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# Effects of Mandating Seatbelt Use: a Series of Surveys on Compliance in Michigan

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## Synopsis.....

*Although proper use of automobile seatbelts reduces risk of serious injury or death in traffic*

*crashes by 30 to 50 percent, seatbelt use remains low. Recently, several States have passed laws requiring the use of seatbelts.*

*Michigan implemented such a law July 1, 1985. Direct-observation surveys of a probability sample of motorists throughout the State were conducted before the law was passed, after passage but before implementation, immediately after the law took effect, and 5 months after implementation.*

*The results showed a significant increase in the use of restraints from 19.8 percent before the law was passed to 58.4 percent immediately after it took effect. A restraint use survey conducted in December 1985, 5 months after implementation, measured the use of restraints at 43.0 percent. Despite that decline, belt use was 117 percent higher than the 19.8 percent measured before passage of the law mandating the use of seatbelts.*

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**M**OTOR VEHICLE CRASHES are a major public health problem, and they are the leading cause of death to people under 40 years of age. In 1984 motor vehicle crashes killed 46,200 and injured an additional 1.7 million people. Estimates of the costs of motor vehicle crashes range from \$47.6 to \$69.1 billion annually, including medical expenses, insurance costs, and loss of wages (1,2). Existing motor vehicle occupant restraint systems have been proven to reduce substantially the risk of death and injuries due to motor vehicle crashes. When properly used, restraint systems for adults are 30 to 50 percent effective in preventing severe injuries and deaths to motor vehicle occupants (3).

In the past 15 years, 32 foreign countries have enacted laws mandating the use of safety belts by drivers and front-seat passengers in automobiles (4). Although the results vary, these jurisdictions typically have experienced significant increases in rates of safety belt use and decreases in motor vehicle crash fatalities and injuries. Belt use rates typically increased from 10 to 30 percent before compulsory use laws were implemented to 50 to 80 percent after such laws took effect. Reductions in crash fatalities and injuries of 5 to 25 percent following passage of laws mandating the use of seatbelts also have been reported frequently. Use rates typically increased immediately following im-

plementation of mandatory-use laws, then decreased somewhat after such laws were in effect for several months. Detailed information on these studies can be found elsewhere (5-11).

In December 1984, New York became the first U.S. State to make the use of seatbelts compulsory. As a consequence, it experienced an increase in the use of seatbelts, from 16 percent before to 57 percent immediately following implementation of the new law. Nine months later, however, use had declined to 46 percent from its postlaw peak (12).

Michigan was among the first States to pass a seatbelt law. In February 1985, the Michigan legislature approved legislation mandating use of seatbelts by drivers and front-seat passengers in vehicles manufactured after 1965, that is, automobiles with factory-equipped seatbelts. From July to December, the penalty for noncompliance was a \$10 fine. Beginning January 1986, the fine increased to \$25.

The study we report measured the effects of the passage and implementation of Michigan's law on the use of seatbelts. The use of seatbelts by motorists was measured in December 1984, before the law was passed; in April 1985, after passage but before implementation; in July 1985, immediately after the law took effect; and in December

Table 1. Number of motor vehicle occupants observed in 4 survey waves in Michigan

Category	Survey wave			
	December 1984	April 1985	July 1985	December 1985
<b>Age (years)</b>				
0-3	538	481	541	385
4-15	1,284	1,506	2,319	1,244
16-29	5,835	5,971	5,990	4,894
30-59	8,100	8,457	8,827	8,902
60 and older	1,723	2,041	2,243	2,034
<b>Seating position</b>				
Driver	11,906	12,345	12,263	12,106
Front center	246	281	301	211
Front right	3,880	4,158	4,782	3,744
Rear left	432	529	811	426
Rear center	349	371	546	295
Rear right	611	723	1,070	580
Extra seats, cargo, lap	144	155	225	115
<b>Sex</b>				
Male	9,258	10,001	10,611	9,469
Female	8,078	8,430	9,238	7,951
<b>Observation site</b>				
Intersection	14,152	15,238	16,524	14,018
Freeway exit	3,416	3,343	3,499	3,482
<b>Type of vehicle<sup>1</sup></b>				
Small car	3,942	...	4,639	4,593
Midsize car	4,554	...	5,896	4,974
Large car	6,004	...	5,990	4,603
Pickup	1,679	...	1,872	1,852
Van	773	...	972	857
Other	533	...	554	540
<b>Total occupants observed</b>	<b>17,568</b>	<b>18,581</b>	<b>20,023</b>	<b>17,500</b>

<sup>1</sup>Vehicle type was not recorded in the April 1985 survey wave.

