93	20.74
37	9.09	40.91	22.73	4.55	59.09	27.27
38	15.38	25.64	12.82	20.51	64.10	17.95
39	9.09	42.42	9.09	6.06	60.61	21.21
40	24.39	29.27	14.63	4.88	63.41	17.07
SUBTOTAL	15.56	33.33	14.07	9.63	62.22	20.00

TABLE A-16
NATURE OF INJURY/BODY PART RATES
ADULTS 20-44 YEARS

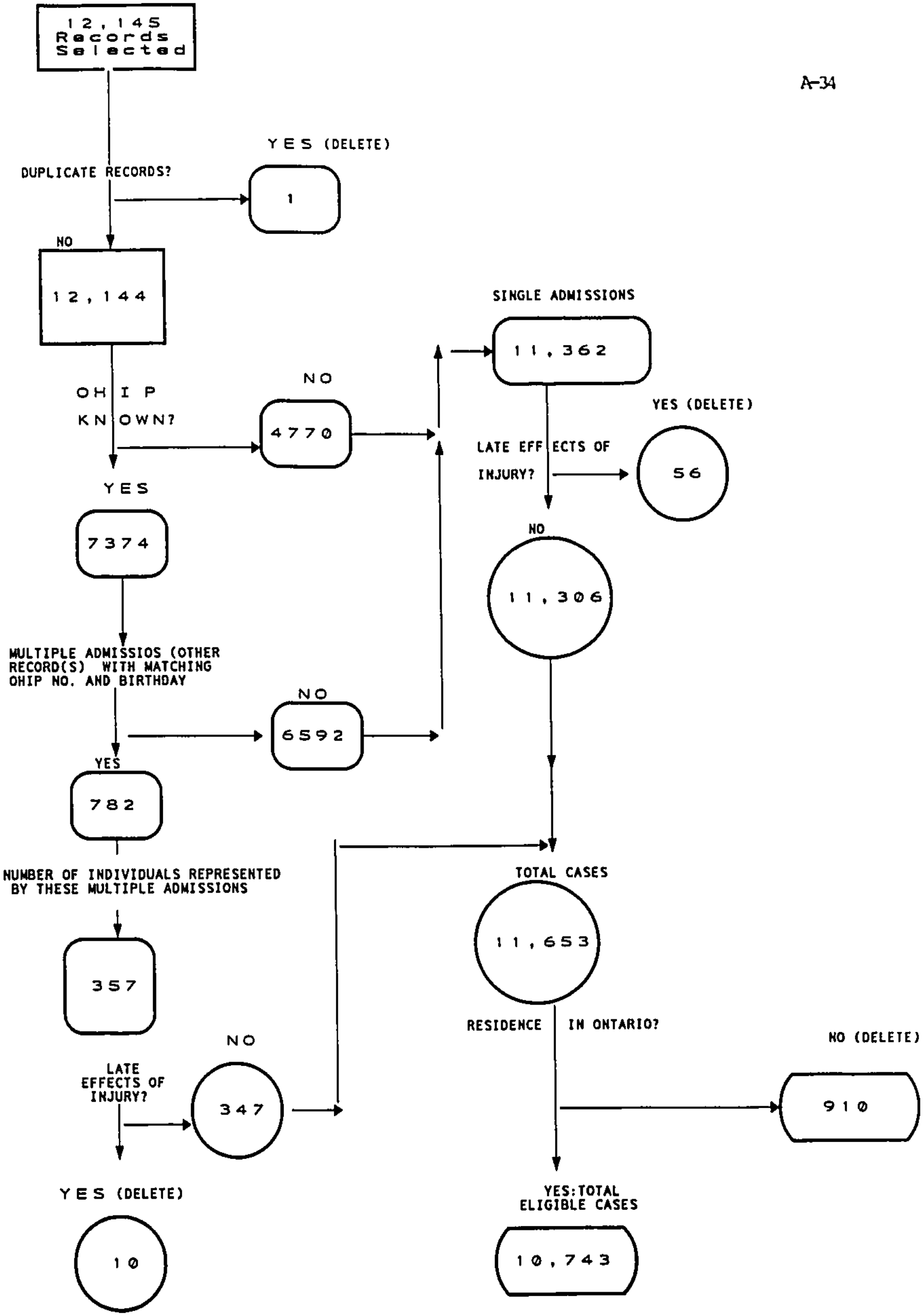
QUARTER	RATE P-1C SKULL FRACT	RATE P-1D INTRACRANIAL INJURY	RATE P-1A LOWER LIMB FRACTURE	RATE P-1B OPEN WOUND HEAD HEAD/NECK/TRUNK	RATE P-2A HEAD INJURIES	RATE P-2B EXTREMITY INJURIES
1	6.48	22.69	9.26	5.56	36.57	26.85
2	8.12	22.51	9.23	6.27	40.59	26.20
3	5.92	22.12	5.30	8.41	38.01	24.92
4	5.94	22.73	11.89	5.94	36.71	27.62
SUBTOTAL	6.58	22.49	8.78	6.67	38.03	26.33
5	8.57	21.43	11.43	3.33	38.10	30.00
6	7.63	26.91	9.24	5.62	40.16	26.10
7	6.13	24.85	9.51	7.06	38.65	26.69
8	4.76	27.89	7.82	5.44	40.14	25.17
SUBTOTAL	6.58	25.49	9.36	5.56	39.30	26.78
9	5.16	18.78	9.86	7.98	32.39	30.05
10	8.85	25.38	8.46	5.77	41.54	23.08
11	8.04	18.01	7.72	5.14	33.12	26.05
12	5.97	26.87	6.34	8.58	42.92	23.51
SUBTOTAL	7.13	22.24	7.98	6.75	37.55	25.48
13	8.56	28.88	7.49	3.21	42.78	20.86
14	8.43	22.89	7.63	6.83	39.76	27.71
15	5.74	16.62	9.97	5.74	30.51	31.12
16	8.88	23.55	10.42	6.18	41.31	24.32
SUBTOTAL	7.70	22.12	9.06	5.65	37.72	26.71
17	4.33	24.04	8.65	7.21	38.94	21.15
18	7.00	27.24	5.84	8.95	44.36	22.57
19	6.71	21.87	8.75	6.71	35.86	27.41
20	6.44	21.02	10.17	7.80	36.95	25.42
SUBTOTAL	6.26	23.30	8.43	7.62	38.71	24.57
21	7.22	18.04	9.79	6.19	33.51	22.68
22	3.29	21.81	9.47	5.76	32.10	32.51
23	8.71	15.92	9.61	5.71	30.93	31.83
24	6.69	21.13	10.21	5.63	36.97	28.87
SUBTOTAL	6.64	19.07	9.77	5.79	33.30	29.51
25	6.05	20.47	12.09	4.65	33.02	29.30
26	8.04	22.19	6.43	7.40	39.87	25.72
27	5.40	21.94	9.71	5.76	34.17	24.46
28	4.07	21.85	8.52	4.44	32.59	25.19
SUBTOTAL	5.96	21.69	8.94	5.68	35.20	25.98
29	5.00	18.75	8.13	8.75	31.25	28.75
30	7.78	17.12	5.45	8.95	35.41	27.63
31	5.68	20.19	7.89	5.36	32.18	29.65
32	7.27	20.73	9.45	4.73	33.45	25.45
SUBTOTAL	6.54	19.33	7.73	6.64	33.20	27.85
33	7.80	21.46	9.76	4.88	34.63	30.24
34	4.68	18.35	7.19	6.12	29.86	32.01
35	6.16	17.60	7.62	7.33	34.90	26.10
36	8.52	18.93	8.83	3.79	34.07	25.87
SUBTOTAL	6.75	18.84	8.24	5.61	33.39	28.22
37	5.12	21.40	8.84	6.05	33.02	28.84
38	7.66	17.88	8.39	4.74	32.48	25.91
39	6.57	20.29	12.29	4.29	32.29	34.00
40	9.56	21.69	10.29	6.25	40.07	22.43
SUBTOTAL	7.29	20.25	10.17	5.22	34.38	28.17

TABLE A-17
MISCELLANEOUS VARIABLES USED IN THE CALCULATION OF RATES

QUARTER	POPULATION 0-4 YEARS	POPULATION 20-44 YEARS	GAS SALES ONTARIO	INVOLVED MOTOR VEHICLES
1	600684	3201110	3006822	24343
2	600684	3201110	3355985	24536
3	600684	3201110	3582264	27213
4	600684	3201110	3366480	30609
SUBTOTAL	600684	3201110	13311551	106701
5	596216	3262417	2617286	22143
6	596216	3262417	2866423	24723
7	596216	3262417	3157398	28575
8	596216	3262417	2882600	31307
SUBTOTAL	596216	3262417	11523707	106748
9	593047	3318783	2677326	24468
10	593047	3318783	2906113	25115
11	593047	3318783	2974714	28642
12	593047	3318783	2645877	27939
SUBTOTAL	593047	3318783	11204030	106164
13	598226	3392768	2463433	23897
14	598226	3392768	2617965	22446
15	598226	3392768	2822497	25486
16	598226	3392768	2569289	25905
SUBTOTAL	598226	3392768	10473184	97734
17	608172	3479993	2342777	19680
18	608172	3479993	2603080	23496
19	608172	3479993	2815204	25368
20	608172	3479993	2661893	28425
SUBTOTAL	609172	3479993	10422954	96969
21	617773	3567706	2434681	22628
22	617773	3567706	2642283	23770
23	617773	3567706	2791816	28638
24	617773	3567706	2705648	29623
SUBTOTAL	617773	3567706	10574428	104659
25	626753	3649987	2405449	25668
26	626753	3649987	2732730	28395
27	626753	3649987	2903222	31078
28	626753	3649987	2692643	34552
SUBTOTAL	626753	3649987	10734044	119693
29	632722	3718277	2457499	25521
30	632722	3718277	2828695	28366
31	632722	3718277	2936103	33888
32	632722	3718277	2718665	32697
SUBTOTAL	632722	3718277	10940962	120472
33	648127	3798521	2532237	28507
34	648127	3798521	2854673	32633
35	648127	3798521	3003302	36918
36	648127	3798521	2849200	36545
SUBTOTAL	648127	3798521	11239412	134603
37	661591	3869017	2648975	29252
38	661591	3869017	2859667	30504
39	661591	3869017	3149392	34139
40	661591	3869017	3040492	34637
SUBTOTAL	661591	3869017	11698526	128532


1350 Records Selected
DUPLICATE RECORDS?
YES (DELETE)
3
NO
1347
TWINS?
YES
8
NO
1339
OHIP KNOWN?
NO
433
YES
906
NO
825
RECORDS WITH AT LEAST ONE OTHER RECORD MATCHING IN OHIP NO. AND BIRTHDATE?
YES
81
NUMBER OF INDIVIDUALS REPRESENTED BY THESE MULTIPLE ADMISSIONS
35
LATE EFFECTS OF INJURY?
NO
35
YES (DELETE)
0
SINGLE ADMISSIONS
1266
LATE EFFECTS OF INJURY?
YES (DELETE)
1
NO
1265
TOTAL CASES
1300
RESIDENCE IN ONTARIO?
NO (DELETE)
112
YES: TOTAL ELIGIBLE CASES
1188

APPENDIX 7: CONTROL GROUP - SELECTED HMRI RECORDS



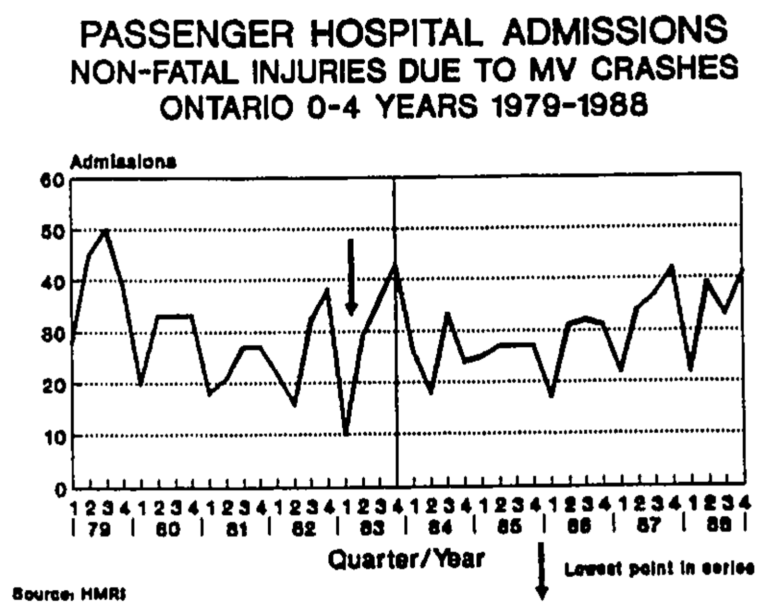
APPENDIX 8

A-8.1 YEARLY AND QUARTERLY TRENDS IN THE VARIABLES USED IN THE CALCULATION OF RATES AND INDICATORS

All variables were plotted quarterly and yearly, the purpose of the latter to (visually) control for the often marked seasonal variations.

A-8.1.1 Non-fatal hospital admissions

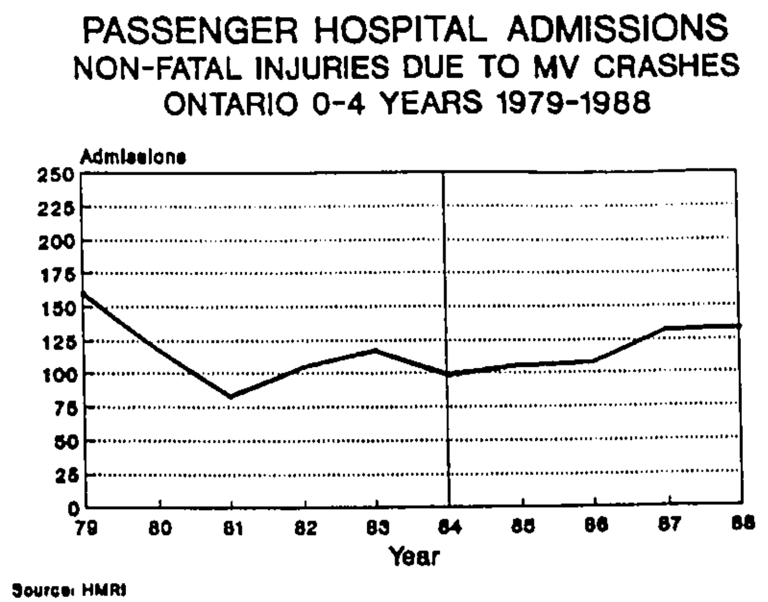
FIGURE A-4



<u>Children</u>: The quarterly plot of non-fatal admissions demonstrated a seasonal pattern (Figure A-4). Between the 4/82 and 1/83 there was a steep drop, with the lowest point in the series occurring in the latter quarter. There followed an immediate sharp rise until the end of 1983 after which there was another (less) steep drop in early 1984.

The yearly plot of the number of non-fatal hospital admissions in children under 5 (Figure A-5) revealed that the number of such admissions fell by nearly half (48.1%) from 1979 until 1981, when it reached its lowest point in the study period. After that year there was a slight upward trend. It should be noted that although the lowest point in the quarterly series occurred in the first quarter of 1983, that year saw the greatest number of admissions between 1981 and 1987.

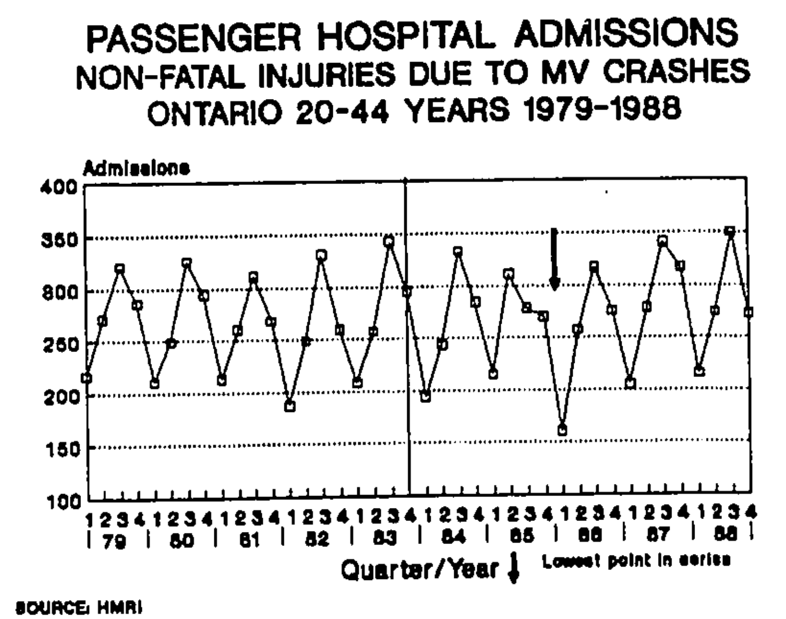
FIGURE A-5

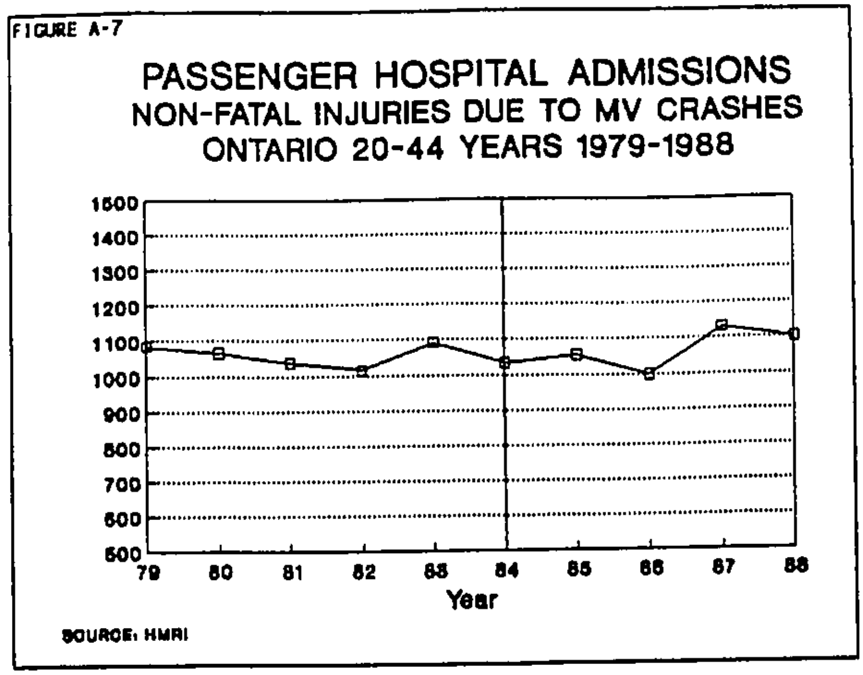


Controls: The number of non-fatal hospital admissions for adult controls in the quarterly plot (Figure A-6) was subject to marked seasonal variations across the study period. There was a steep, but temporary drop in 1/86.

