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DIRECT OBSERVATION OF SAFETY BELT USE IN MICHIGAN: FALL 1996

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16. Abstract

Results of a direct observation survey of safety belt use in Michigan for fall of 1996 are reported. In the present survey, 8,907 occupants traveling in four vehicle types (passenger cars, sport-utility vehicles, vans, and pickup trucks) were surveyed between August 29 and September 30, 1996. Belt use was estimated separately for each vehicle type. Within each vehicle type, belt use by gender, age, road type, day of week, and time of day was estimated. Overall belt use for passenger cars was 70.8 percent, for sport-utility vehicles was 71.6 percent, for vans/minivans was 67.6 percent, and for pickup trucks was 47.7 percent. For all vehicles types, belt use was higher for females than for males, and was generally higher for the zero-to-three-year-old age group than for any other age group. The 16-to-29-year-old age group showed the lowest belt use. In general, belt use was highest during morning rush hour and at interstate exit ramps. Belt use did not vary systematically by day of week or weather conditions.

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October 1996

INTRODUCTION

The safety belt has prevented more injuries and saved more lives in motor vehicle crashes than, perhaps, any other traffic safety technology. The safety belt is effective, however, only if it is consistently used. Despite its clear safety benefits, many people still do not use the safety belt.

As part of a national program to reduce motor vehicle fatalities and injuries, in the late 1970s numerous states began writing legislation to mandate statewide safety belt use. Since the first safety belt law was passed in 1984 (New York), 49 states and the District of Columbia have passed similar laws. In general, these laws have produced a dramatic increase in belt use immediately following implementation, followed by a subsequent decline in belt use that is generally above prelaw levels. This was the case in Michigan following implementation of a safety belt law in July 1985 (see Streff, Molnar, and Christoff, 1993).

To measure compliance with Michigan's mandatory safety belt law, the University of Michigan Transportation Research Institute (UMTRI) is conducting a series of direct-observation surveys of safety belt use among motor vehicle occupants statewide. Seventeen previous survey waves have been completed. The first two waves were conducted prior to implementation of the law to establish a baseline safety belt use rate (Wagenaar and Wiviott, 1985a; Wagenaar, Wiviott, and Compton, 1985). The third wave was conducted during the first month of implementation (Wagenaar and Wiviott, 1985b). The next eight survey waves were conducted roughly every five months between December 1985 and May 1988 (Wagenaar, Wiviott, and Businski, 1986; Wagenaar, Businski, and Molnar, 1986a, 1986b; Wagenaar, Molnar, and Businski, 1987a, 1987b, 1987c, 1988a, 1988b). The twelfth, thirteenth, and fourteenth survey waves were conducted in April 1989 (Wagenaar and Molnar, 1989), May 1990 (Streff and Molnar, 1990), and June 1992 (Streff, Molnar, and Christoff, 1993). The fifteenth, sixteenth, and seventeenth survey waves were conducted during September 1993 (Streff, Eby, Molnar, Joksch, and Wallace, 1993), September 1994 (Eby, Streff, and Christoff, 1994), September 1995 (Eby, Streff, and Christoff, 1995) The eighteenth survey wave, reported here, was conducted 146 months after the mandatory safety belt law first took effect in Michigan.

In all but the fifteenth survey, belt use was examined by age, gender, seating position, time of day, day of week, type of road, weather conditions, vehicle type, and region of the state by direct observation of vehicles stopped at traffic lights or stop signs. In order to better relate Michigan's belt use rates to other states, the fifteenth, sixteenth, and seventeenth survey waves used a new sample design that took advantage of federal guidelines for safety belt surveys (National Highway Traffic Safety Administration, 1992). Based upon these guidelines, belt use could be estimated by observing only shoulder belt use of front outboard occupants. Therefore, in these survey waves only the front outboard occupants in various vehicle types were observed. The same survey design and method was used in the present survey.

METHODS

Sample Design

The sample design for the present survey was closely based upon the one used by Streff, Eby, Molnar, Joksch, and Wallace (1993). While the entire sampling procedure is presented in the previous report, it is repeated here for completeness, with the modifications noted.

The goal of this sample design was to select observation sites that represent accurately all vehicle motorists in eligible vehicles in Michigan (i.e., passenger cars, vans, sport-utility vehicles, and pickup trucks), while following federal guidelines for safety belt survey design (National Highway Traffic Safety Administration, 1992). An ideal sample minimizes total survey error while providing sites that can be surveyed efficiently and economically. To achieve this goal, the following sampling procedure was used.