1985, 5 months after implementation. (The exact dates of field observations were November 26 through December 16, 1984; April 17 through May 8, 1985; July 17 through August 8, 1985; and December 2 through December 21, 1985.)

## Method

The use of seatbelts among Michigan motorists was observed directly. Because the rate of belt use varies greatly depending on location, a carefully designed set of observation sites was used to sample motorists traveling during daylight hours on Michigan roads. The goal was to minimize total survey error, including sampling error and measurement error, while using sites where observations could be made efficiently and economically. To observe all modes of restraint use among all occupants of motor vehicles—not just shoulder belt use among drivers and right-front passen-

gers—vehicles had to be motionless for at least several seconds. As a result, observation sites generally were limited to intersections with three-color cycling traffic signals. Observations were limited to daylight hours for accurate observation of restraint use and were distributed carefully across hours of the day and days of the week.

A total of 240 intersections was selected with the use of a multistage stratified probability sampling procedure. To provide sufficient cases for region-specific analyses, the upper peninsula and northern lower peninsula regions were overrepresented in the sample in relation to their populations, and the densely populated southeastern region of the State was underrepresented. Therefore, all results are based on data reweighted according to the sampling fraction used in each region. Within each region, counties were selected so that the largest counties had the highest probability of inclusion in the sample; that is, counties were selected with a probability proportional to their size. Some counties were selected more than once because of their large populations.

Within each county, intersections were selected randomly from lists of possible intersections. Because an estimated 23 percent of all traffic in Michigan occurs on freeways (13), one freeway exit was selected for every three nonfreeway intersections. Additional details on sampling procedures can be found elsewhere (14).

For each of the survey waves (December 1984, April 1985, July 1985, December 1985), specially trained field staff visited each sampled intersection and observed a sample of about 50 vehicles during a preselected 1-hour period. For each occupant in each sampled vehicle, information on restraint use, seating position, estimated age, and sex was recorded on precoded forms. Other information recorded included type of vehicle, site location, time of day, day of week, and weather conditions at the time of observation. Observers also recorded whether occupants were riding in nonstandard positions, that is, standing, kneeling, or lying on the seat, floor, or cargo area. In July and December 1985, occupants who incorrectly used seatbelts by placing the shoulder harness under the arm or behind the back, or by sharing the seatbelt with another occupant, were also noted.

Data on approximately 18,500 motorists were collected in each of the four survey waves, for a total of 73,672 occupants observed. Rates of missing data were extremely low. The highest rate of missing data, 3 percent, was for restraint use. Typically, these omissions were data on occupants

in rear seats of station wagons and vans, where accurate observation of belt use was occasionally obscured by tinted windows.

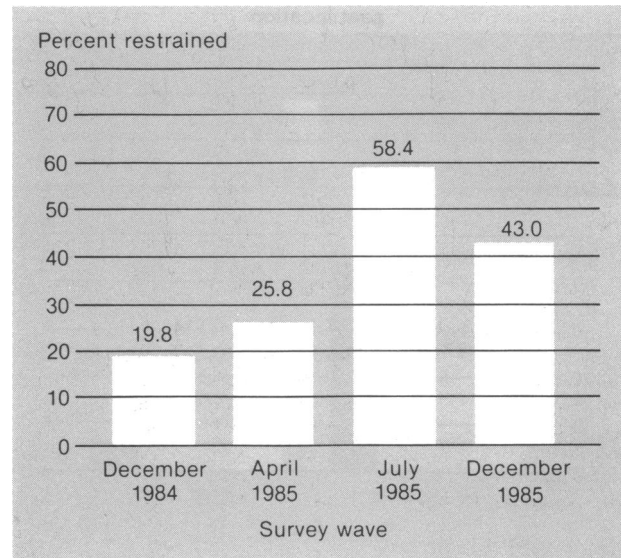
Calculation of exact sampling errors and confidence intervals for the multistage stratified sample design used in this survey is complex (15). Sampling error is introduced at each stage of the sample: selection of counties within each region, selection of intersections within each county, and selection of vehicles at each intersection. In some densely populated counties an additional stage involved selection of districts prior to selection of specific intersections. Each stage in a multistage sample contributes sampling error, typically making the total sampling error considerably larger than a simple random sample. However, each stage in the current sample design, other than selection of intersections and vehicles, included stratification, which reduced sampling error.