The yearly plot (Figure A-7) shows that the number of control admissions fell slightly between 1979 and 1982, then rose in 1983 to beyond its '79 level. Although 1986 was the lowest point in the yearly series, the years since then have seen the highest levels in the study period. (Figure A-7)

FIGURE A-6

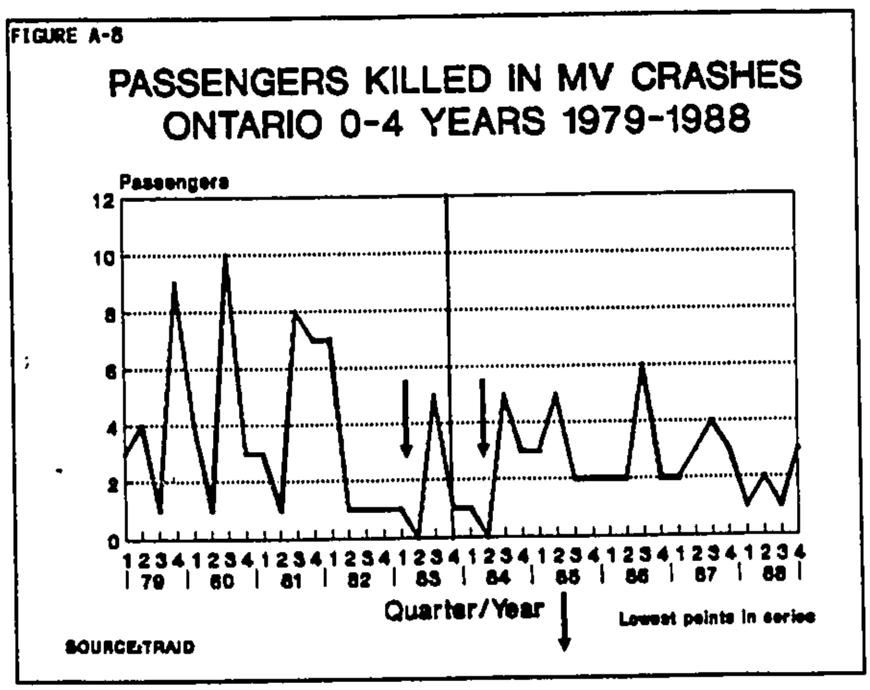




A-8.1.2 Injured and killed persons (TRAID)

Children- Fatalities: The second quarters of 1983 and 1984 were the lowest points on the quarterly plot, in which the number of fatalities fell to zero. (Figure A-8)

In the yearly plot there was a dramatic drop in the number of children killed between 1981 (19 fatalities - the highest year in the study period) and 1983 (7 fatalities - the lowest year in the study period). After 1983, the number of fatalities began to rise, reaching a plateau of 12 fatalities in 1985. By 1988, the number of fatalities had again dropped to seven. (Figure A-9)



<u>Children - Non-fatal injuries</u>: Figures A-10 and A-11 show that the number of non-fatally injured children had been falling steadily since 1979 and reached its lowest level in 1983, the first quarter of that year being the lowest quarter in the ten-year period. However, there was also a corresponding fall in the number of children who were **involved** in injury-related crashes, even though at least one other person in the same crash was injured. The number of children involved in an injury-related crash rose steadily after 1983 to exceed the '79 levels, reaching the highest level in 1987. However, the increase in the number of those children who were injured was less steep, although the 1987 level was also the highest in the series.

FIGURE A-9

PASSENGERS KILLED IN MV CRASHES
ONTARIO 0-4 YEARS 1979-1988

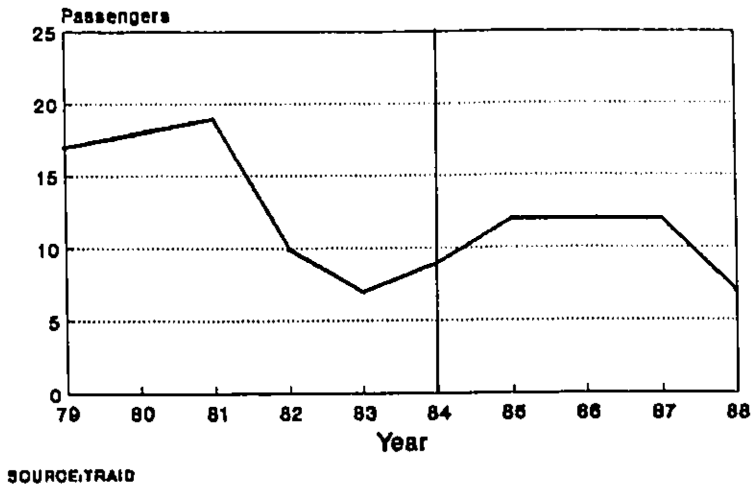


FIGURE A-10

PASSENGERS INVOLVED*
INJURY RELATED MV CRASHES
ONTARIO 0-4 YEARS 1979-1988

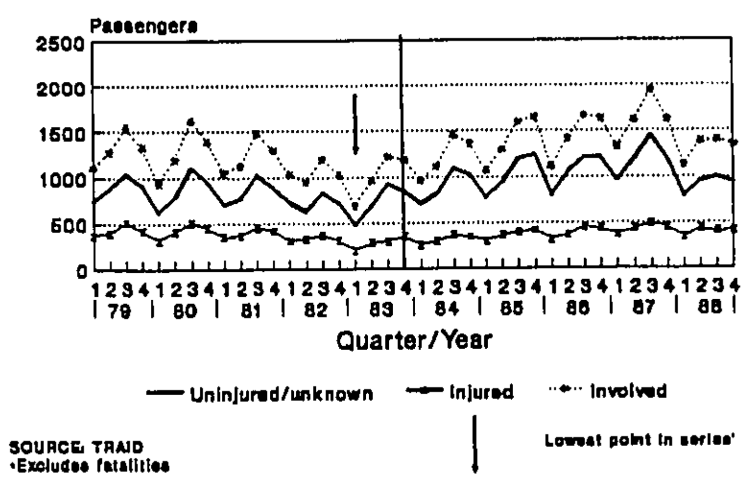


FIGURE A-11

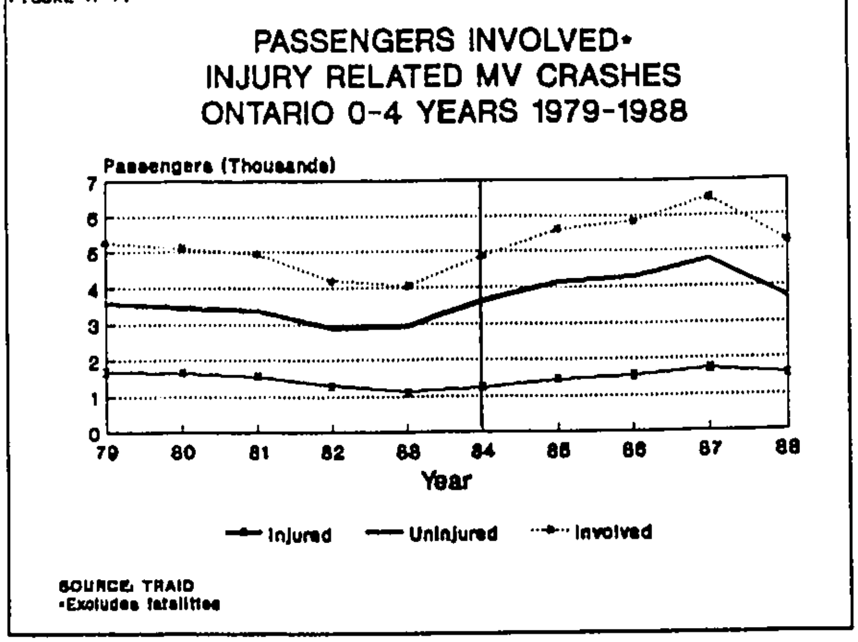
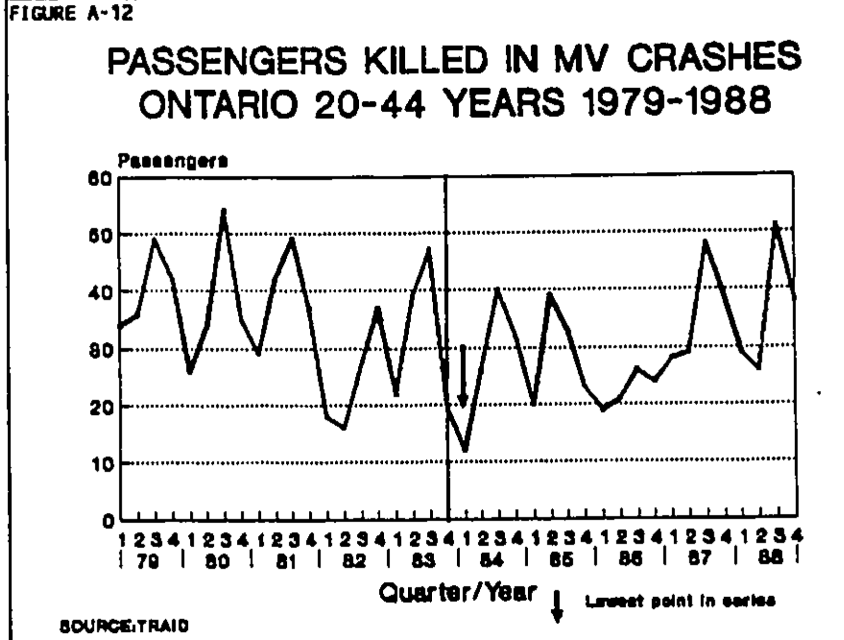


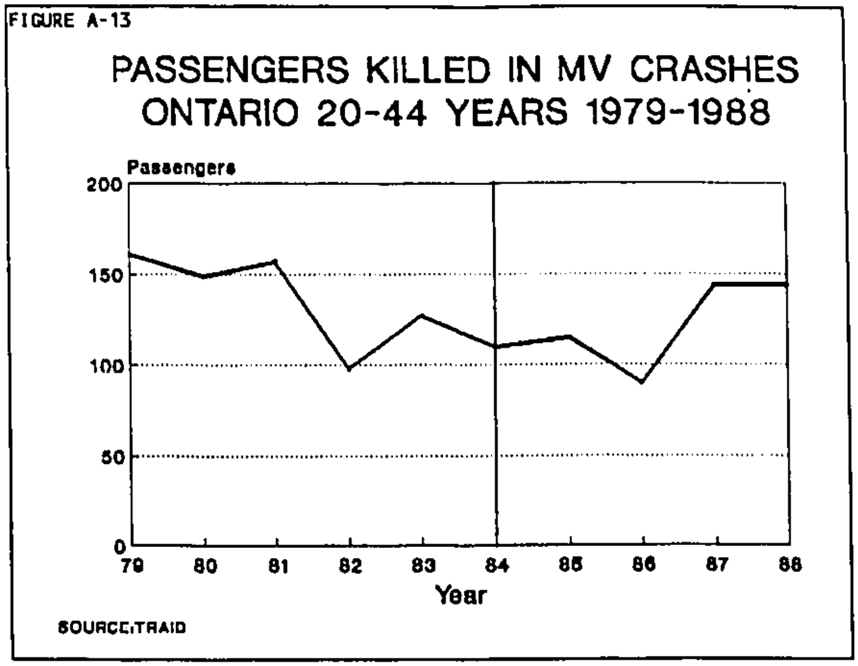
FIGURE A-12



<u>Controls - Fatalities</u>: There was marked seasonal variation in the quarterly plot of fatalities in adult controls, the lowest quarter being 1/84 (Figure A-12).

The yearly plot (Figure A-13) showed that the number of fatalities in adult controls fell from 1979 (161 fatalities) until 1982.

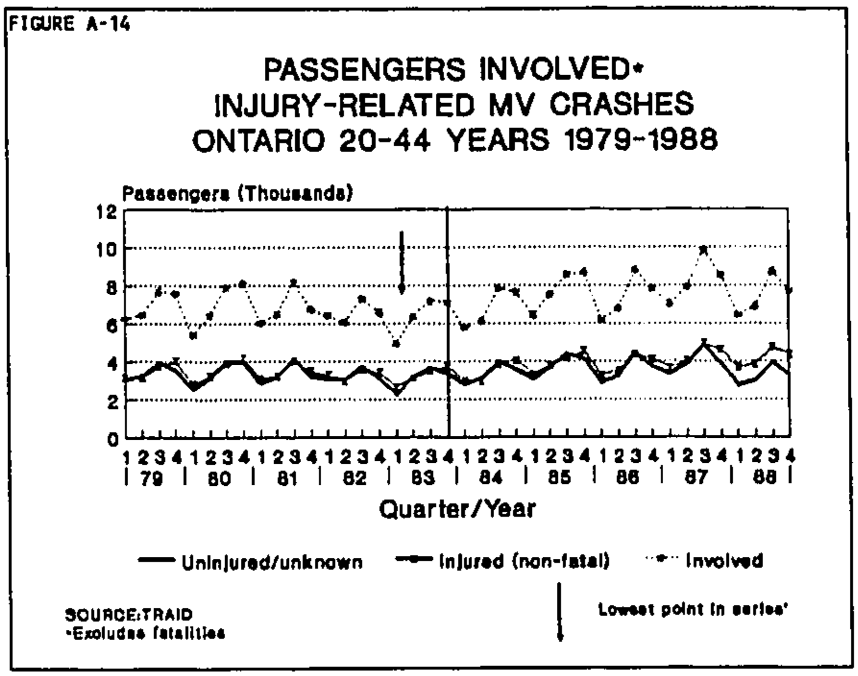
FIGURE A-13

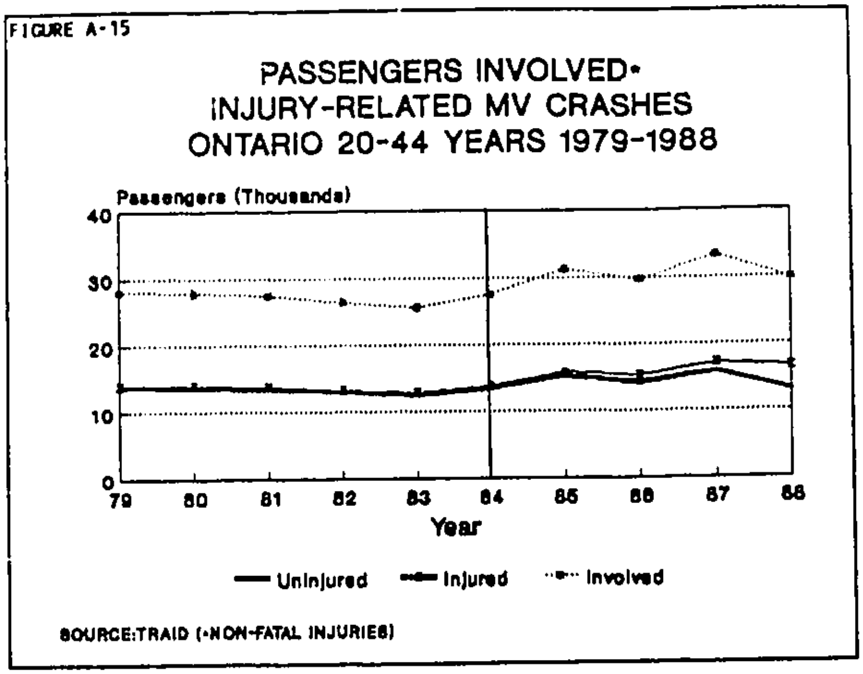


After reaching its lowest year of the study period in 1986, the number of fatalities began to climb sharply, almost attaining its '80 level during the last two years of the study period.

Controls - Non-fatal injuries: The pa·terns in the se..s' for injured and involved controls (Figures A-14 and A-15) were astonishingly similar to those observed for the study group. A decline had occurred from 1979 until 1983 (the first quarter of that year being the lowest quarter each of the three series'), after which time the levels began to rise above the '79 levels.

FIGURE A-14





All ages: **Similar** results to those observed for children and adult controls were observed in the series' of injured, killed and involved passengers of all ages (Figures A-16, A-17, A-18 and A-19).