To reduce the costs associated with direct observation of remote sites, the National Highway Traffic Safety Administration (NHTSA) guidelines allow states to omit from their sample space the lowest population counties, provided these counties account for 15 percent or less of the state's total population. Therefore, all 83 Michigan counties were rank ordered by population (U.S. Bureau of the Census, 1992) and the low population counties were eliminated from the sample space. This step reduced the sample space to 28 counties.

These 28 counties were then separated into four strata. The strata were constructed by obtaining historical belt use rates and vehicle miles of travel (VMT) for each county. Historical belt use rates were determined by averaging results from three previous UMTRI surveys (Wagenaar, Molnar, and Businski, 1987b, 1988b; Wagenaar and Molnar, 1989). Since no historical data were available for six of the counties, belt use rates for these counties were estimated using multiple regression based on per capita income and education for the other 22 counties ($r^2 = .56$; U.S. Bureau of the Census, 1992).[1] These

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[1] Education was defined as the proportion of population in the county over 25 years of age with a professional or graduate degree.

factors have been shown previously to correlate positively with belt use (e.g., Wagenaar, et al., 1987a). Because of the disproportionately high VMT for Wayne County, and because we wanted to ensure that observation sites were selected within this county, Wayne County was chosen as a separate stratum. Three other strata were constructed by rank ordering each county by historical belt use rates and then adjusting the stratum boundaries until there was roughly equal total VMT within each stratum. The stratum boundaries were: high belt use (greater than 54.0 percent), medium belt use (45.0 percent to 53.0 percent), low belt use (44.9 percent or lower), and Wayne County (41.9 percent belt use). The historical belt use rates and VMT by county and strata are shown in Table 1.

To achieve the NHTSA required precision of less than five percent relative error, the minimum number of observation sites for the survey (N = 56) was determined based on within- and between-county variances from previous belt use surveys and an estimated 50 vehicles per observation period in the current survey. This minimum number was then increased (N = 168) to get an adequate representation of belt use for each day of the week and all daylight hours.

Because total VMT within each stratum was roughly equal, observation sites were evenly divided among the strata (42 each). In addition, since an estimated 23 percent of all traffic in Michigan occurs on limited-access roadways (Federal Highway Administration, 1982), ten (24 percent) of the sites within each stratum were freeway exit ramps, while the remaining 32 were roadway intersections.

Table 1. Descriptive Characteristics of the Four Strata[2]					
Strata	County	Historical Belt Use, Percentage	Belt Use Average, %	VMT, billions of miles	Total VMT, billions of miles
1			56.3		17.48
	Ingham	54.3		1.98	
	Kalamazoo	54.3		1.98	
	Oakland	54.5		10.66	
	Washtenaw	62.0		2.86	
2			48.8		17.42
	Allegan	***45.2***		0.86	
	Bay	53.7		1.13	
	Eaton	52.5		0.90	
	Gr. Traverse	47.2		0.63	
	Jackson	46.2		1.41	
	Kent	48.9		4.07	
	Livingston	***48.7***		1.44	
	Macomb	48.0		4.83	
	Midland	***50.7***		0.68	
	Ottawa	47.4		1.45	
3			40.9		17.15
	Berrien	41.6		1.68	
	Calhoun	***43.2***		1.40	
	Genesee	42.8		4.12	
	Lapeer	39.6		0.71	
	Lenawee	44.4		0.82	
	Marquette	39.6		0.56	
	Monroe	44.2		1.53	
	Muskegon	41.8		1.11	
	Saginaw	40.7		1.86	
	Shiawassee	***41.6***		0.64	
	St. Clair	34.1		1.38	
	St. Joseph	***41.6***		0.51	
	Van Buren	36.7		0.83	
4					
	Wayne	41.9	41.9	15.29	15.29

[2]Note: Boldface italic type indicates values estimated from multiple regression. The belt use percentages were used only for statistical purposes in this design. Caution should be taken in interpreting these values.