A correct assessment of the statistical significance of changes in the proportion of the population using seatbelts requires an accurate estimate of the sampling variance. Therefore, the design effect for restraint use in each survey wave was calculated, using the Taylor series expansion method (16). The design effect indicates the extent to which the sampling error is larger than the sampling error of a simple random sample of the same size. Design effects for each survey wave were as follows: 9.36 for December 1984, 13.17 for April 1985, 9.28 for July 1985, and 16.79 for December 1985. These design effects indicate that standard errors calculated using the conventional formulas (which assume a simple random sample) are only a third or less of the true standard errors. Although the design effect of the sample is large, the sample size compensated for the increase in standard errors and, in most cases, provided more than enough statistical power to detect hypothesized changes in restraint use associated with the mandatory seat belt law. Changes in restraint use for certain subpopulations, such as young children, were not statistically significant due to small numbers of cases in those categories (unweighted numbers of cases observed are shown in table 1). All percentages and Z-statistics reported in table 2 have been adjusted to take into account effects of the stratified multistage cluster sample design.

## Results

The seatbelt law in Michigan was passed by the legislature in February 1985, was signed by the Governor in March 1985, and took effect July 1,

Figure 1. Use of restraints among occupants of automobiles and light trucks in Michigan



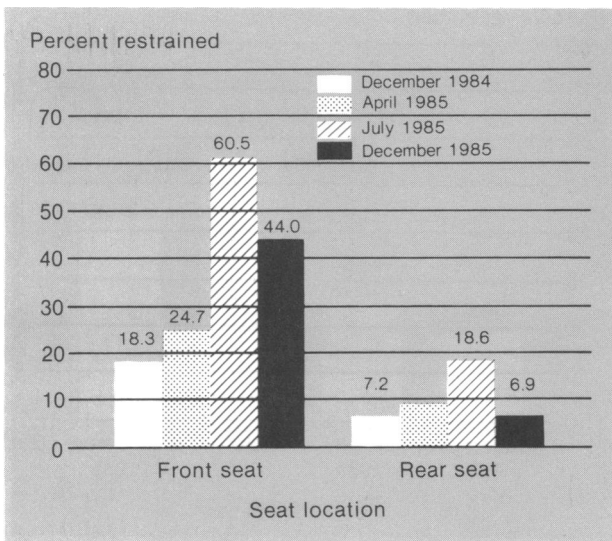
1985. The effects of the mandatory use of seatbelts and the attendant publicity were evident months before implementation and enforcement began. The use of restraints among drivers and passengers in Michigan during April 1985 averaged 25.8 percent, a significant increase from the 19.8 percent using restraints in December 1984. It appears that publicity surrounding passage of the law resulted in an increase in the use of seatbelts even before the law took effect.

In July, 58.4 percent of all motor vehicle occupants who were observed were using restraints. This percentage represents a significant 126 percent increase from April 1985 (fig. 1; table 2). Comparison of use rates in December 1984 (19.8 percent) with those of July 1985 (58.4 percent) reveals a large increase after the law was passed (195 percent).

Of all the occupants observed during December 1985, 43 percent were using seatbelts or child restraint devices. The use of restraints decreased significantly in the first 5 months the law was in effect. The December 1985 rate of restraint use represents a 26 percent decrease from the 58.4 percent rate observed in July. Although the use of restraints was lower in December 1985 than in July 1985, the rate of use remained higher than before the law was implemented. Over the 12-month period studied (December 1984 to December 1985), restraint use in Michigan increased 117 percent.

The effects of the law mandating the use of seatbelts can be seen clearly by examining the use of restraints among front-seat occupants aged 16

Figure 2. Use of restraints among occupants aged 16 and older of automobiles and light trucks in Michigan by seat location



years and older, for two reasons. First, young children have particularly high rates of restraint use as a result of mandatory child restraint legislation implemented in 1982 (17, 18). Second, the law requires the use of seatbelts by adults who are in front-seat positions only.