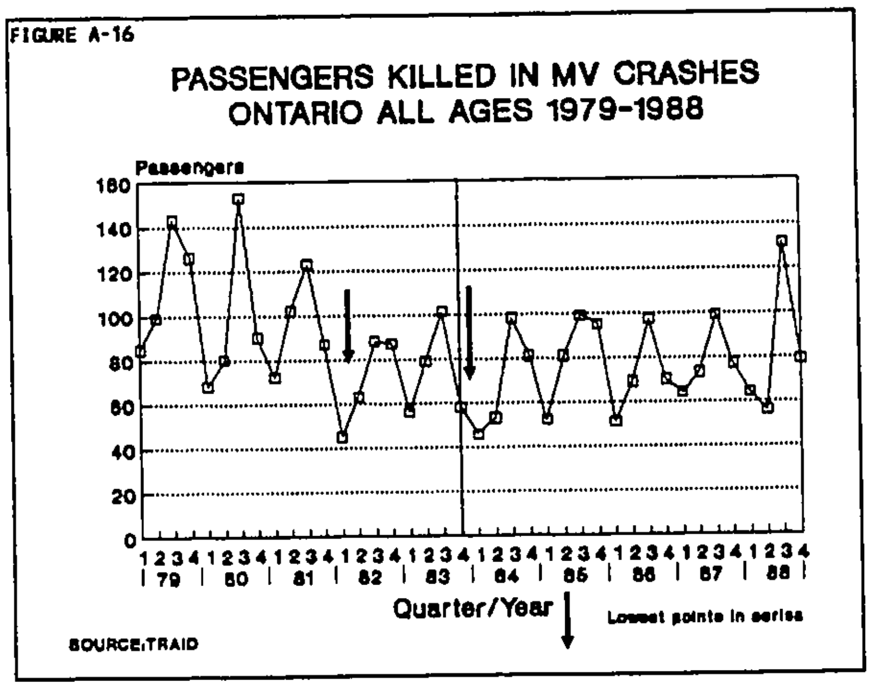
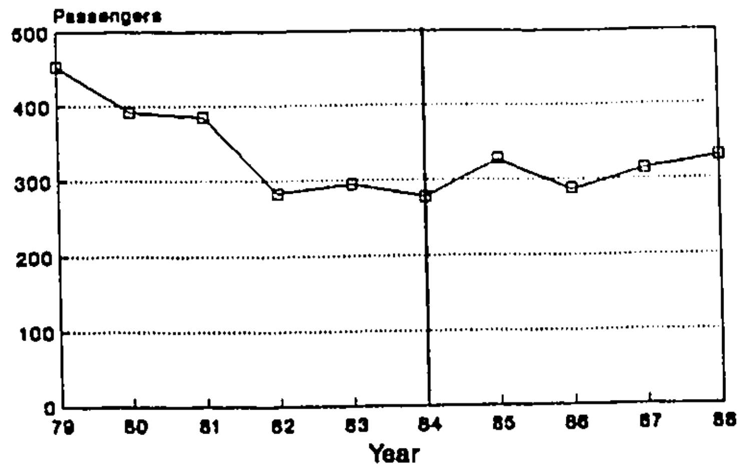


FIGURE A-17

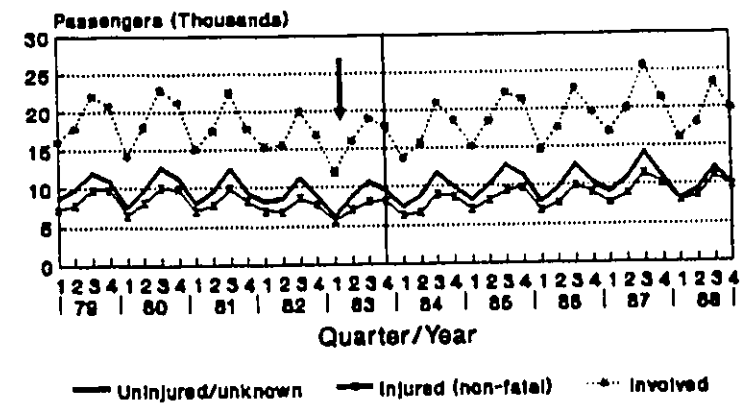
PASSENGERS KILLED IN MV CRASHES ONTARIO ALL AGES 1979-1988



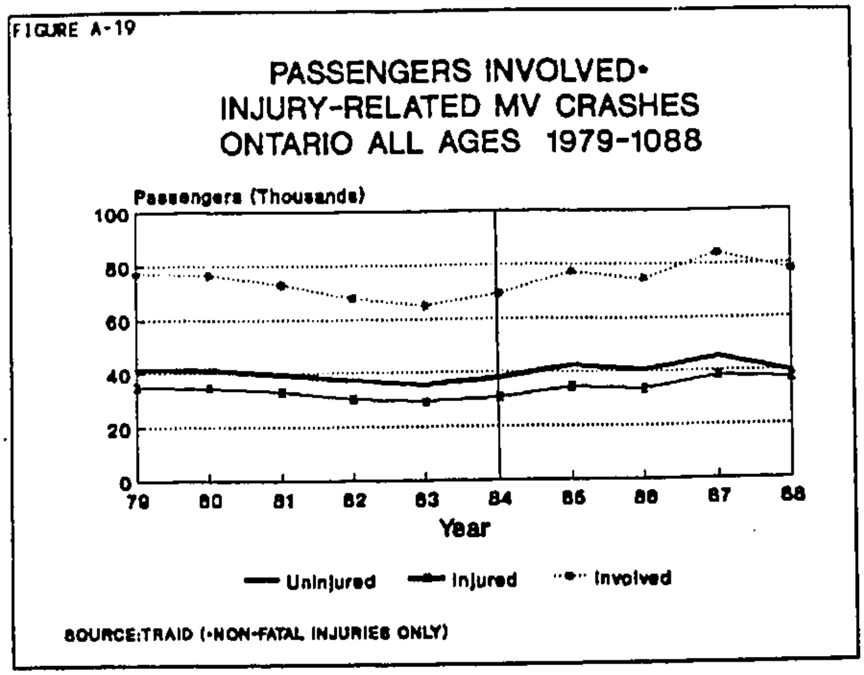
SOURCE:TRAID

FIGURE A-18

PASSENGERS INVOLVED* INJURY-RELATED MV CRASHES ONTARIO ALL AGES 1979-1988



SOURCE:TRAID
*excludes fatalities



A-8.1.3 Gasoline sales

Retail sales of motor gasoline had been falling steadily from 1979 until 1983, when they reached their lowest level in the study period. After that year, sales began to climb slowly, approximating '80 levels by 1988. (Figures A-20 and A-21)

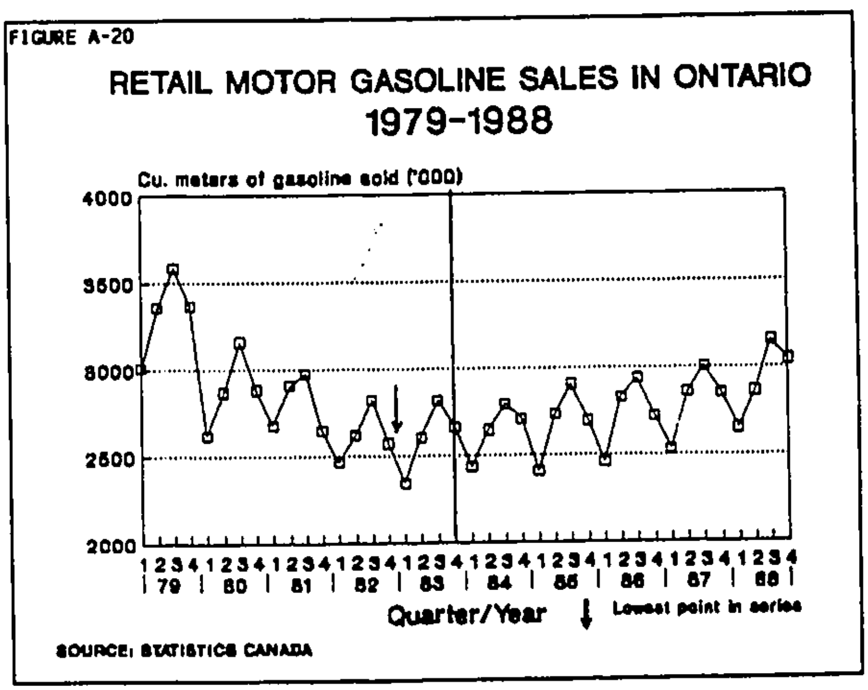
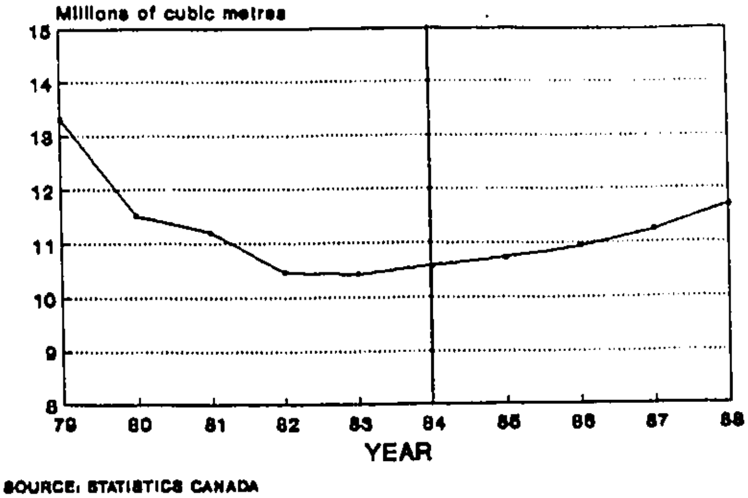


FIGURE A-21

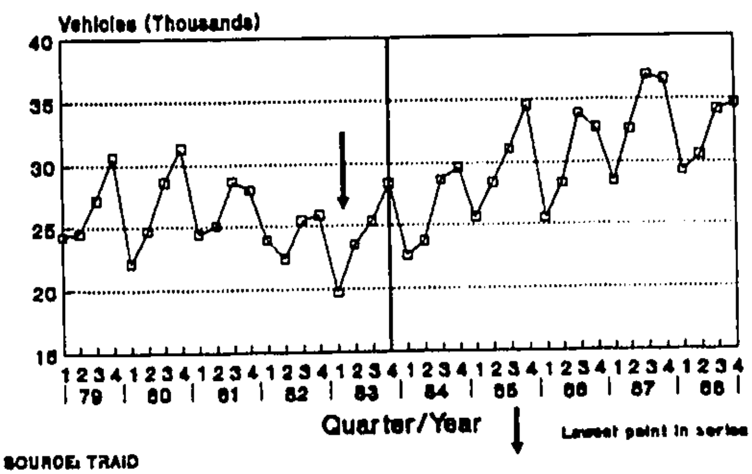
RETAIL SALES OF MOTOR GASOLINE, BY YEAR ONTARIO, 1979-1988

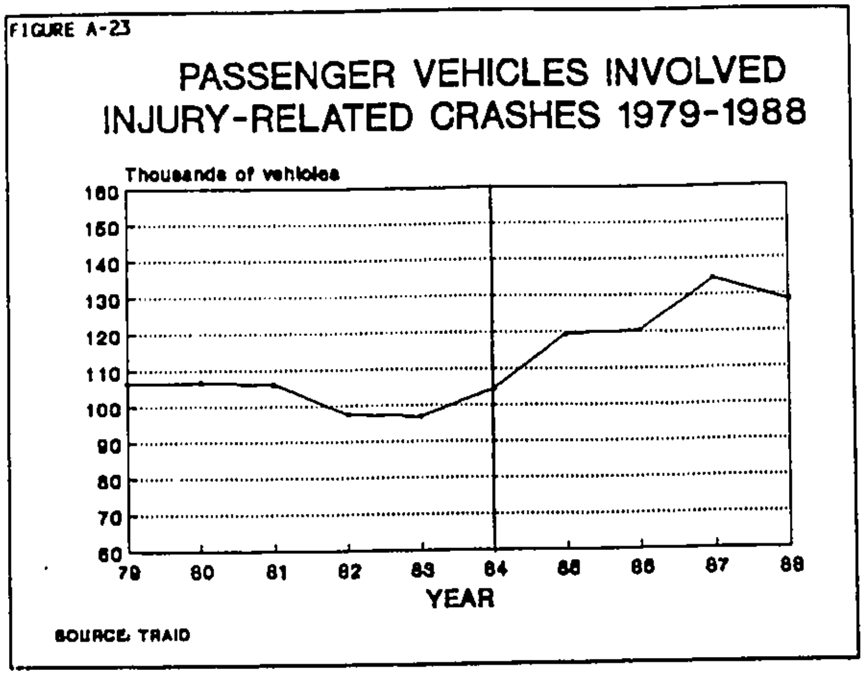


Vehicles involved in injury-related crashes: Since gasoline sales volumes are a proxy for kilometres driven, and hence a proxy for exposure to the risk of being involved in a motor-vehicle crash, one might expect a corresponding pattern in the number of vehicles involved in injury-related crashes. (Figure 22 and 23) However, the rate of increase in the last half of the study period was much greater for involved vehicles than it was for gasoline sales during the corresponding time period. Nevertheless, the first quarter of 1983 represented the lowest quarter in the entire study period for both involved vehicles and sales volume of motor gasoline.

FIGURE A-22

PASSENGER VEHICLES INVOLVED INJURY-RELATED CRASHES ONTARIO 1979-1988





A-8.1.4
Mid-year Population (Figures 24 and 25)

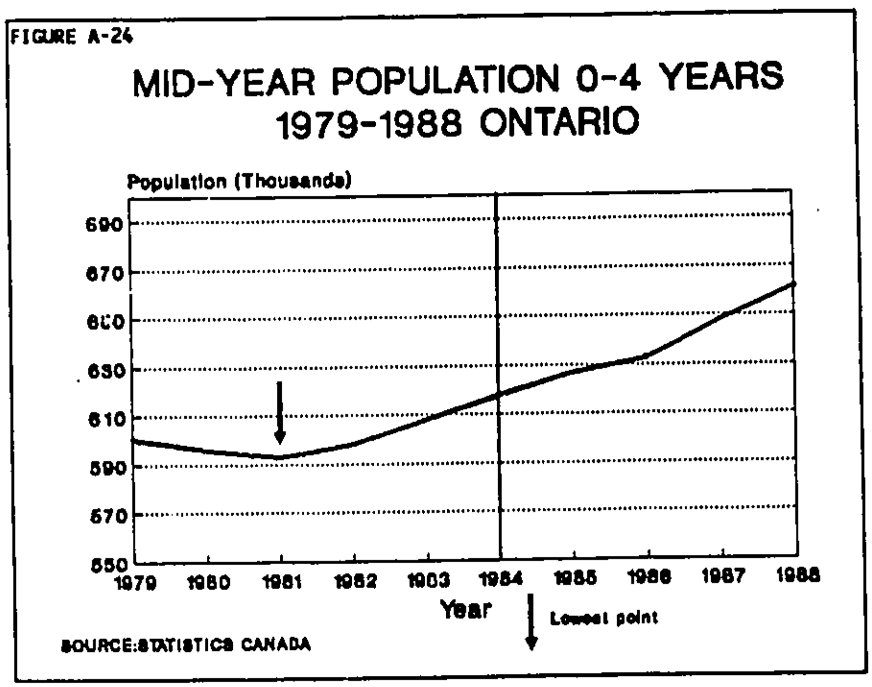
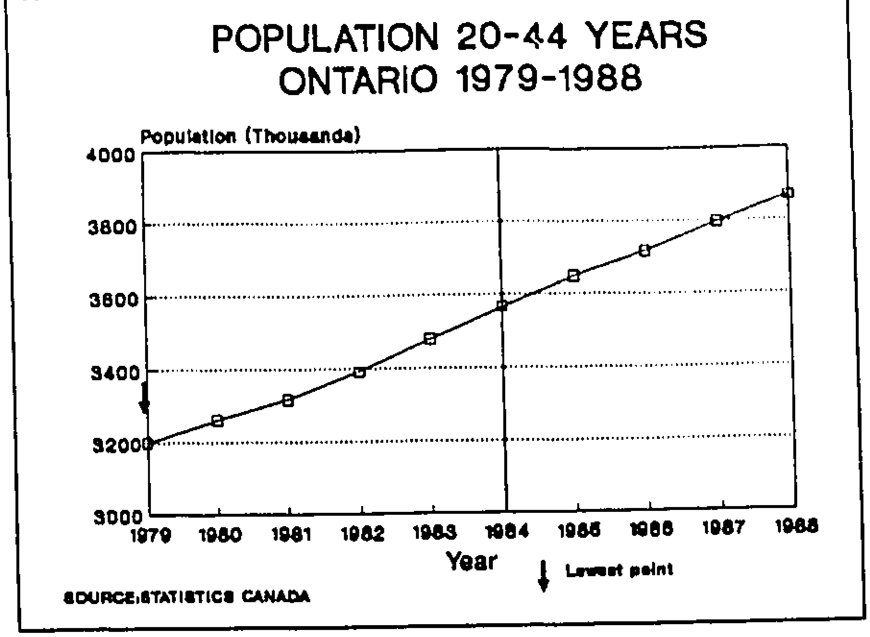


FIGURE A-25

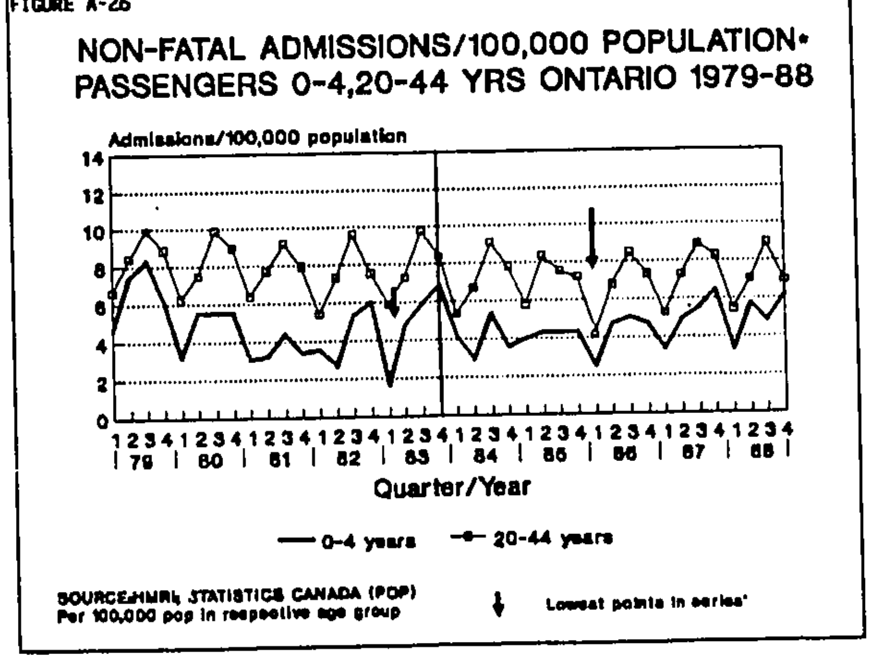


A-8.2 TIME SERIES ANALYSIS OF SUPPLEMENTARY RATES AND INDICATORS

A-8.2.1 Non-fatal admissions/100,000 population

Rate I-4 calculated non-fatal admissions, controlling for the effects of population growth over the ten-year period. (Figures A-24 and A-25)

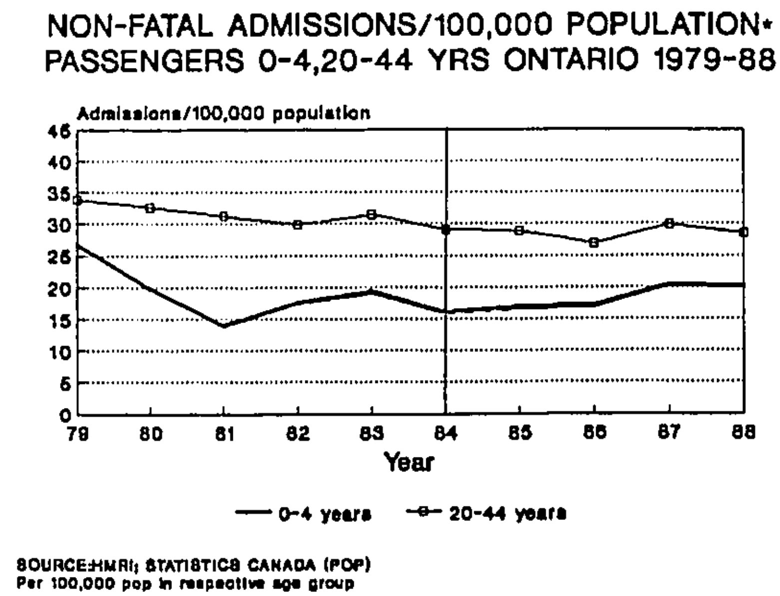
FIGURE A-26



Children: The yearly rate series (Figure A-27) declined from its highest level in 1979 until 1981, reaching its lowest level in the ten-year period. After reaching its first peak in 1983, the rate dropped in 1984, then increased until, in 1987, almost attaining its '83 level. No significant step intervention points) were detected* at in the quarterly series. (Figure A-26)

<u>Controls</u>: Despite the increase in population from 1979 to 1988, the adult yearly rate series for non-fatal admissions per 100,000 population (Figure A-27) declined slightly over the study period, reaching its lowest point in 1986. No significant step changes in level were detected (see Figure A-26).