Within each stratum, observation sites were randomly assigned to a location using different methods for intersections and freeway exit ramps. The intersection sites were chosen using a method that ensured each intersection within a stratum had an equal probability of selection. Detailed, equal-scale road maps for each county were obtained and a grid pattern was overlaid on each county map. The grid dimensions were 62 lines horizontally and 42 lines vertically. The lines of the grid were separated by 1/4 inch. With the *3/8 inch:mile* scale of the maps, this created grid squares that were .67 miles per side. (Because Marquette County is so large, it was divided into four maps and each part was treated as a separate county.) Each grid square was uniquely identified by two numbers, a horizontal (or x) coordinate and a vertical (or y) coordinate.

The 42 sites for each stratum were sampled sequentially. The 32 local intersection sites were chosen by first randomly selecting a grid number containing a county within a stratum.[3] This was achieved by generating a random number between 1 and the number of grids within the stratum. So, for example, since the high belt use stratum had four grid patterns overlaying four counties, a random number between 1 and 4 was generated to determine which grid would be selected. Thus, each grid had an equal probability of selection at this step. Once the grid was selected, a random x and a random y coordinate were chosen and the corresponding grid square identified. Thus, each intersection had an equal probability of selection. If a single intersection was contained within the square, that intersection was chosen as an observation site. If the square did not fall within the county, there was no intersection within the square, or there was an intersection but it was located one road link from an already selected intersection, then a new grid number and x, y coordinate were selected randomly. If there was more than one intersection within the grid square, the grid square was subdivided into four equal sections and a random number between 1 and 4 was selected until one of the intersections was randomly chosen. This happened for only two of the sites.

[3] It is important to note that grids were selected during this step rather than counties. This was necessary only because it was impractical to construct a single grid that was large enough to cover all of the counties in the largest stratum when they were laid side by side.

Once a site was chosen, the following procedure was used to determine the particular street and direction of traffic flow that would be observed. For each intersection, all possible combinations of street and traffic flow were determined. From this set of observer locations, one location was randomly selected with a probability equal to 1/number of locations. For example, if the intersection, was a "+" intersection, as shown in Figure 1, then there would be four possible combinations of street and direction of traffic flow to be observed (observers watched traffic only on the side of the street on which they were standing). In Figure 1, observer location number one indicates that the observer would watch westbound traffic and stand next to Main Street. For observer location number two, the observer would watch southbound traffic and stand next to Second Street, and so on. In this example, a random number between 1 and 4 would be selected to determine the observer location for this specific site. The probability of selecting an intersection approach is dependent on the type of intersection. Four-legged intersections like that shown in Figure 1 have four possible observer locations, while three-legged intersections like "T" and "Y" intersections have only three possible observer locations. The effect of this slight difference in probability accounts for .01 percent or less of the standard error in the belt use estimate.

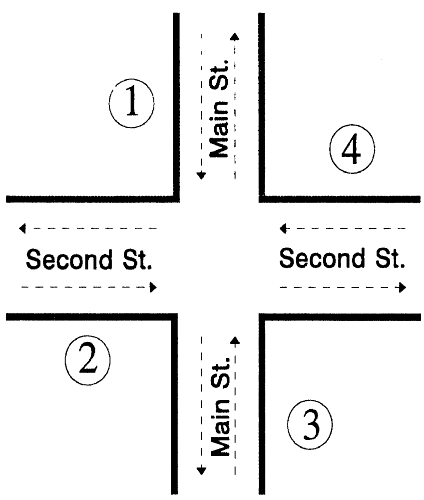

Figure 1. An example "+" intersection showing four possible observer locations.

For each chosen primary intersection site, an alternate site was also selected. The alternate sites were chosen within a 20 x 20 square unit area around the grid square containing the original intersection, corresponding to a 13.4 square mile area around the site. This was achieved by randomly picking an *x*, *y* grid coordinate within the alternate site area. Grid coordinates were selected until a grid square containing an intersection was found. No grid squares were found that contained more than one intersection. The observer location at the alternate intersection was determined in the same way as at the primary site.[4]

The ten freeway exit ramp sites within each stratum also were selected so that each exit ramp had an equal probability of selection.[5] This was done by enumerating all of the exit ramps within a stratum and randomly selecting without replacement ten numbers between one and the number of exit ramps in the stratum. For example, in the high belt use stratum there was a total of 109 exit ramps. To select an exit ramp, a random number between one and 109 was generated. This number corresponded to a specific exit ramp. To select the next exit ramp, another random number between one and 109 was selected with the restriction that no previously selected numbers could be chosen. Once the exit ramps were determined, the observer location for the actual observation was determined by enumerating all possible combinations of direction of traffic flow and side of ramp on which to stand. As in the determination of the observer locations at the roadway intersections, the possibilities were then randomly sampled with equal probability. The alternate exit ramp sites were selected by taking the first interchange encountered after randomly selecting a direction of travel along the freeway from the primary site. If this alternate site was outside of the county or it was already selected as a primary site, then the other direction of travel along the freeway was used. If the exit ramp had no traffic control device (N = 7) on the selected direction of travel, then a researcher visited the site and randomly picked a travel direction and lane that had traffic control.