Front-seat belt use among adults increased from 18.3 percent to 24.7 percent between December 1984 and April 1985 and jumped to 60.5 percent in July 1985, immediately after the law took effect (fig. 2). However, front-seat belt use among adults declined to 44 percent by December 1985. A similar pattern of increased seatbelt use the first half of the year was seen among adults occupying rear seats, though the rates of seatbelt use were much lower. Changes in rates of use for each of the three rear-seat positions—the data were examined separately—were not significant statistically because of the small number of cases observed. Analysis of the three rear-seat positions as a single group, however, showed a significant increase from April (33.5 percent) to July (43.1 percent;  $Z=1.83$ ). The use of rear-seat restraints declined to 31.2 percent by December ( $Z=-1.95$ ). These results indicate a possible spillover effect of the law in increasing the use of seatbelts in the rear seat. This effect was short-lived, however, with belt use in December 1985 among adults in the rear seat virtually identical to the rate of use a year earlier.

All age groups, except children under 4 years, experienced the anticipation effect, that is, increased their use of seatbelts before the law took effect (fig. 3; table 2). Restraint use among young

children did not change between the two baseline waves. All age groups other than young children had similar increases in seatbelt use between December 1984 and April 1985, with the possible exception of the 16- to 29-year-old group for whom the increase in seatbelt use was slightly smaller than for the other age groups.

After implementation of the law, children aged 0 to 3 years continued to have the highest rate of restraint use, 70.0 percent in July, up from 60.2 percent in April (increase not statistically significant because of the small number of young children observed). In December 1985, the 0-3 age group returned to the levels of restraint use observed in the two pre-law surveys (fig. 3, table 2). Since April 1982, restraints have been required in Michigan on children under age 4; significant increases in restraint use rates among young children followed implementation of that law (17). The adult belt law appears to have had a spillover effect in further increasing restraint use among young children, but this effect also was short-lived.

Incorrect use of child restraint devices continues to be a problem. Throughout this series of surveys, the rate of incorrect use remained constant at about 20 percent of all child restraint devices observed. As a result of the nature of the data collection process—a brief observation of vehicles in traffic—these figures include only incorrect use that was obvious to the observer, such as failing to use the child seat harness or facing an infant seat forward when it was designed to face rearward. Therefore, the data presented should be considered a minimum estimate of incorrect use. Studies that carefully examine how the child is traveling in the safety seat and how the seat is attached to the automobile have found incorrect use rates as high as 65 to 75 percent (19,20).

All other age groups showed statistically significant increases in restraint use in July, immediately after the seatbelt law for adults took effect. The largest increase occurred among occupants aged 60 and older. In both December 1984 and April 1985, this cohort had the lowest rate of seatbelt use of any age group (14.6 percent in December and 21.8 percent in April). In July, however, restraint use jumped to 65.9 percent, second only to 0- to 3-year-olds. The July rate represents a 202 percent increase over April. Although older motorists tend to use seatbelts at lower than average rates when use is voluntary, they appear more responsive to mandated use than do motorists of other ages. Seatbelt use decreased from July to December 1985 for all age groups. This decrease was fairly

Table 2. Weighted percent use of seatbelts in Michigan and Z-statistics for major variables across 4 survey waves<sup>1</sup>