FIGURE A-27

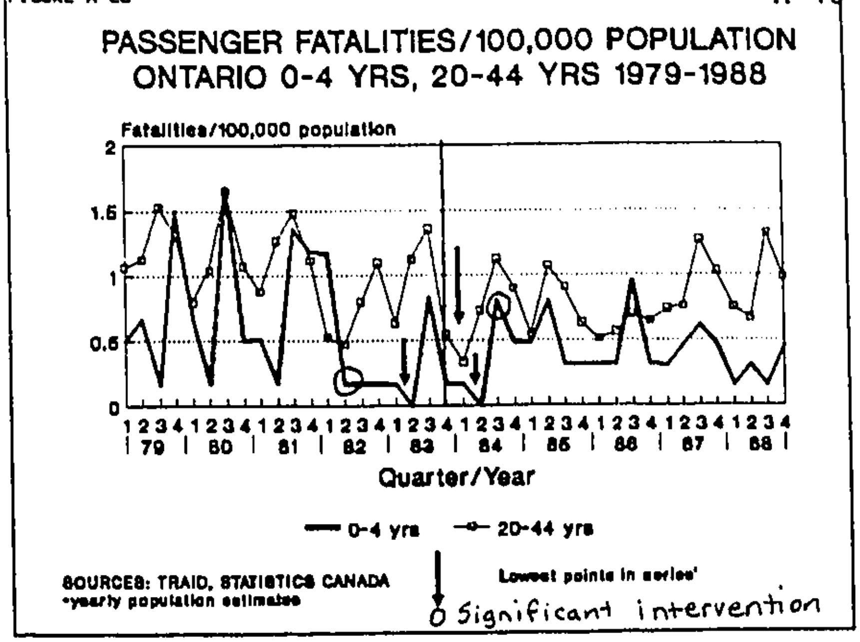


A-8.2.2 Fatalities/100,000 population

Rate I-5 calculated the number of fatalities per quarter, controlling for population growth over the ten-year period. It should be noted that the number of child fatalities per quarter is very small, resulting in a great deal of variability.

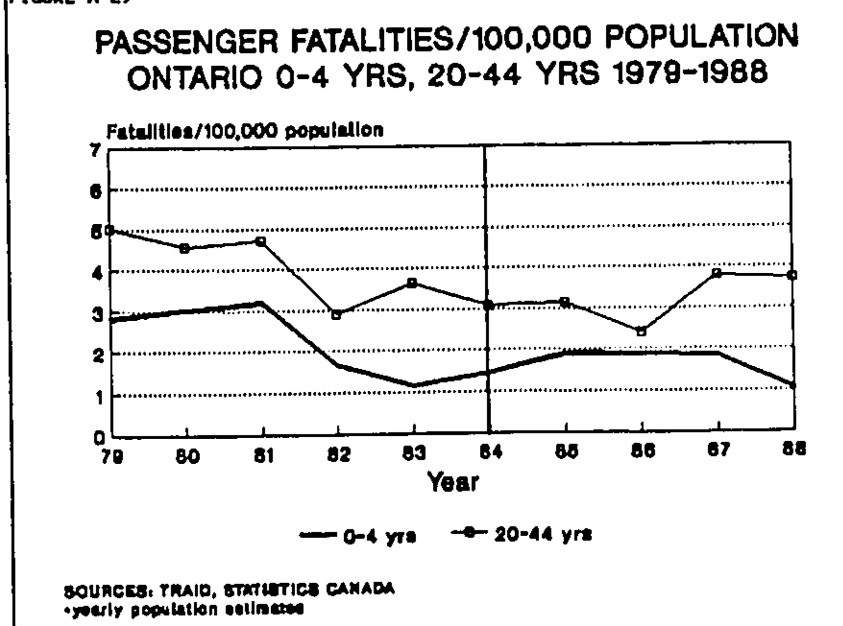
Children: The yearly rate series (Figure A-29) climbed from 1979-1981, reaching its highest level in the ten years. It then climbed to just above its '82 level before reaching a plateau in 1985. The 1988 rate was marginally lower than the '83 rate. The second quarter of 1982 (Figure 28) was detected as a significant **downward** change in level, while the third quarter of 1984 was detected as the beginning of a significant upward change in level.

FIGURE A-28



Controls: There was a downward trend throughout the yearly series (Figure A-29) until 1986, after which the rate began to climb. No significant step intervention points were detected (Figure A-28)

FIGURE A-29



A-8.2.3 Non-fatal admissions / million M^3 of gasoline sold

Rate I-8 calculated the number of non-fatal admissions per quarter, controlling for retail sales of motor gasoline.

Children: The pattern of the yearly (Figure A-31) rate series is strikingly similar to the other rates pertaining to non-fatal admissions. The rate had a downward trend from 1979 until 1981 (the lowest level in the ten-year period), after which time it rose to reach its first peak, in 1983, to a level close to the '79 rate.

(Note that the first quarter of 1983 was the lowest quarter in the quarterly series (Figure A-30) After a slight drop in 1984, the rate began an slight upward trend. No significant step changes in level were detected.

FIGURE A-30

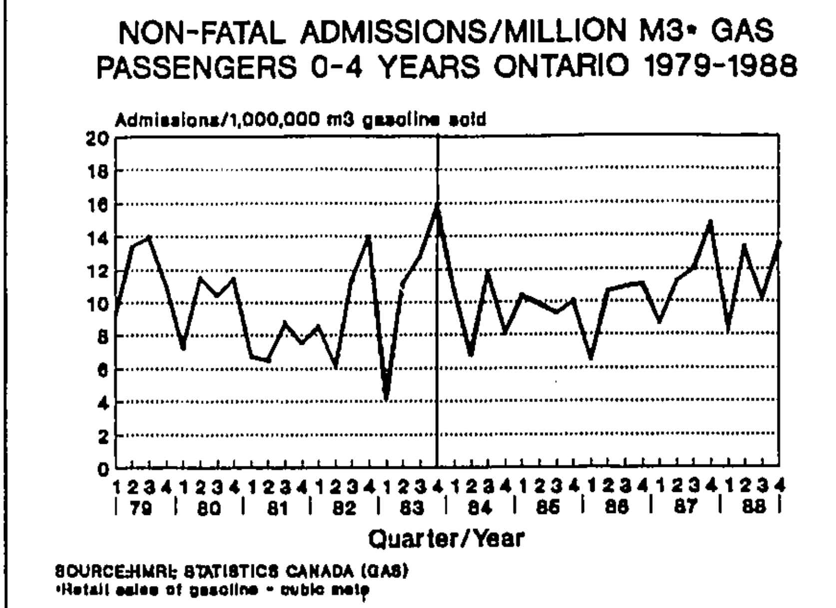
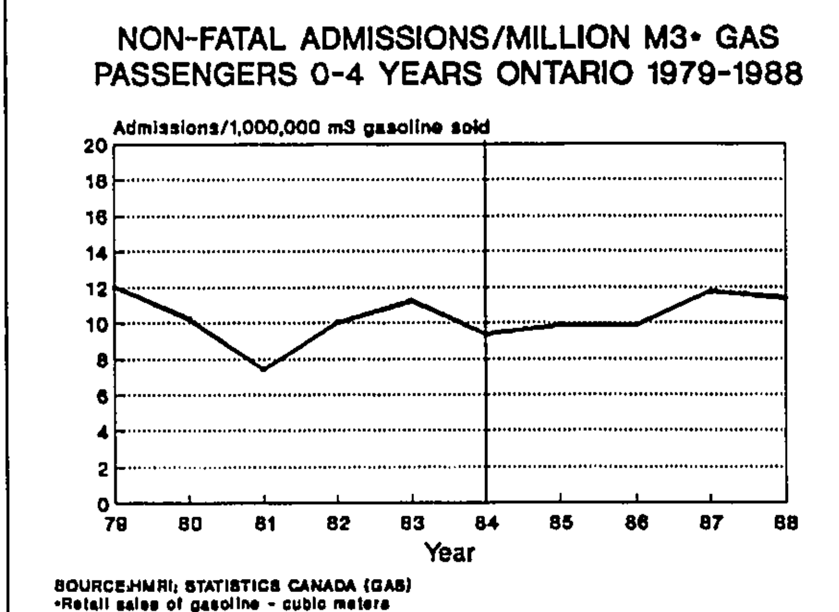
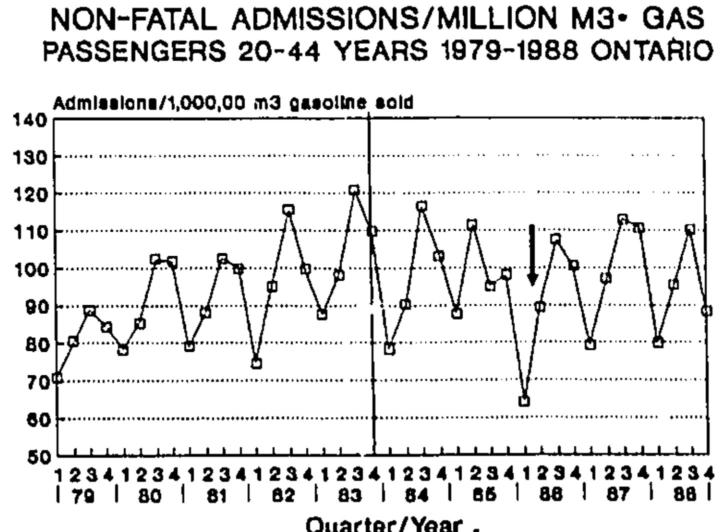


FIGURE A-31



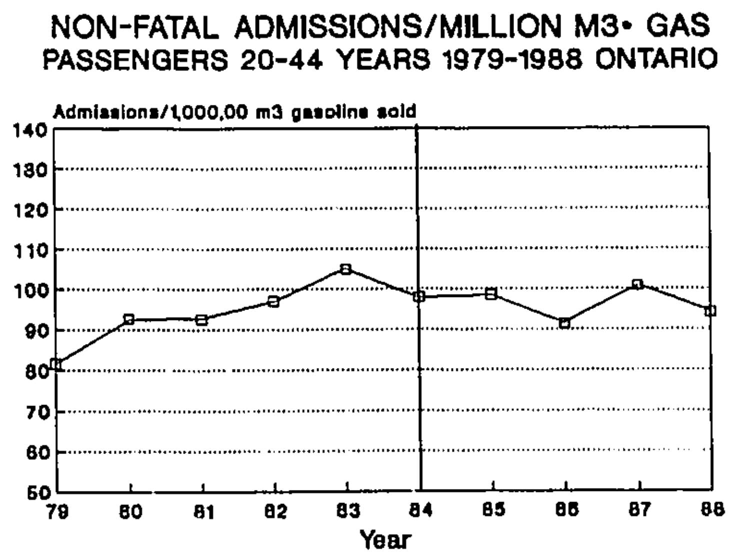
<u>Controls:</u> The yearly rate was lowest in the 1979, after which it rose to its highest level in 1983 (Figure A-33). It then fell until 1986, the second lowest year in the series. No significant step changes in level were detected in the quarterly series (Figure A-32).

FIGURE A-32



SOURCE:HMRI; STATISTICS CANADA (GAS)
•Retail sales of gasoline - cubic meters

FIGURE A-33



SOURCE:HMRI; STATISTICS CANADA (GAS)
•Retail sales of gasoline - cubic meters

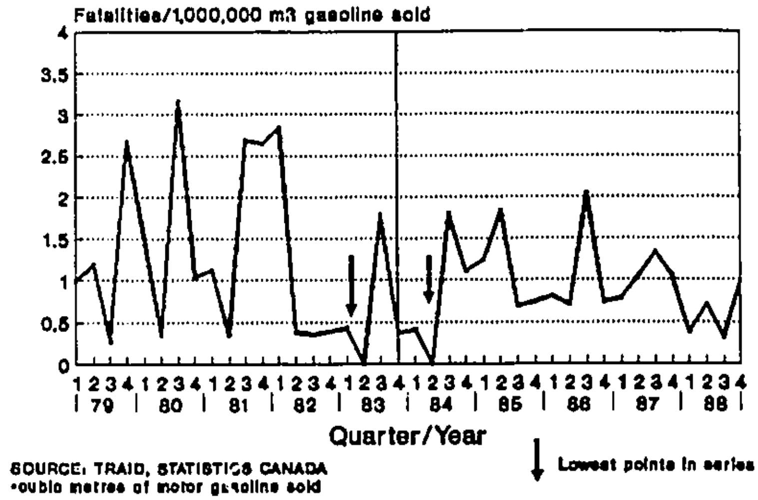
A-8.2.4 Fatalities/million cubic metres of gasoline sold

Rate I-9 calculated the number of fatalities per quarter, controlling for the volume of gasoline sales.

Children: Both the quarterly and yearly rate series' (Figures 34 and 35) are almost identical in shape to the other fatality series'. However, no significant step intervention points were detected.

FIGURE A-34

PASSENGER FATALITIES/ MILLION M3 GAS• ONTARIO 0-4 YEARS OLD 1979-1988



Controls: Both the quarterly and yearly patterns (Figure 36 and 37) of this series, too, strongly resemble the other fatality rates for controls. No significant step intervention points were detected.

FIGURE A-35

PASSENGER FATALITIES/ MILLION M3 GAS• ONTARIO 0-4 YEARS OLD 1979-1988

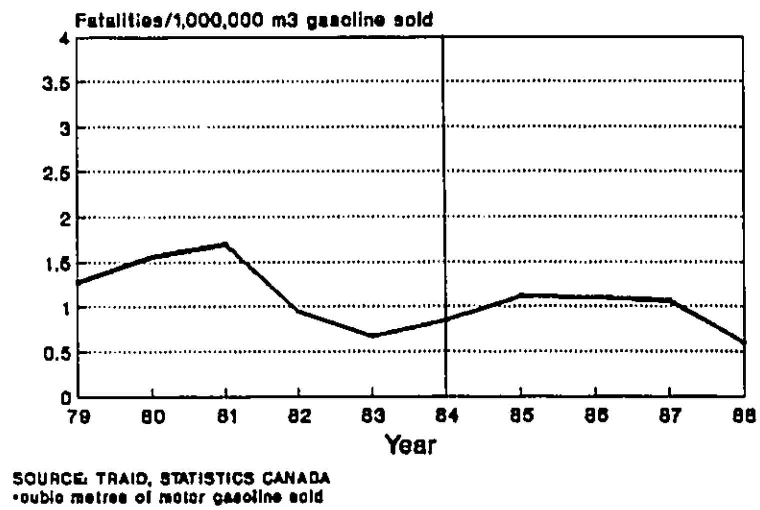


FIGURE A-36

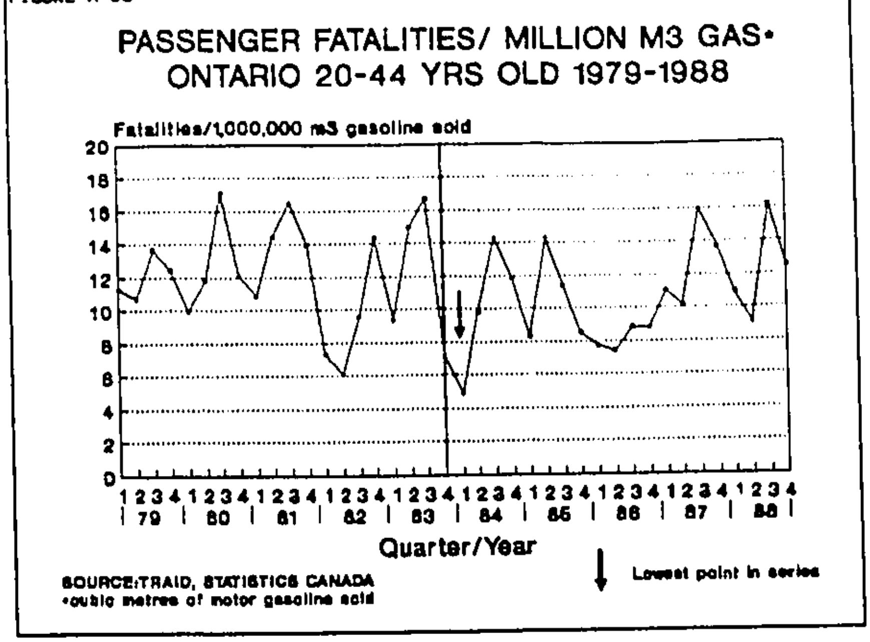
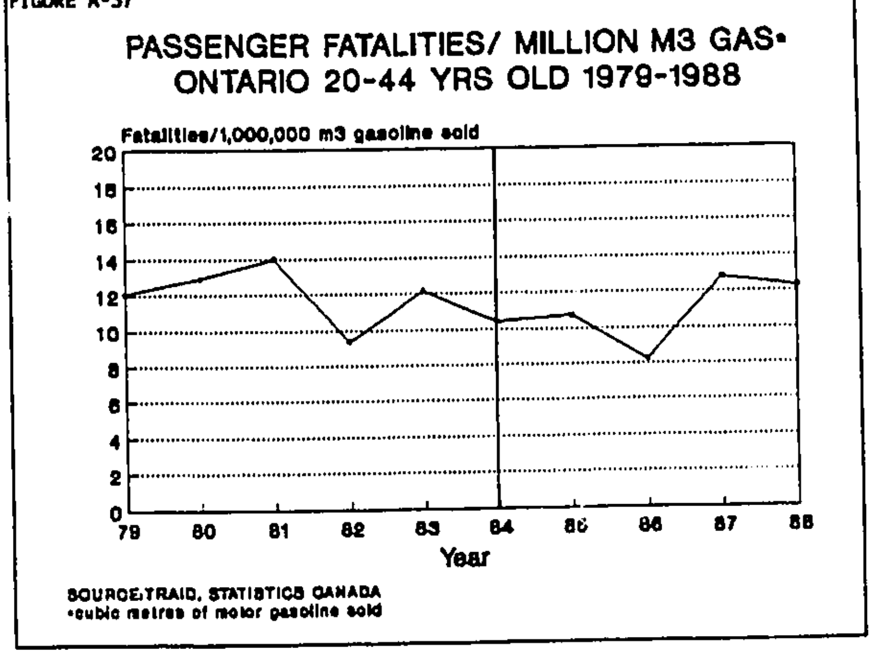


FIGURE A-37



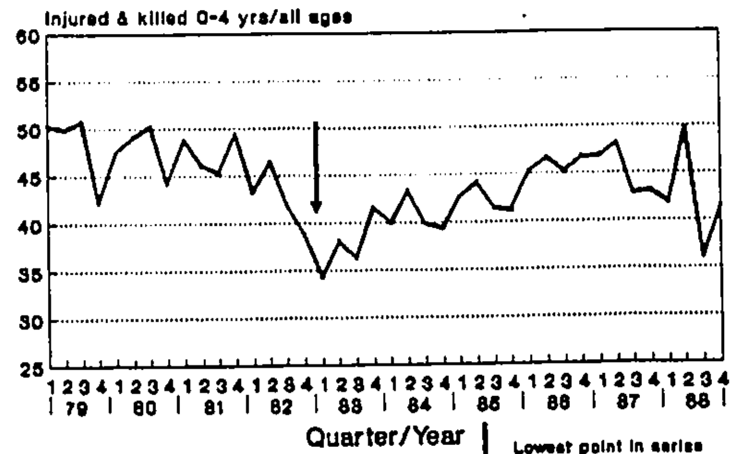
A-8.2.5 Injured or killed/1,000 all ages injured or killed

Rate I-1 calculated the number of children and adult controls who sustained <u>any degree of injury</u> (including minor injury or death) per 1,000 persons of all ages injured or killed.