Category	Percent restraint use				Z-statistics <sup>2</sup>			
	December 1984	April 1985	July 1985	December 1985	December 1984 to April 1985	April to July 1985	July to December 1985	December 1984 to December 1985
<b>Age (years)</b>								
0-3 .....	60.8	60.2	70.0	59.1	-0.06	0.97	-0.92	-0.14
4-15 .....	23.9	31.4	48.9	38.7	1.32	3.26	-1.57	2.20
16-29 .....	18.5	23.0	53.2	36.4	1.79	10.84	-4.89	5.56
30-59 .....	18.4	25.9	61.8	44.2	3.45	15.35	-6.59	10.21
60 and older .....	14.6	21.8	65.9	54.0	1.71	9.79	-2.18	7.54
<b>Seating position</b>								
Driver .....	19.5	26.0	61.3	45.4	3.57	17.96	-6.94	11.97
Front center .....	20.2	19.0	34.6	22.1	-0.09	1.18	-0.83	0.13
Front right .....	17.4	23.9	61.3	42.5	2.12	11.50	-4.75	6.59
Rear left .....	35.8	35.9	45.5	34.1	0.01	0.95	-1.01	-0.14
Rear center .....	25.4	28.4	31.4	22.5	0.26	0.27	-0.73	0.23
Rear right .....	30.6	34.6	48.1	28.6	0.41	1.48	-2.05	-0.20
Extra seats, cargo, lap....	54.1	30.2	28.3	11.5	-1.64	-0.12	-1.10	-3.15
<b>Sex</b>								
Male .....	17.5	23.4	54.9	38.5	3.02	14.81	-6.50	8.83
Female .....	21.9	28.5	62.5	48.5	2.92	14.45	-5.07	9.87
<b>Observation site</b>								
Intersection .....	18.8	24.3	56.5	41.2	3.41	18.69	-7.39	11.32
Freeway exit .....	23.3	32.4	66.4	49.5	2.47	8.92	-3.99	6.36
<b>Type of vehicle<sup>3</sup></b>								
Small car .....	27.4	...	63.8	47.5	...	...	-4.40	5.40
Midsize car .....	23.9	...	61.1	45.8	...	...	-4.39	6.29
Large car .....	16.2	...	57.0	40.3	...	...	-4.71	7.30
Pickup .....	10.4	...	45.8	30.3	...	...	-2.76	4.03
Van .....	19.3	...	53.1	38.2	...	...	-1.78	2.34
Other .....	17.2	...	53.6	52.1	...	...	-0.14	3.44
Overall .....	19.8	25.8	58.4	43.0	3.99	20.38	-8.20	12.91

<sup>1</sup>All percents are based on analyses weighted according to the sample design to accurately represent the entire State.

<sup>2</sup>Z statistics are not based on simple random sample assumptions but take into account design effects of the cluster sample used.

<sup>3</sup>Vehicle type was not recorded in the April 1985 survey wave.

uniform across all ages, with those aged 60 and over showing a slightly smaller reduction than other ages (fig. 3).

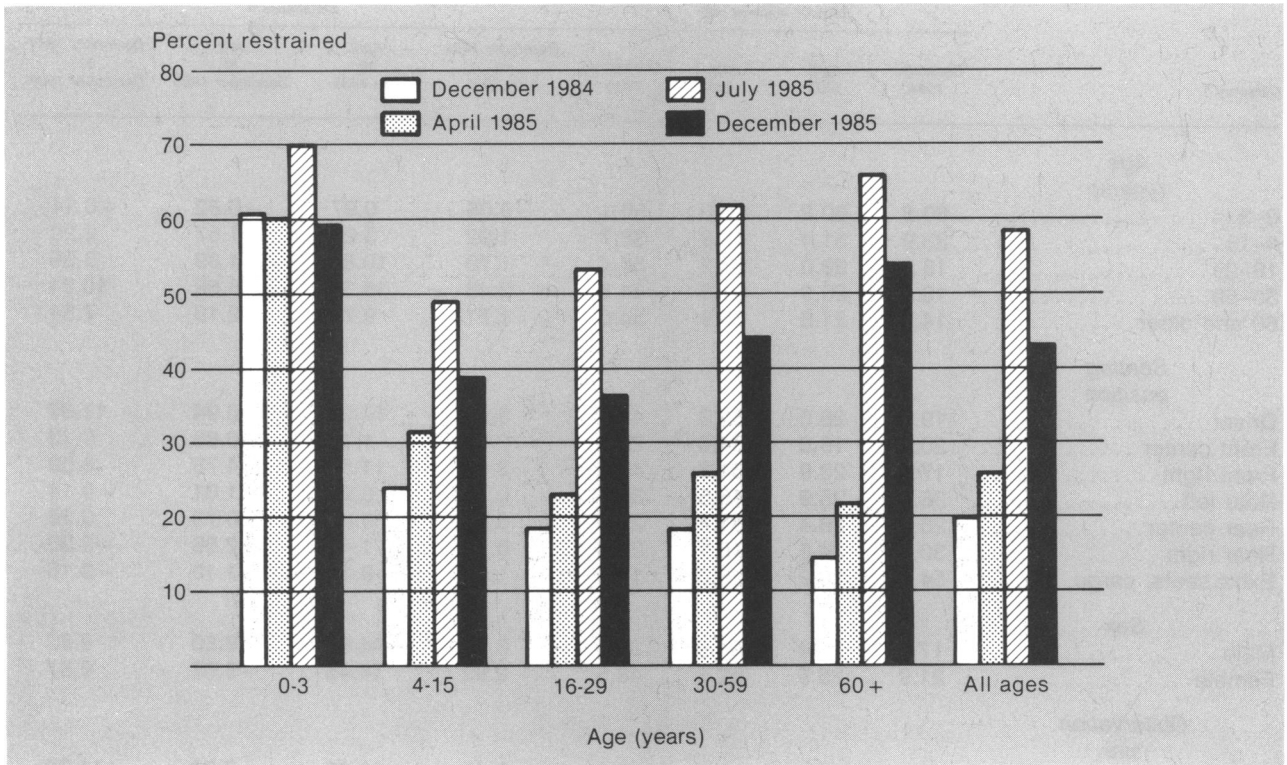
As a result, motorists aged 60 and older had the largest 12-month (December 1984 to December 1985) increase in seatbelt use, 270 percent, compared with a 62 percent increase among those aged 4 to 15 years, a 97 percent increase among those aged 16 to 29 years, and a 140 percent increase among those aged 30 to 59 years. The larger than average 12-month increase among older motorists is a result of three factors:

- Older drivers had a lower baseline use rate.

- Older motorists had a larger increase in seatbelt use immediately after the law took effect.
- Older motorists had a smaller decline in rate of use after the law had been in effect 5 months.

The increase in restraint use from December 1984 to April 1985 among drivers and front-right passengers was larger than the increase at the other seating positions (fig. 4). Similarly, the increase in use from April to July was largest for drivers and right-front passengers. This pattern is consistent with expectations, given that the Michigan seatbelt law for adults applies only to front-seat occupants. The law also requires belt use in the front-center

Figure 3. Use of restraints among occupants of automobiles and light trucks in Michigan by age of occupant



position, but only modest increases in belt use were observed for that position. Five months after the law took effect, belt use in the front-center position was essentially the same as in December 1984.

Females had consistently higher rates of restraint use than males, but both sexes were influenced similarly by the law. In anticipation of the law, females increased their rate of restraint use from 21.9 percent to 28.5 percent, and males increased theirs from 17.5 percent to 23.4 percent. After the law took effect in July, restraint use among males increased to 54.9 percent and among females, to 62.5 percent. Five months later, restraint use among females had declined to 48.5 percent; among males, to 38.5 percent. Between December 1984 and December 1985, use among female occupants increased to 122 percent; among male occupants it increased 120 percent. A sex differential is clear, with males significantly less likely to use seatbelts than females, but the effects of the seatbelt law were similar for the two groups.

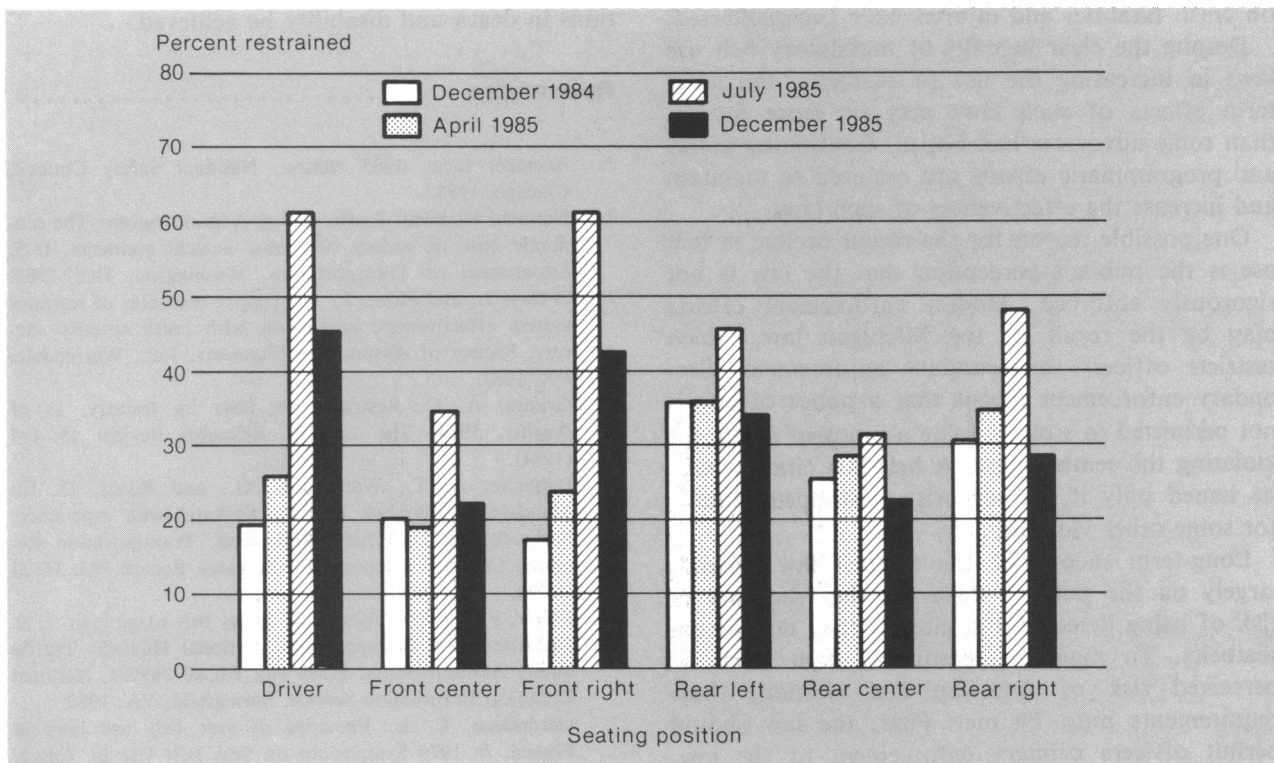
Significant increases in the use of seatbelts in April and July occurred for occupants observed both at freeway exits and regular intersections. Belt use was higher among motorists exiting freeways than among those traveling through regu-

lar intersections—this information is consistent with that in the literature (21).

Incorrect positioning of lap belts appears to lead to significant increases in abdominal injuries, when compared with correct use (22-24). However, injuries suffered when lap belts are used incorrectly are rarely as serious as injuries suffered when seatbelts are not used. No studies on the injury rate were found for occupants who use three-point lap and shoulder belts incorrectly. It is likely, however, that occupants incorrectly using three-point belts will suffer greater internal and head and face injuries than those using such belts correctly. A study currently in progress at the University of Michigan School of Medicine supports this view. Initial results indicate that some deaths and severe injuries would have been avoided among occupants who crashed if they had been belted correctly rather than incorrectly.

Our surveys provide tentative evidence that the number of people using seatbelts incorrectly increased with the increase in the proportion of motorists using seatbelts after the law took effect. In July, 5.9 percent of all belted occupants used seatbelts incorrectly (excluding child safety seats). In December 1985, 5.0 percent incorrectly used belts. Although data on seatbelt misuse by adults

Figure 4. Use of restraints among occupants of automobiles and light trucks in Michigan by seating position



were not explicitly collected and analyzed in December and April, field observers noticed an increase in the number of occupants incorrectly using three-point seatbelts after the law took effect. Most cases of misused seatbelts involved drivers and front-right passengers who incorrectly positioned the shoulder harness under the out-board arm, behind the back, or over the inside shoulder. Occasionally, passengers were seen sharing seatbelts.

Incorrect use was highest among occupants aged 60 and older (6.9 percent of restrained occupants in July and 7.4 percent in December 1985), although the differences from other age groups were small. Incorrect seatbelt use was more common among front-right occupants than among drivers (8.4 percent versus 5.7 percent in July and 7.3 percent versus 4.7 percent in December 1985) and higher among females than among males (7.7 percent versus 4.3 percent in July and 6.1 percent versus 3.9 percent in December 1985).

Continued efforts to educate the public on the importance of using seatbelts correctly are warranted. The apparent increase in incorrect use, however, does not reduce substantially the aggregate benefits of a seatbelt law because only a small portion of the population uses belts incorrectly.