<u>Children</u>: The yearly rate for children fell dramatically after 1981, reaching its lowest level in 1983 (Figure A-39), i.e., prior to the full inplementation of the legislation. By 1986 it had almost attained its '81 level, before declining again in 1987-1988. No significant step intervention points were detected (Figure A-38).

FIGURE A-38

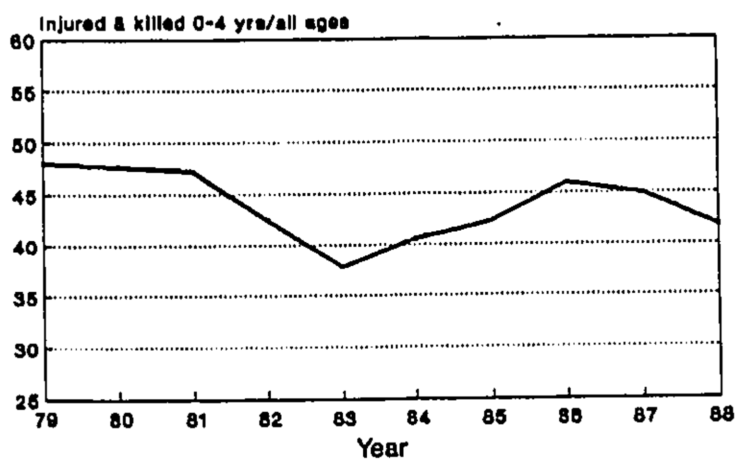
PASSENGERS 0-4 YRS INJURED• AND KILLED PER 1,000 ALL AGES INJURED• AND KILLED



SOURCE:TRAID 1979-1988
•incl.minor injuries (non-hospitalized)

FIGURE A-39

PASSENGERS 0-4 YRS INJURED• OR KILLED PER 1,000 ALL AGES INJURED• OR KILLED

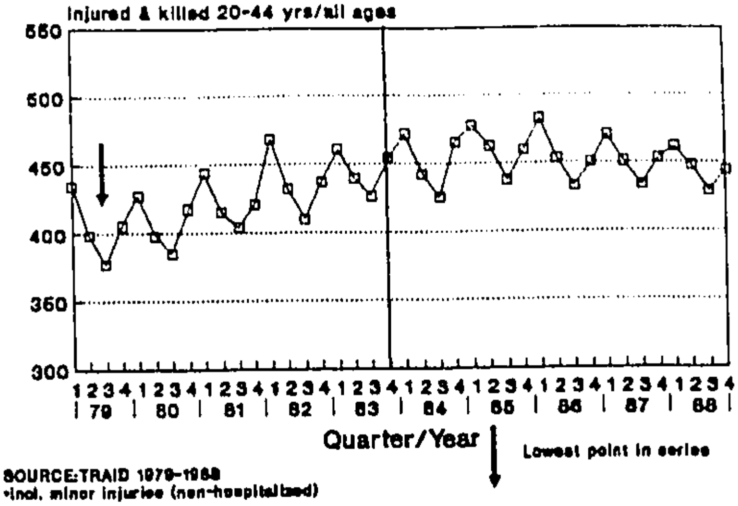


SOURCE:TRAID 1979-1988
•incl.minor injuries (non-hospitalized)

<u>Controls</u>: In contrast, the yearly rate for the adult control group increased steadily from 1979 to 1985 (Figure A-41) and then declined slightly. No significant step intervention points were detected (Figure A-40).

FIGURE A-40

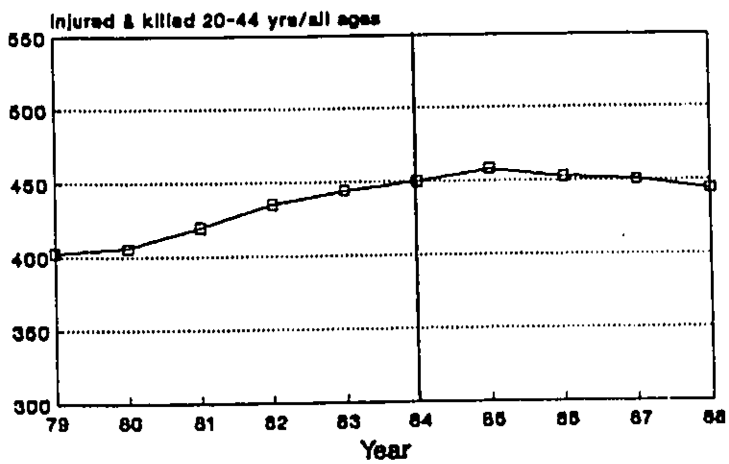
PASSENGERS 20-44 YRS INJURED* AND KILLED PER 1,000 ALL AGES INJURED* AND KILLED



SOURCE:TRAID 1979-1988
*incl. minor injuries (non-hospitalized)

FIGURE A-41

PASSENGERS 20-44 YRS INJURED* OR KILLED PER 1,000 ALL AGES INJURED* OR KILLED



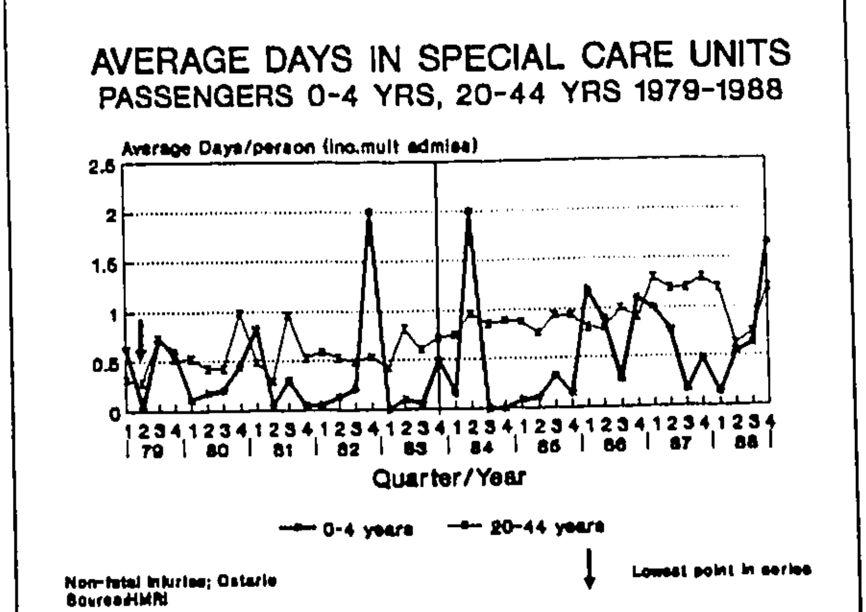
SOURCE:TRAID 1979-1988
*incl. minor injuries (non-hospitalized)

A-8.2.6 Average Days in Intensive Care Units (ICU)

Rate S-3 calculated the average number of days in ICU per non-fatal admissions in each quarter. When multiple admissions occurred for the same individual, the total of ICU days for all admissions were assigned to the quarter in which the first admission took place.

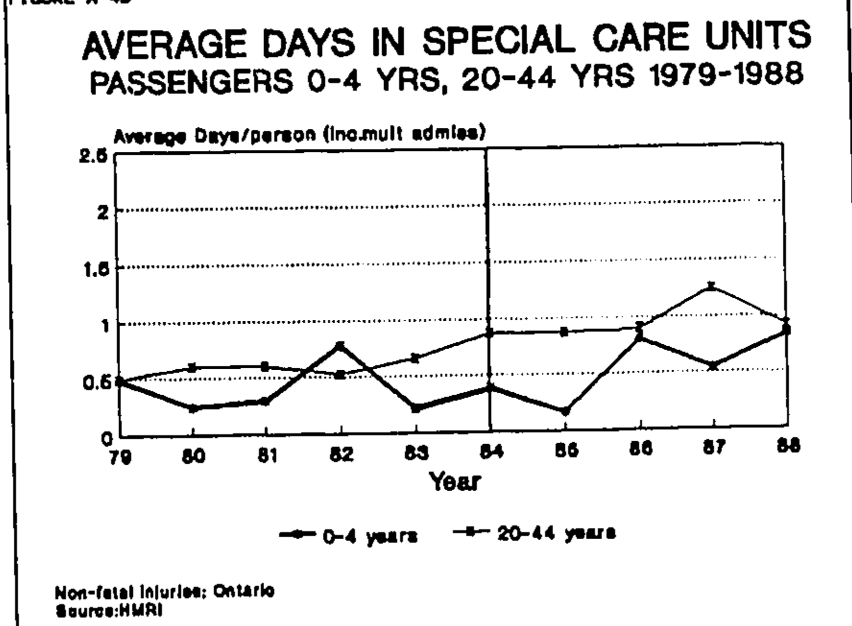
Children: The utilization of special care units was relatively low, many points in the quarterly series (Figure A-42) were at, or close to, zero. The yearly series was relatively stable until 1985 (save for a peak in 1982), then begar. to rise in 1986. (Figure A-43) No significant intervention points were detected.

FIGURE A-42



Controls: This rate slowly increased throughout the ten-year study period. No significant step intervention points were detected. (Figures A-42 and A-43)

FIGURE A-43

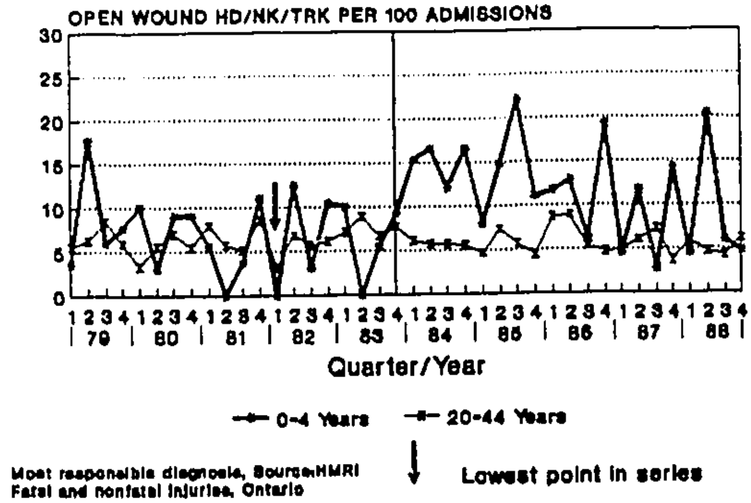


A-8.2.7 Open Wound of Head/Neck/Trunk per 100 admissions

Children: There was a noticeable increase in the overall level of this rate in the post-legislation period (Figures A-44 and A-45). However, no significant step intervention points were detected.

FIGURE A-44

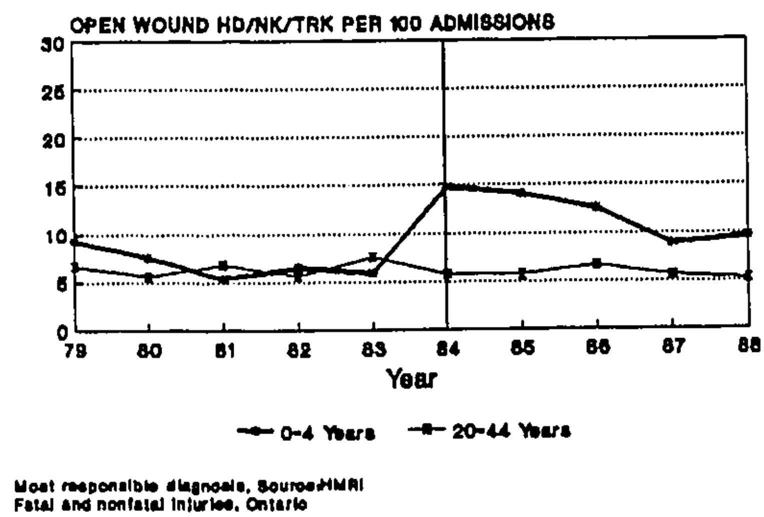
OPEN WOUND HD/NK/TRK PER 100 ADMISSIONS PASSENGERS 0-4 YRS, 20-44 YRS 1979-1988



Controls: The level was constant throughout the ten-year period. No significant step intervention points were detected.(Figures A-44 and A-45)

FIGURE A-45

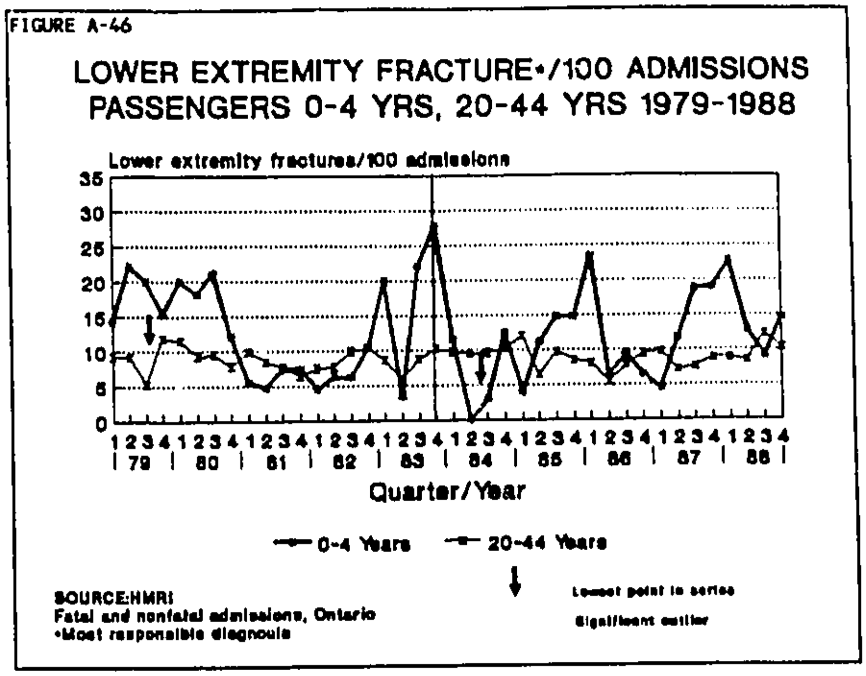
OPEN WOUND HD/NK/TRK PER 100 ADMISSIONS PASSENGERS 0-4 YRS, 20-44 YRS 1979-1988



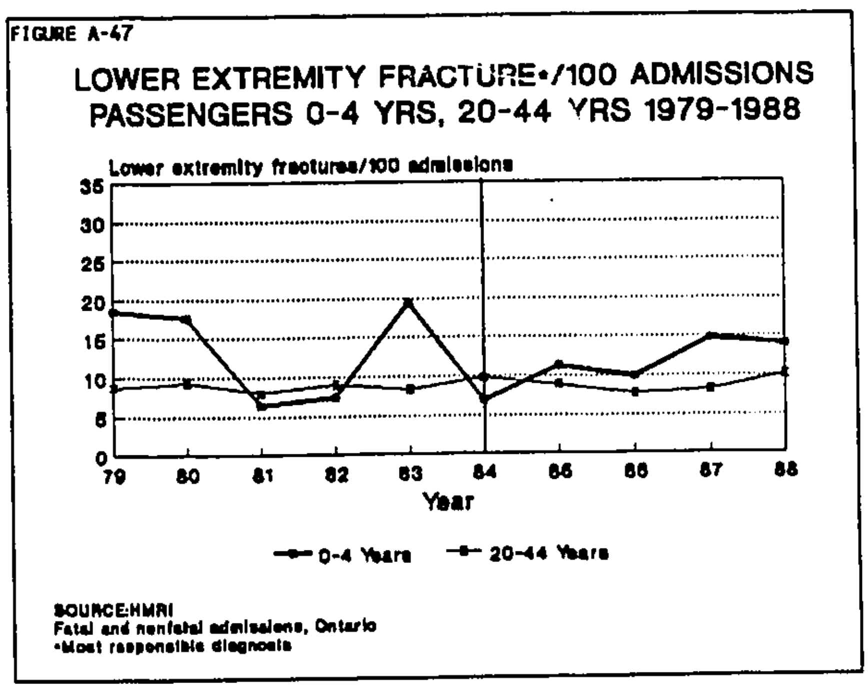
A-8.2.8 Lower extremity fractures per 100 admissions

Children: The yearly rate for lower extremity fractures (Figure A-47) was the most variable of all rates pertaining to nature of injury. Nevertheless, no obvious decrease in the overall post-legislation levels was evident, nor was one detected by time series analysis.