Further, in almost all cases, the incorrect use of belts provides significantly more protection from injury than does nonuse. Although increased rates of incorrect use of belts may be a concern among health professionals, the more serious problem is the large number of motorists who remain entirely unprotected by belts even after use of safety belts is required by law.

## Discussion

The Michigan mandatory seatbelt law had a significant and immediate effect in increasing daytime seatbelt use throughout the State. The increase was particularly large among drivers and front-right passengers, a result consistent with expectations, given that the law is limited to persons traveling in the front seat. There also appeared to be a short-term spillover effect on rear-seat occupants, who also increased their use of seatbelts. The effects of the belt law were great, indicating that compulsory belt use is a useful public health policy. Despite the observed reduction in compliance 5 months after the law took effect, residual effects documented in this study are expected to have a significant effect in reducing crash fatalities and injuries. The extent and

nature of such health benefits of the belt law will be assessed in further research, after adequate data on crash fatalities and injuries have been collected.

Despite the clear benefits of mandatory belt use laws in increasing the use of seatbelts, the long-term effects of such laws may be more modest than some advocates had hoped. Continuing policy and programmatic efforts are required to maintain and increase the effectiveness of such laws.

One possible reason for the recent decline in belt use is the public's perception that the law is not rigorously enforced. Modest enforcement efforts may be the result of the Michigan law, which restricts officers to secondary enforcement. Secondary enforcement means that a police officer is not permitted to stop and cite a motorist solely for violating the seatbelt law. A belt law citation may be issued only if the motorist is stopped initially for some other violation.

Long-term success of the seatbelt law depends largely on the public's believing that they are at risk of being detected and cited if they do not use seatbelts. To maintain reasonably high levels of perceived risk of detection and citation, these requirements must be met: First, the law should permit officers *primary* enforcement of the law. Prohibiting police officers from primary enforcement sends a mixed message to the public—and to police officers—concerning the seriousness of failure to use seatbelts. Second, the number of citations issued for violating the seatbelt law should be increased substantially. In the first 6 months under the seatbelt law, only 9,254 citations were issued by the Michigan State Police. Third, extensive publicity about these enforcement actions is needed to make motorists aware of enforcement activities and to increase their perceived risk of receiving a citation. The experience in Elmira, NY, is instructive. An intensive 3-week enforcement and publicity campaign increased seatbelt use from 49 percent to 66 percent (25).

The results of this series of surveys demonstrate that a mandatory seatbelt law can increase dramatically the proportion of motorists protected by seatbelts. These results also show, however, that some of the beneficial effects diminish without extensive enforcement and effective publicity.

Finally, health professionals should be aware that the most effective means of reducing crash-induced injury and death is a combination of air bags and seatbelts. The air bag not only protects occupants who travel without belts, despite the law, but also provides added protection to those who use seatbelts. Only with a combination of

effective strategies to reduce death and injury caused by traffic crashes will the greatest reductions in death and disability be achieved.

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## Overview of Research on Women in Medicine —Issues for Public Policymakers

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### Synopsis .....

*The recent expansion of the nation's supply of physicians has brought with it dramatic increases in the number of women entering medical school and practice. This paper provides an overview of the literature on women in medicine and synthesizes major findings on the differences between male and female physicians in terms of specialty choice, productivity, income, geographic location of practice, practice settings and types of patients, leadership within the profession, and other characteristics.*

*Between 1981 and the year 2000, the total supply of physicians in practice is expected to increase by 27 percent; the number of women in practice is expected to increase by 153 percent. By the year 2000, one physician in five will be a woman.*

*The fairly limited research on gender-related differences indicate that women tend to cluster in a few specialties (pediatrics, psychiatry, pathology, preventive medicine, physical medicine and rehabilitation, and anesthesiology,) many of which are specialties expected to have fewer physicians than needed nationally by 1990. Women have also been shown to have lower productivity and lower income than male physicians, to choose urban locations more frequently, to prefer salaried and institutional settings more often, to serve different types of patients, and to belong to medical organizations less frequently.*

*From the standpoint of public policy, the differences between the characteristics of male and female physicians have mixed implications. For example, the choice of specialty and lower productivity of women could lessen the negative impact of future physician surpluses. On the other hand, a preference for urban practice could exacerbate geographic maldistribution problems. More research will be required to define and predict the long-term effect of significant increases in the number of female physicians in the United States.*