There was marked variability in the quarterly rate series over the ten-year period (Figure A-46). A very steep drop from the highest to the lowest (zero) points occurred between 4/83 and 2/84. No significant step intervention points were detected.

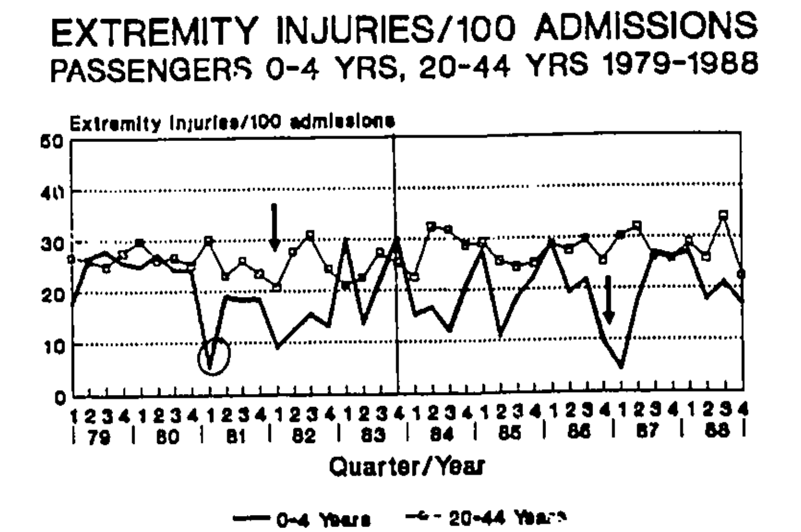


Controls: The variability in both the yearly and quarterly rate series' was much less than in the corresponding series' for children. There was no observable change in the overall post-legislation levels. No significant step intervention points were detected. (Figures A-46 and A-47)



Children: There was a great deal of variability in both the quarterly and yearly series' of this rate (Figures A-48 and A-49). One of the two lowest quarters, namely 1/81, was detected as the beginning of a significant downward change in level (t = -2.47).

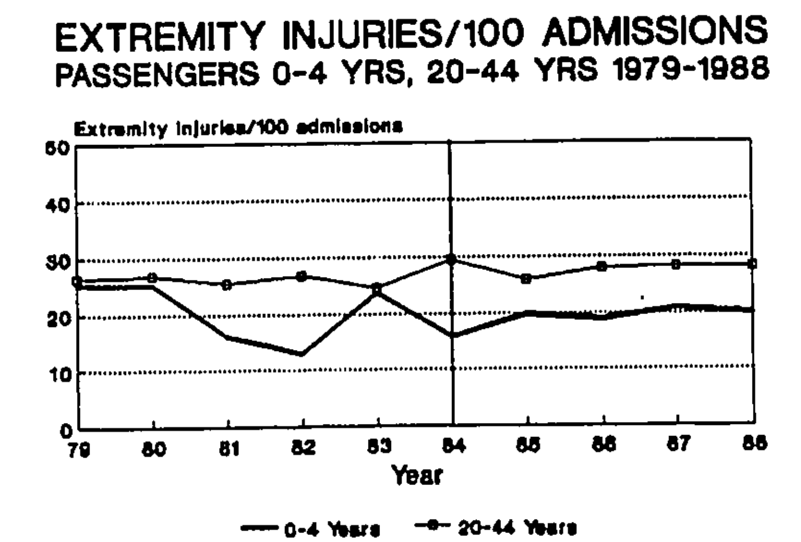
FIGURE A-48



Fatal and nonfatal injuries, Ontario
Source:HMRI

Controls: There was a decreasing trend from 1979 until 1933, after which time there was an observable increase in the level of this rate. However, no significant step intervention points were detected. (Figures A-48 and A-49)

FIGURE A-49



Fatal and nonfatal injuries, Ontario
Source:HMRI

TABLE A-18: RESULTS OF NATIONAL CHILD RESTRAINT USE SURVEYS ONTARIO (CANADA)

	USE OF APPROPRIATE RESTRAINTS (B/A)*	PROPER USE OF APPROPRIATE RESTRAINTS (C/B)*	OVERALL PROPER USE OF APPROPRIATE RESTRAINTS (C/A)*
1985			
< 1 YEAR	91.8% (80.6%)	53.3% (53.9%)	48.9% (43.5%)
1-4 YEARS	45.9% (36.5%)	40.2% (44.4%)	18.5% (16.2%)
TOTAL <5	55.5% (45.4%)	44.7% (47.8%)	24.8% (21.7%)
1987			
< 1 YEAR	90.1% (85.6%)	55.8% (54.2%)	50.3% (46.4%)
1-4 YEARS	71.9% (68.6%)	62.6% (61.8%)	45.0% (44.4%)
TOTAL <5	75.7% (72.3)	60.9% (62.1)	46.1% (44.9%)
1989			
< 1 YEAR	87.2% (85.4%)	33.9% (38.8%)	29.5% (33.1%)
1-4 YEARS	76.7% (66.9%)	61.6% (63.6%)	47.3% (42.5%)
TOTAL <5	78.9% (70.3%)	55.3% (58.1%)	43.6% (40.8%)

* A: ALL CHILDREN 0-4 YEARS WHO WERE SURVEYED, WHETHER OR NOT THEY WERE RESTRAINED

B: ALL CHILDREN WHO WERE USING A RESTRAINT SYSTEM APPROPRIATE TO THEIR AGE, WHETHER OR NOT IT WAS BEING USED PROPERLY

C: ALL CHILDREN WHO WERE USING AN APPROPRIATE RESTRAINT PROPERLY

APPENDIX 10

TABLE A-19: RESTRAINT USE IN CRASH-INVOLVED CHILDREN 0-4 YEARS, BY SEVERITY OF INJURY 1981-1989

YEAR	% OF UNRESTRAINED		% OF RESTRAINED	
	MINIMAL/ MINOR	MAJOR/ FATAL	MINIMAL/ MINOR	MAJOR/ FATAL
1981	93.8	6.2	95.0	5.0
1982	89.5	10.5	93.4	6.6
1983	88.6	11.4	92.7	7.3
1984	90.7	9.2	96.4	3.6
1985	87.9	12.1	95.9	5.1
1986	89.3	10.7	94.8	5.2
1987	91.1	8.9	96.1	3.9

YEAR	TYPE OF RESTRAINT	MAJOR/ FATAL %	MINIMAL /MINOR %	NO INJ %
1988	Child restraint-correct use	23.1	35.3	35.6
	Child restraint-incorrect use	----	----	----
	Lap/lap-shoulder belt	36.1	45.4	38.3
	Not available	7.4	5.9	15.4
	Available/not used	23.2	9.8	3.1
	Unknown	10.2	3.4	7.6

YEAR	TYPE OF RESTRAINT	MAJOR/ FATAL %	MINIMAL MINOR %	NO INJ %
1989	Child restraint-correct use	23.1	33.6	37.3
	Child restraint-incorrect use	3.4	1.9	1.5
	Lap/Lap-shoulder belt	39.3	47.9	39.5
	Not available	9.4	4.0	12.4
	Available/not used	13.7	7.5	3.0
	Unknown	11.1	5.1	6.3

TABLE A-20: ONTARIO SEAT BELT CONVICTIONS 1979-1989

YEAR	DRIVERS	PASSENGERS 16 YRS AND OVER	PASSENGERS < 16 YEARS	TOTAL
1976	7,893	1,652	147	10,534
1977	29,233	4,656	427	35,399
1978	84,317	11,164	700	97,706
1979	63,333	1,073	555	66,198
1980	51,744	7,640	494	60,736
1981	67,242	9,307	622	78,257
1982	74,583	6,159	841	82,777
1983	85,646	6,540	2,447	95,947
1984	59,478	4,134	3,839	68,447
1985	42,223	3,758	3,231	49,809
1986	58,213	3,137	4,790	66,902
1987	64,233	4,679	5,608	75,075
1988	86,019	N/AVAILABLE	7,906	94,691*
1989	106,543	N/AVAILABLE	9,308	116,620*

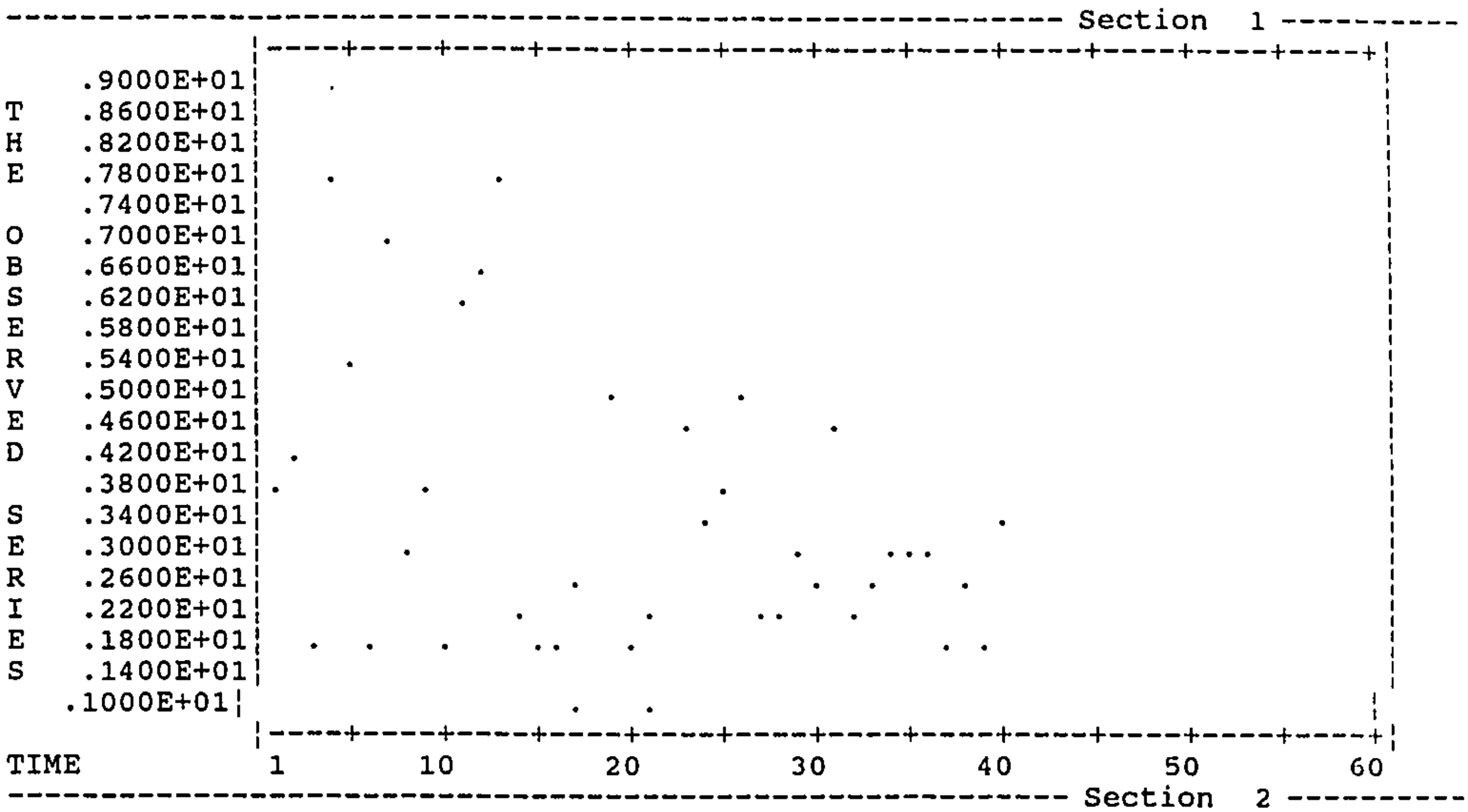
* Totals exclude convictions for passengers 16 years of age and over

APPENDIX 12: THE RESULTS OF AN AUTOBOX SESSION ON 10-25-1991 AT 13:32:11

```
=====================================================================
What is the number of the option that you choose ? ....  1
How many time series are in this analysis ? ..........  1
Filename where output is to be stored ? .............. I-3KID.OUT
=====================================================================
What is the number of the identification option ? .....  3
=====================================================================
Use the same time series as last time ? .............. NO
=====================================================================
INPUT THE TIME SERIES ->
=====================================================================
What is the DOS filename of this file ? .............. I-3KID.PRN
Which one is your first observation ? ................  1
Which one is your last observation ? .................  40
Enter the label/comment for this series .............. 0-4 FATALITIES/1,000
INVOLVED
What is the Periodicity of your data ? ..............  4
=====================================================================
TIME SERIES 0-4 FATALITIES/1,000 INVOLVED
=====================================================================
 3.7  4.12  1.65  7.76  5.28
 1.84  7.17  3.17  3.87  1.88
 6.39  6.4  7.82  2.05  1.84
 1.98  2.47  1  5.08  1.84
 2.04  1  4.44  3.2  3.81
 4.85  2.25  2.21  2.8  2.41
 4.59  2.22  2.51  2.85  3.06
 2.85  1.89  2.44  1.71  3.23
SCALE FACTORS:  DIVISOR =  1  ADDITIVE =  1
=====================================================================
Use the default specifications ? .................... YES
=====================================================================
=====================================================================
Use filtering strategy #1: filter series by ARIMA model.YES
Use filtering strategy #2: bypass initial filtering.....NO
Specify the form of the initial ARIMA filter...........NO
=====================================================================
Confidence level for intervention detection............95
Suppress the inclusion of pulse variables..............NO
Suppress the inclusion of step variables...............NO
Suppress the inclusion of seasonal pulse variables......YES
Filename where program will store the adjusted series...NUL.ADJ
=====================================================================
Plot the time series observations......................YES
Display the noise series ARIMA model development processYES
Display the transfer function model development process.YES
Number of autocorrelations to compute..................12
Search for the optimal transformation (lambda value)....YES
Use backcasting in the final estimation................YES
=====================================================================
Display the autocorrelations in tabular form...........YES
Plot the autocorrelations..............................YES
Display the significant autocorrelations...............YES
```

```
Display the partial autocorrelations in tabular form....YES
Plot the partial autocorrelations.......................YES
Display the significant partial autocorrelations........YES
=====================================================================
Move to transfer function modeling after identification.YES
Filename where the program will store the fit values....NUL.FIT
Filename where the program will store the model form....NUL.TFM
Create a data file for each intervention variable.......YES
```

PLOT OF THE ORIGINAL TIME SERIES



AUTOMATIC INTERVENTION DETECTION : USING FILTERING STRATEGY #1

AUTOBOX will now build an ARIMA model for the original series. This model will be used to filter the original series in order to examine the residuals for potential interventions.

TIME SERIES IDENTIFICATION

AUTOBOX WILL NOW PERFORM A LAMBDA SEARCH FOR THE ORIGINAL SERIES

IMPACT OF THE LAMBDA VALUE ON THE BOX-COX ERROR SUM OF SQUARES

	LAMBDA	ERROR SUM OF SQUARES	
INITIAL LAMBDA VALUE ->	1.000	.126428E+03	
	-1.000	.115376E+03	
	-.500	.928994E+02	
	.000	.885975E+02	<- OPTIMAL LAMBDA VALUE
	.500	.988658E+02	
	1.000	.126428E+03	

SINCE THE LAMBDA OF .000 GIVES THE LOWEST ERROR SUM OF SQUARES, AUTOBOX WILL APPLY THIS LAMBDA TO THE ORIGINAL SERIES.

Section 3

AUTOBOX WILL EXAMINE THE AUTOCORRELATIONS AND THE PARTIAL AUTOCORRELATIONS IN ORDER TO DETERMINE THE APPROPRIATE LEVEL OF DIFFERENCING REQUIRED. THE PATTERN IN THE ACF AND THE PACF ALSO TELL AUTOBOX ABOUT THE TYPE OF PARAMETERS NEEDED

Section 4

THE ORIGINAL SERIES HAS BEEN TRANSFORMED : DATA = LN(Z(T))

MEAN OF THE ORIGINAL SERIES	:	.10766E+01
STANDARD DEVIATION	:	.50715E+00
NUMBER OF OBSERVATIONS	:	40
MEAN DIVIDED BY STANDARD ERROR	:	.13425E+02

THE AUTOCORRELATIONS

LAGS 1- 8	-.015	.126	-.036	.111	-.055	.100	.052	.033
STANDARD ERROR	(.158)	(.158)	(.161)	(.161)	(.163)	(.163)	(.165)	(.165)
LAGS 9- 12	-.233	-.082	-.137	.246				
STANDARD ERROR	(.165)	(.173)	(.174)	(.177)				

-- Section 5 ----------

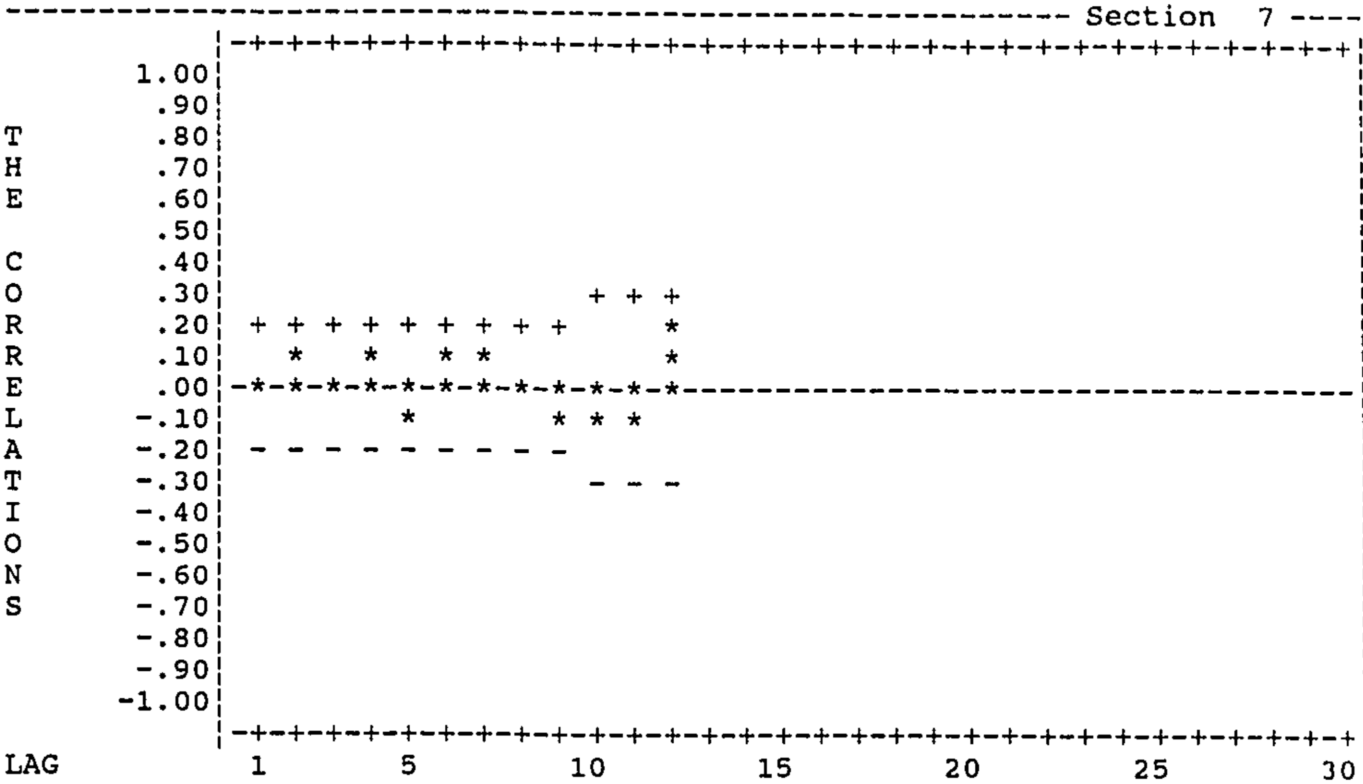
T-TEST FOR SIGNIFICANCE AT EACH LAG :

THERE ARE 0 AUTOCORRELATIONS SIGNIFICANT AT 1.450 SIGMA.

-- Section 6 ----------

PLOT OF THE AUTOCORRELATIONS

-- Section 7 ----------



-- Section 8 ----------

THE PARTIAL AUTOCORRELATIONS

LAGS 1- 8	-.015	.126	-.033	.096	-.046	.076	.073	.000
STANDARD ERROR	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)

LAGS 9- 12	-.240	-.114	-.100	.282
STANDARD ERROR	(.158)	(.158)	(.158)	(.158)

-- Section 9 ----------

AUTOBOX IDENTIFIES 2 PARTIAL AUTOCORRELATIONS OUTSIDE 1.450 SIGMA.
LAGS: 9, 12,

```
------------------------------------------------------------ Section 10 ----------
                    PLOT OF THE PARTIAL AUTOCORRELATIONS
                    ------------------------------------
------------------------------------------------------------ Section 11 ----------
           |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
       1.00|                                                            |
        .90|                                                            |
T       .80|                                                            |
H       .70|                                                            |
E       .60|                                                            |
        .50|                                                            |
C       .40|                                                            |
O       .30|                       *                                    |
R       .20| + + + + + + + + + + + +                                    |
R       .10|   *   *   * *         *                                    |
E       .00|-*-*-*-*-*-*-*-*-*-*-*-*------------------------------------|
L      -.10|                 * * *                                      |
A      -.20| - - - - - - - - - - - -                                    |
T      -.30|                                                            |
I      -.40|                                                            |
O      -.50|                                                            |
N      -.60|                                                            |
S      -.70|                                                            |
       -.80|                                                            |
       -.90|                                                            |
      -1.00|                                                            |
           |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
LAG          1       5         10        15        20        25        30
------------------------------------------------------------ Section 12 ----------

       IMPACT OF THE LAMBDA VALUE ON THE BOX-COX ERROR SUM OF SQUARES
       ==============================================================

                              LAMBDA    ERROR SUM OF SQUARES

 INITIAL LAMBDA VALUE ->       .000          .885975E+02

                             -1.000          .115376E+03
                              -.500          .928994E+02
                               .000          .885975E+02 <- OPTIMAL LAMBDA VALUE
                               .500          .988658E+02
                              1.000          .126428E+03

       SINCE THE LAMBDA OF   .000 GIVES THE LOWEST ERROR SUM OF
       SQUARES, AUTOBOX WILL APPLY THIS LAMBDA TO THE ORIGINAL SERIES.
```

-- Section 13 ----------

ESTIMATION OF THE TENTATIVELY IDENTIFIED MODEL FORM
===

****

DATA :   Z = 0-4 FATALITIES/1,000 INVOLVED   40 OBSERVATIONS

MODEL DEVELOPED WITH TRANSFORMED DATA = LN(Z)

DIFFERENCING FACTORS : NONE

BACKCASTING : OFF

****

UNIVARIATE MODEL PARAMETERS

****

FACTOR	LAG	COEFFICIENT	T RATIO
1 MEAN		.10766E+01	13.26

****

-- Section 14 ----------

THE RESIDUAL AND MODEL STATISTICS
=================================

(IN TERMS OF THE ORIGINAL DATA)

SUM OF SQUARES :	.13306E+03	DEGREES OF FREEDOM :	39
MEAN SQUARE :	.34118E+01	NUMBER OF RESIDUALS :	40
R SQUARED :	.00000E+00		

-- Section 15 ----------

THE RESIDUAL AND MODEL STATISTICS
=================================

(IN TERMS OF THE TRANSFORMED DATA)

SUM OF SQUARES :	.10288E+02	DEGREES OF FREEDOM :	39
MEAN SQUARE :	.26380E+00	NUMBER OF RESIDUALS :	40
R SQUARED :	.00000E+00		

-- Section 16 ----------

THE RESIDUAL AUTOCORRELATION ANALYSIS
=====================================

MEAN OF THE RESIDUAL SERIES	:	.67055E-07
STANDARD DEVIATION	:	.50715E+00
NUMBER OF OBSERVATIONS	:	40
MEAN DIVIDED BY STANDARD ERROR	:	.83623E-06

THE AUTOCORRELATIONS

LAGS 1- 8	-.015	.126	-.036	.111	-.055	.100	.052	.033
STANDARD ERROR	(.158)	(.158)	(.161)	(.161)	(.163)	(.163)	(.165)	(.165)
LAGS 9- 12	-.233	-.082	-.137	.246				
STANDARD ERROR	(.165)	(.173)	(.174)	(.177)				

-- Section 17 ----------

T-TEST FOR SIGNIFICANCE AT EACH LAG :

THERE ARE 0 AUTOCORRELATIONS SIGNIFICANT AT 1.450 SIGMA.

-- Section 18 ----------

PLOT OF THE AUTOCORRELATIONS

-- Section 19 ----------

```
           |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
       1.00|                                                            |
        .90|                                                            |
T       .80|                                                            |
H       .70|                                                            |
E       .60|                                                            |
        .50|                                                            |
C       .40|                                                            |
O       .30|                   + + +                                    |
R       .20| + + + + + + + + +     *                                    |
R       .10|   *   *   * *         *                                    |
E       .00|-*-*-*-*-*-*-*-*-*-*-*-*------------------------------------|
L      -.10|         *       * * *                                      |
A      -.20| - - - - - - - - -                                          |
T      -.30|                   - - -                                    |
I      -.40|                                                            |
O      -.50|                                                            |
N      -.60|                                                            |
S      -.70|                                                            |
       -.80|                                                            |
       -.90|                                                            |
      -1.00|                                                            |
           |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
LAG          1       5        10        15        20        25        30
```

-- Section 20 ----------

THE DIAGNOSTIC CHECKS
====================

1) NECESSITY CHECK : ALL OF THE PARAMETERS ARE STATISTICALLY SIGNIFICANT.

2) INVERTIBILITY CHECK : ALL OF THE PARAMETERS ARE INVERTIBLE.

3) SUFFICIENCY TEST : AUTOBOX ADDED A SEASONAL FACTOR TO THE MODEL.

-- Section 21 ----------

ESTIMATION OF THE TENTATIVELY IDENTIFIED MODEL FORM
===

****

DATA : Z = 0-4 FATALITIES/1,000 INVOLVED 40 OBSERVATIONS

MODEL DEVELOPED WITH TRANSFORMED DATA = LN(Z)

DIFFERENCING FACTORS : NONE

BACKCASTING : OFF

****

UNIVARIATE MODEL PARAMETERS

****

	FACTOR	LAG	COEFFICIENT	T RATIO
1	MEAN		.11064E+01	11.69
2	MOVING AVERAGE 1	12	-.23165E+00	-1.69

****

-- Section 22 ----------

THE RESIDUAL AND MODEL STATISTICS
=================================

(IN TERMS OF THE ORIGINAL DATA)

SUM OF SQUARES	: .12487E+03	DEGREES OF FREEDOM	:	38
MEAN SQUARE	: .32860E+01	NUMBER OF RESIDUALS	:	40
R SQUARED	: .12347E-01			

-- Section 23 ----------

THE RESIDUAL AND MODEL STATISTICS
=================================

(IN TERMS OF THE TRANSFORMED DATA)

SUM OF SQUARES	: .95817E+01	DEGREES OF FREEDOM	:	38
MEAN SQUARE	: .25215E+00	NUMBER OF RESIDUALS	:	40
R SQUARED	: .68660E-01			

-- Section 24 ---------

THE RESIDUAL AUTOCORRELATION ANALYSIS

MEAN OF THE RESIDUAL SERIES	:	-.28253E-01
STANDARD DEVIATION	:	.48861E+00
NUMBER OF OBSERVATIONS	:	40
MEAN DIVIDED BY STANDARD ERROR	:	.36571E+00

THE AUTOCORRELATIONS

LAGS 1- 8	.073	.184	.027	.123	-.063	.077	.022	.020
STANDARD ERROR	(.158)	(.159)	(.164)	(.164)	(.167)	(.167)	(.168)	(.168)

LAGS 9- 12	-.277	-.162	-.157	-.002
STANDARD ERROR	(.168)	(.179)	(.183)	(.186)

-- Section 25 ---------

T-TEST FOR SIGNIFICANCE AT EACH LAG :

AUTOBOX IDENTIFIES 1 AUTOCORRELATIONS OUTSIDE 1.450 SIGMA.
LAGS: 9,

-- Section 26 ---------

PLOT OF THE AUTOCORRELATIONS

-- Section 27 ---------

```
          |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
      1.00|                                                            |
       .90|                                                            |
T      .80|                                                            |
H      .70|                                                            |
E      .60|                                                            |
       .50|                                                            |
C      .40|                                                            |
O      .30|                   + + +                                    |
R      .20| + + + + + + + + +                                          |
R      .10| * *   *   *                                                |
E      .00|-*-*-*-*-*-*-*-*-*-*-*-*------------------------------------|
L     -.10|         *       * * *                                      |
A     -.20| - - - - - - - - - * *                                      |
T     -.30|                 * - - -                                    |
I     -.40|                                                            |
O     -.50|                                                            |
N     -.60|                                                            |
S     -.70|                                                            |
      -.80|                                                            |
      -.90|                                                            |
     -1.00|                                                            |
          |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
LAG         1       5        10        15        20        25        30
```

-- Section 28 ----------

THE DIAGNOSTIC CHECKS

1) NECESSITY CHECK : ALL OF THE PARAMETERS ARE STATISTICALLY SIGNIFICANT.

2) INVERTIBILITY CHECK : ALL OF THE PARAMETERS ARE INVERTIBLE.

3) SUFFICIENCY TEST : NO MORE PARAMETERS ARE NEEDED.

-- Section 29 ----------

AUTOBOX WILL NOW EXAMINE THE ALTERNATIVE LAMBDA VALUES (FOR THE LAST TIME) IN ORDER TO DETERMINE THE OPTIMAL LAMBDA FOR THE IDENTIFIED MODEL. THE CRITERION USED IN THIS TEST IS THE BOX-COX ERROR SUM OF SQUARES.

IMPACT OF THE LAMBDA VALUE ON THE BOX-COX ERROR SUM OF SQUARES

	LAMBDA	ERROR SUM OF SQUARES	
INITIAL LAMBDA VALUE ->	.000	.825111E+02	
	-1.000	.109218E+03	
	-.500	.865502E+02	
	.000	.825111E+02	<- OPTIMAL LAMBDA VALUE
	.500	.932752E+02	
	1.000	.121450E+03	

SINCE THE LAMBDA OF .000 GIVES THE LOWEST ERROR SUM OF SQUARES, AUTOBOX WILL APPLY THIS LAMBDA TO THE ORIGINAL SERIES.

-- Section 30 ----------

CORRELATION MATRIX OF THE PARAMETERS

	1	2
1	1.0000	
2	-.0630	1.0000

-- Section 31 ----------

FINAL ESTIMATION OF THE MODEL

(CONCLUDES THIS PHASE OF MODEL IDENTIFICATION)

```
*******************************************************************
DATA :    Z = 0-4 FATALITIES/1,000 INVOLVED        40 OBSERVATIONS

MODEL DEVELOPED WITH TRANSFORMED DATA = LN(  Z)

DIFFERENCING FACTORS : NONE

BACKCASTING : OFF
*******************************************************************
UNIVARIATE MODEL PARAMETERS
*******************************************************************
              FACTOR    LAG COEFFICIENT       T RATIO

*******************************************************************
 1 MEAN                     .11088E+01        11.67
 2 MOVING AVERAGE 1    12  -.28820E+00        -1.73
*******************************************************************
```

-- Section 32 ----------

THE RESIDUAL AND MODEL STATISTICS

(IN TERMS OF THE ORIGINAL DATA)

```
SUM OF SQUARES :  .12473E+03          DEGREES OF FREEDOM    :        38
MEAN SQUARE    :  .32823E+01          NUMBER OF RESIDUALS   :        40
R SQUARED      :  .13461E-01
```

-- Section 33 ----------

THE RESIDUAL AND MODEL STATISTICS

(IN TERMS OF THE TRANSFORMED DATA)

```
SUM OF SQUARES :  .95813E+01          DEGREES OF FREEDOM    :        38
MEAN SQUARE    :  .25214E+00          NUMBER OF RESIDUALS   :        40
R SQUARED      :  .68700E-01
```

-- Section 34 ----------

THE RESIDUAL AUTOCORRELATION ANALYSIS

```
MEAN OF THE RESIDUAL SERIES          :  -.30143E-01
STANDARD DEVIATION                   :   .48849E+00
NUMBER OF OBSERVATIONS               :    40
MEAN DIVIDED BY STANDARD ERROR       :   .39027E+00
```

THE AUTOCORRELATIONS

```
LAGS   1- 8       .075    .185    .028    .122   -.063    .076    .021    .019
STANDARD ERROR   (.158)  (.159)  (.164)  (.164)  (.167)  (.167)  (.168)  (.168)

LAGS   9- 12     -.278   -.165   -.157   -.008
STANDARD ERROR   (.168)  (.179)  (.183)  (.186)
```

-- Section 35 ----------

T-TEST FOR SIGNIFICANCE AT EACH LAG :

AUTOBOX IDENTIFIES 1 AUTOCORRELATIONS OUTSIDE 1.450 SIGMA.
LAGS: 9,

-- Section 36 ----------

PLOT OF THE AUTOCORRELATIONS

-- Section 37 ----------

```
            |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
        1.00|                                                            |
         .90|                                                            |
T        .80|                                                            |
H        .70|                                                            |
E        .60|                                                            |
         .50|                                                            |
C        .40|                                                            |
O        .30|                  + + +                                     |
R        .20| + + + + + + + + +                                          |
R        .10| * *   *   *                                                |
E        .00|-*-*-*-*-*-*-*-*-*-*-*-*------------------------------------|
L       -.10|        *       * * *                                       |
A       -.20| - - - - - - - - - * *                                      |
T       -.30|                * - - -                                     |
I       -.40|                                                            |
O       -.50|                                                            |
N       -.60|                                                            |
S       -.70|                                                            |
        -.80|                                                            |
        -.90|                                                            |
       -1.00|                                                            |
            |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
LAG          1       5         10        15        20        25        30
```

-- Section 38 ----------

==

This marks the end of the automatic development of the ARIMA model for time series 0-4 FATALITIES/1,000 INVOLVED

==

==

AUTOBOX will now examine the residuals from this ARIMA model for potential outlier (intervention) variables. Very briefly, this is a straightforward process that checks for up to 3 types of outlier variables at each time period via a series of ordinary regressions. A modified F test is used to determine which, if any, of the regression variables is most significant. (A more detailed explanation of this process can be found in your User's Guide.). Please note that if the ARIMA model contains a transformation parameter, then the residuals are in terms of the transformed data.

```
==============================================================================
------------------------------------------------------------ Section 39 ----------

==============================================================================
THE AUTOMATIC INTERVENTION OPTION FINDS  1 POTENTIAL
INTERVENTION VARIABLES SIGNIFICANT AT ALPHA =    .050000

THE POTENTIAL INTERVENTIONS ARE :

 NUMBER    TYPE  TIME PERIOD OF      DESCRIPTION                    SUGGESTED W0
                 INTERVENTION                                      STARTING VALUE
 ------    ----  --------------      -----------                   --------------

   1        2          14           X1(T)  = 0 AT T LT  14           -.63691E+00
                                           = 1 AT T GE  14


WHERE TYPE INDICATES :

TYPE    DEFINITION
----    ----------

  1     PULSE VARIABLE - A SINGLE PULSE AT THE TIME PERIOD OF INTERVENTION
  2     STEP  VARIABLE - A SINGLE STEP  AT THE TIME PERIOD OF INTERVENTION
  3     SEASONAL PULSE - PULSES AT THE TIME PERIOD OF INTERVENTION
                         AND AT EVERY   4 PERIODS FOLLOWING THAT PERIOD

==============================================================================
------------------------------------------------------------ Section 40 ----------

==============================================================================
```

This marks the end of the automatic intervention detection using filtering strategy #1. The initial ARIMA model serves as the tentative noise model in a transfer function model, where the output series is 0-4 FATALITIES/1,000 and the input series are the 1 intervention variables that were detected.

```
==============================================================================
==============================================================================
```

AUTOBOX finds that this series is affected by outlier (intervention) variables. The program will now move to automatic modeling, starting with the tentative transfer function - noise model. The input series are the interventions found using filtering strategy # 1

```
==============================================================================
```

IMPACT OF THE LAMBDA VALUE ON THE BOX-COX ERROR SUM OF SQUARES
==

```
                                  LAMBDA    ERROR SUM OF SQUARES

INITIAL LAMBDA VALUE ->            .000          .555251E+02

                                 -1.000          .815622E+02
                                  -.500          .600584E+02
                                   .000          .555251E+02 <- OPTIMAL LAMBDA VALUE
                                   .500          .628327E+02
                                  1.000          .822839E+02
```

SINCE THE LAMBDA OF .000 GIVES THE LOWEST ERROR SUM OF SQUARES, AUTOBOX WILL APPLY THIS LAMBDA TO THE ORIGINAL SERIES.

--- Section 41 ----------

ESTIMATION OF THE USER SPECIFIED INITIAL MODEL FORM
===

```
*****************************************************************
DATA :   Y = 0-4 FATALITIES/1,000 INVOLVED       40 OBSERVATIONS

MODEL DEVELOPED WITH TRANSFORMED DATA = LN(  Y)

DIFFERENCING FACTORS : NONE

BACKCASTING : OFF
*****************************************************************
*****************************************************************
NOISE SERIES

DIFFERENCING FACTORS ON NOISE : NONE
*****************************************************************
NOISE MODEL PARAMETERS
*****************************************************************
              FACTOR    LAG COEFFICIENT      T RATIO

*****************************************************************
 1 MEAN                      .14753E+01        13.93
 2 MOVING AVERAGE 1    12  -.58886E+00        -3.94
*****************************************************************
```

--- Section 42 ----------

```
INTERVENTION  1
DATA -  X1 = A STEP AT TIME PERIOD     14

DIFFERENCING FACTORS : NONE

VALUE OF LAG PARAMETER IS  0
*****************************************************************
TRANSFER FUNCTION PARAMETERS
              FACTOR    LAG COEFFICIENT      T RATIO
*****************************************************************
 3 INPUT LAG      1     0  -.59587E+00        -4.75
*****************************************************************
```

-- Section 43 ----------

THE RESIDUAL AND MODEL STATISTICS

(IN TERMS OF THE ORIGINAL DATA)

SUM OF SQUARES :	.87407E+02	DEGREES OF FREEDOM :	37
MEAN SQUARE :	.23624E+01	NUMBER OF RESIDUALS :	40
R SQUARED :	.30864E+00		

-- Section 44 ----------

(IN TERMS OF THE TRANSFORMED DATA)

SUM OF SQUARES :	.64475E+01	DEGREES OF FREEDOM :	37
MEAN SQUARE :	.17426E+00	NUMBER OF RESIDUALS :	40
R SQUARED :	.37331E+00		

-- Section 45 ----------

THE RESIDUAL AUTOCORRELATION ANALYSIS

MEAN OF THE RESIDUAL SERIES :	.80589E-02
STANDARD DEVIATION :	.40140E+00
NUMBER OF OBSERVATIONS :	40
MEAN DIVIDED BY THE STANDARD ERROR OF THE MEAN :	.12698E+00

-- Section 46 ----------

THE AUTOCORRELATIONS

LAGS 1- 8	-.196	.082	-.072	.024	-.084	.060	.058	.113
STANDARD ERROR	(.158)	(.164)	(.165)	(.166)	(.166)	(.167)	(.168)	(.168)
Q STATISTIC	2.	2.	2.	2.	3.	3.	3.	4.
P-VALUE	.099	.372	.532	.695	.768	.841	.894	.894

LAGS 9- 12	-.206	-.068	.047	-.040
STANDARD ERROR	(.170)	(.176)	(.177)	(.177)
Q STATISTIC	6.	6.	6.	6.
P-VALUE	.754	.805	.856	.898

-- Section 47 ----------

T-TEST FOR SIGNIFICANCE AT EACH LAG :
THERE ARE 0 AUTOCORRELATIONS SIGNIFICANT AT 1.640 SIGMA.

-- Section 48 ----------

PLOT OF THE AUTOCORRELATIONS

-- Section 49 ----------

```
          |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
      1.00|                                                            |
       .90|                                                            |
T      .80|                                                            |
H      .70|                                                            |
E      .60|                                                            |
       .50|                                                            |
C      .40|                                                            |
O      .30| + + + + + + + + + + + +                                    |
R      .20|                                                            |
R      .10|   *       * * *                                            |
E      .00|-*-*-*-*-*-*-*-*-*-*-*-*------------------------------------|
L     -.10| *   *   *       * *                                        |
A     -.20| *               *                                          |
T     -.30| - - - - - - - - - - - -                                    |
I     -.40|                                                            |
O     -.50|                                                            |
N     -.60|                                                            |
S     -.70|                                                            |
      -.80|                                                            |
      -.90|                                                            |
     -1.00|                                                            |
          |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
LAG         1       5        10        15        20        25        30
```

-- Section 50 ----------

THE PARTIAL AUTOCORRELATIONS

LAGS 1- 8	-.196	.045	-.050	-.002	-.076	.028	.087	.133
STANDARD ERROR	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)
LAGS 9- 12	-.176	-.164	.053	-.010				
STANDARD ERROR	(.158)	(.158)	(.158)	(.158)				

-- Section 51 ----------

THERE ARE 0 PARTIAL AUTOCORRELATIONS SIGNIFICANT AT 1.640 SIGMA.

-- Section 52 ----------

PLOT OF THE PARTIAL AUTOCORRELATIONS

-- Section 53 ----------

```
               |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
          1.00 |                                                             |
           .90 |                                                             |
T          .80 |                                                             |
H          .70 |                                                             |
E          .60 |                                                             |
           .50 |                                                             |
C          .40 |                                                             |
O          .30 | + + + + + + + + + + + +                                     |
R          .20 |                                                             |
R          .10 |             * *     *                                       |
E          .00 |-*-*-*-*-*-*-*-*-*-*-*-*-------------------------------------|
L         -.10 | *       *       * *                                         |
A         -.20 | *               * *                                         |
T         -.30 | - - - - - - - - - - - -                                     |
I         -.40 |                                                             |
O         -.50 |                                                             |
N         -.60 |                                                             |
S         -.70 |                                                             |
          -.80 |                                                             |
          -.90 |                                                             |
         -1.00 |                                                             |
               |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
LAG              1       5         10        15        20        25        30
```

-- Section 54 ----------

THE DIAGNOSTIC CHECKS
=====================

INVERTIBILITY CHECK : ALL OF THE PARAMETERS ARE INVERTIBLE.

SUFFICIENCY TEST : THE CURRENT PARAMETERS ARE SUFFICIENT.

NECESSITY CHECK : ALL OF THE PARAMETERS ARE SIGNIFICANT

AUTOBOX WILL NOW ESTIMATE THE IDENTIFIED MODEL USING THE BACKCASTING METHOD.

```
ESTIMATION OF THE TENTATIVELY IDENTIFIED MODEL FORM
===================================================
*****************************************************************
DATA :   Y = 0-4 FATALITIES/1,000 INVOLVED        40 OBSERVATIONS

MODEL DEVELOPED WITH TRANSFORMED DATA = LN(  Y)

DIFFERENCING FACTORS : NONE

BACKCASTING : ON
*****************************************************************
*****************************************************************
NOISE SERIES

DIFFERENCING FACTORS ON NOISE : NONE
*****************************************************************
NOISE MODEL PARAMETERS
*****************************************************************
              FACTOR   LAG COEFFICIENT      T RATIO

*****************************************************************
 1 MEAN                     .14268E+01          5.87
 2 MOVING AVERAGE 1    12  -.91844E+00        -20.26
*****************************************************************
------------------------------------------------------ Section 55 ----------
*****************************************************************
INTERVENTION  1
DATA -  X1 = A STEP AT TIME PERIOD     14

DIFFERENCING FACTORS : NONE

VALUE OF LAG PARAMETER IS  0
*****************************************************************
TRANSFER FUNCTION PARAMETERS
              FACTOR   LAG COEFFICIENT      T RATIO

*****************************************************************
 3 INPUT LAG      1     0  -.54707E+00         -2.23
*****************************************************************
------------------------------------------------------ Section 56 ----------

                THE RESIDUAL AND MODEL STATISTICS
                =================================
                (IN TERMS OF THE ORIGINAL DATA)

SUM OF SQUARES :  .51991E+02        DEGREES OF FREEDOM    :      37
MEAN SQUARE    :  .14052E+01        NUMBER OF RESIDUALS   :      40
R SQUARED      :  .58877E+00
------------------------------------------------------ Section 57 ----------
               (IN TERMS OF THE TRANSFORMED DATA)

SUM OF SQUARES :  .36572E+01        DEGREES OF FREEDOM    :      37
MEAN SQUARE    :  .98842E-01        NUMBER OF RESIDUALS   :      40
R SQUARED      :  .64452E+00
```

-- Section 58 ----------

THE RESIDUAL AUTOCORRELATION ANALYSIS

MEAN OF THE RESIDUAL SERIES	:	.63550E-03
STANDARD DEVIATION	:	.30237E+00
NUMBER OF OBSERVATIONS	:	40
MEAN DIVIDED BY THE STANDARD ERROR OF THE MEAN	:	.13292E-01

-- Section 59 ----------

THE AUTOCORRELATIONS

LAGS 1- 8	-.034	.099	-.133	.172	-.152	.135	.042	.066
STANDARD ERROR	(.158)	(.158)	(.160)	(.163)	(.167)	(.171)	(.173)	(.173)
Q STATISTIC	5.	0.	1.	3.	4.	5.	5.	5.
P-VALUE	.411	.784	.731	.615	.581	.585	.688	.758

LAGS 9- 12	-.224	-.005	-.047	.044
STANDARD ERROR	(.174)	(.181)	(.181)	(.181)
Q STATISTIC	8.	8.	8.	8.
P-VALUE	.564	.657	.728	.789

-- Section 60 ----------

T-TEST FOR SIGNIFICANCE AT EACH LAG :

THERE ARE 0 AUTOCORRELATIONS SIGNIFICANT AT 1.640 SIGMA.

-- Section 61 ----------

PLOT OF THE AUTOCORRELATIONS

-- Section 62 ----------

```
          |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
     1.00|                                                              |
      .90|                                                              |
T     .80|                                                              |
H     .70|                                                              |
E     .60|                                                              |
      .50|                                                              |
C     .40|                                                              |
O     .30| + + + + + + + + + + + +                                      |
R     .20|       *                                                      |
R     .10|   *   *   *   *                                              |
E     .00|-*-*-*-*-*-*-*-*-*-*-*-*-------------------------------------|
L    -.10|     *   *       *                                            |
A    -.20|         *       *                                            |
T    -.30| - - - - - - - - - - - -                                      |
I    -.40|                                                              |
O    -.50|                                                              |
N    -.60|                                                              |
S    -.70|                                                              |
     -.80|                                                              |
     -.90|                                                              |
    -1.00|                                                              |
          |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
LAG        1       5         10        15        20        25        30
```

-- Section 63 ----------

THE PARTIAL AUTOCORRELATIONS

LAGS 1- 8	-.034	.098	-.128	.160	-.131	.099	.107	-.016
STANDARD ERROR	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)
LAGS 9- 12	-.176	-.044	-.006	.008				
STANDARD ERROR	(.158)	(.158)	(.158)	(.158)				

-- Section 64 ----------

THERE ARE 0 PARTIAL AUTOCORRELATIONS SIGNIFICANT AT 1.640 SIGMA.

-- Section 65 ----------

PLOT OF THE PARTIAL AUTOCORRELATIONS

-- Section 66 ----------

```
           |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
       1.00|                                                            |
        .90|                                                            |
T       .80|                                                            |
H       .70|                                                            |
E       .60|                                                            |
        .50|                                                            |
C       .40|                                                            |
O       .30| + + + + + + + + + + + +                                    |
R       .20|       *                                                    |
R       .10|   *   *   * *                                              |
E       .00|-*-*-*-*-*-*-*-*-*-*-*-*------------------------------------|
L      -.10|     *   *       *                                          |
A      -.20|                 *                                          |
T      -.30| - - - - - - - - - - - -                                    |
I      -.40|                                                            |
O      -.50|                                                            |
N      -.60|                                                            |
S      -.70|                                                            |
       -.80|                                                            |
       -.90|                                                            |
      -1.00|                                                            |
           |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
LAG          1       5         10        15        20        25        30
```

--- Section 67 ----------

THE DIAGNOSTIC CHECKS

INVERTIBILITY CHECK : ALL OF THE PARAMETERS ARE INVERTIBLE.

SUFFICIENCY TEST : THE CURRENT PARAMETERS ARE SUFFICIENT.

NECESSITY CHECK : ALL OF THE PARAMETERS ARE SIGNIFICANT

CORRELATION MATRIX OF THE PARAMETERS

	1	2	3
1	1.0000		
2	.5338	1.0000	
3	-.9210	-.5284	1.0000

--- Section 68 ----------

FINAL ESTIMATION OF THE MODEL

(CONCLUDES THIS PHASE OF MODEL IDENTIFICATION)

```
****************************************************************
DATA :   Y = 0-4 FATALITIES/1,000 INVOLVED        40 OBSERVATIONS

MODEL DEVELOPED WITH TRANSFORMED DATA = LN(  Y)

DIFFERENCING FACTORS : NONE

BACKCASTING : ON
****************************************************************
****************************************************************
NOISE SERIES

DIFFERENCING FACTORS ON NOISE : NONE
****************************************************************
NOISE MODEL PARAMETERS
****************************************************************
              FACTOR   LAG COEFFICIENT      T RATIO
****************************************************************
 1 MEAN                    .14263E+01         5.77
 2 MOVING AVERAGE 1    12  -.92230E+00       -21.48
****************************************************************
```

-- Section 69 ----------

INTERVENTION 1

DATA - X1 = A STEP AT TIME PERIOD 14

DIFFERENCING FACTORS : NONE

VALUE OF LAG PARAMETER IS 0

TRANSFER FUNCTION PARAMETERS

	FACTOR	LAG	COEFFICIENT	T RATIO
3 INPUT LAG	1	0	-.54724E+00	-2.20

-- Section 70 ----------

THE RESIDUAL AND MODEL STATISTICS

(IN TERMS OF THE ORIGINAL DATA)

SUM OF SQUARES :	.52222E+02	DEGREES OF FREEDOM :	37
MEAN SQUARE :	.14114E+01	NUMBER OF RESIDUALS :	40
R SQUARED :	.58695E+00		

-- Section 71 ----------

(IN TERMS OF THE TRANSFORMED DATA)

SUM OF SQUARES :	.36585E+01	DEGREES OF FREEDOM :	37
MEAN SQUARE :	.98879E-01	NUMBER OF RESIDUALS :	40
R SQUARED :	.64439E+00		

-- Section 72 ----------

THE RESIDUAL AUTOCORRELATION ANALYSIS

MEAN OF THE RESIDUAL SERIES :	.34329E-03
STANDARD DEVIATION :	.30243E+00
NUMBER OF OBSERVATIONS :	40
MEAN DIVIDED BY THE STANDARD ERROR OF THE MEAN :	.71791E-02

-- Section 73 ----------

THE AUTOCORRELATIONS

LAGS 1- 8	-.031	.099	-.133	.176	-.151	.135	.044	.066
STANDARD ERROR	(.158)	(.158)	(.160)	(.163)	(.167)	(.171)	(.173)	(.174)
Q STATISTIC	4.	0.	1.	3.	4.	5.	5.	5.
P-VALUE	.419	.788	.735	.606	.577	.581	.683	.753

LAGS 9- 12	-.220	-.003	-.050	.041
STANDARD ERROR	(.174)	(.181)	(.181)	(.181)
Q STATISTIC	8.	8.	8.	8.
P-VALUE	.567	.660	.729	.791

-- Section 74 ----------

T-TEST FOR SIGNIFICANCE AT EACH LAG :

THERE ARE 0 AUTOCORRELATIONS SIGNIFICANT AT 1.640 SIGMA.

-- Section 75 ----------

PLOT OF THE AUTOCORRELATIONS

-- Section 76 ----------

```
           |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
       1.00|                                                            |
        .90|                                                            |
T       .80|                                                            |
H       .70|                                                            |
E       .60|                                                            |
        .50|                                                            |
C       .40|                                                            |
O       .30| + + + + + + + + + + + +                                    |
R       .20|       *                                                    |
R       .10|   *   *   *   *                                            |
E       .00|-*-*-*-*-*-*-*-*-*-*-*-*------------------------------------|
L      -.10|     *   *       *                                          |
A      -.20|         *       *                                          |
T      -.30| - - - - - - - - - - - -                                    |
I      -.40|                                                            |
O      -.50|                                                            |
N      -.60|                                                            |
S      -.70|                                                            |
       -.80|                                                            |
       -.90|                                                            |
      -1.00|                                                            |
           |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
LAG          1       5        10        15        20        25        30
```

-- Section 77 ----------

THE PARTIAL AUTOCORRELATIONS

LAGS 1- 8	-.031	.098	-.128	.165	-.131	.100	.110	-.017
STANDARD ERROR	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)	(.158)
LAGS 9- 12	-.172	-.041	-.011	.005				
STANDARD ERROR	(.158)	(.158)	(.158)	(.158)				

-- Section 78 ----------

THERE ARE 0 PARTIAL AUTOCORRELATIONS SIGNIFICANT AT 1.640 SIGMA.

```
-------------------------------------------------------- Section 79 ----------
                      PLOT OF THE PARTIAL AUTOCORRELATIONS
                      ------------------------------------
-------------------------------------------------------- Section 80 ----------
             |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
         1.00|                                                            |
          .90|                                                            |
T         .80|                                                            |
H         .70|                                                            |
E         .60|                                                            |
          .50|                                                            |
C         .40|                                                            |
O         .30| + + + + + + + + + + + +                                    |
R         .20|       *                                                    |
R         .10|   *   *   * *                                              |
E         .00|-*-*-*-*-*-*-*-*-*-*-*-*------------------------------------|
L        -.10|     *   *       *                                          |
A        -.20|                 *                                          |
T        -.30| - - - - - - - - - - - -                                    |
I        -.40|                                                            |
O        -.50|                                                            |
N        -.60|                                                            |
S        -.70|                                                            |
         -.80|                                                            |
         -.90|                                                            |
        -1.00|                                                            |
             |-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+|
LAG            1       5        10        15        20        25        30
-------------------------------------------------------- Section 81 ----------
```