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[4] For those interested in designing a safety belt survey for their county or region, a guidebook for selecting and surveying sites for safety belt use is available (Eby and Streff, 1994) by contacting UMTRI -SBA 2901 Baxter Rd., Ann Arbor, MI 48109-2150 or visiting our Internet World Wide Web site at: *http://www-personal.umich.edu/~eby/sba.html* and looking at our online articles.

[5] An exit ramp is defined here as egress from a limited-access freeway, irrespective of the direction of travel. Thus, on a north-south freeway corridor, the north and south bound exit ramps at a particular cross street are considered a single exit ramp location.

The day of week and time of day for site observation were pseudo-randomly assigned to sites in such a way that all days of the week and all daylight hours (7:00 a.m. - 7:00 p.m.) had essentially equal probability of selection. The sites were observed using a clustering procedure. That is, sites that were located spatially adjacent to each other were considered to be a cluster. Within each cluster, a shortest route between all of the sites was decided (essentially a loop) and each site was numbered. An observer watched traffic at all sites in the cluster during a single day. The day in which the cluster was to be observed was randomly determined. After taking into consideration the time required to finish all sites before darkness, a random starting time for the day was selected. In addition, a random number between one and the number of sites in the cluster was selected. This number determined the site within the cluster where the first observation would take place. The observer then visited sites following the loop in either a clockwise or counter-clockwise direction (whichever direction left them closest to home at the end of the day). This direction was determined by the project manager prior to sending the observer into the field. Because of various scheduling limitations (e.g., observer availability, number of hours worked per week) certain days and/or times were selected that could not be observed. When this occurred, a new day and/or time was randomly selected until a usable one was found. The important issue about the randomization is that the day and time assignments to the sites were not correlated with belt use at a site. This pseudo-random method is random with respect to this issue.

The sample design was constructed so that each observation site was self-weighted by VMT within each stratum. This was accomplished by selecting sites with equal probability and by setting the observation interval to a constant duration (50 minutes) for each site.[6] Thus the number of cars observed at an observation site reflected safety belt use by VMT; that is, the higher the VMT at a site, the greater the number of vehicles that would pass during the 50-minute observation period. However, since all vehicles passing an observer could not be surveyed, a vehicle count of all eligible vehicles (i.e., passenger cars, vans, sport-utility vehicles, and pickup trucks) on the traffic leg under observation was

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[6] Because of safety considerations, sites in the city of Detroit were observed for a different duration. See data collection section for more information.

conducted for a set duration (five minutes) immediately prior to and immediately following the observation period (ten minutes total).

Table 2 shows descriptive statistics for the 168 observation sites. As shown in this table, the observations were fairly well distributed over day of week and time of day. Note that an observation session was included in the time slot that represented the majority of the observation period. If the observation period was evenly distributed between two time slots, then it was included in the later time slot. This table also shows that nearly every site observed was the primary site and most observations occurred on sunny or cloudy days. Note that some of the totals do not add to 100 percent because of rounding.

Table 2. Descriptive Statistics for the 168 Observation Sites

Day of Week		Start Time		Site Choice		Weather	
Monday	12.5%	7-9 AM	13.1%	Primary	97.0%	Sunny	72.0%
Tuesday	16.7%	9-11 AM	16.1%	Alternate	3.0%	Cloudy	24.4%
Wednesday	11.9%	11-1 PM	17.9%			Rain	2.4%
Thursday	17.9%	1-3 PM	17.3%			Snow	0.0%
Friday	14.9%	3-5 PM	21.4%			Unknown	1.2%
Saturday	14.3%	5-7 PM	14.3%				
Sunday	11.9%						
TOTALS	100%		100%		100%		100%

Data Collection

Data collection for the study involved direct observation of shoulder belt use, estimated age, and gender. Trained field staff observed shoulder belt use of drivers and front-right passengers traveling in passenger cars, sport-utility vehicles, vans, and pickup trucks during daylight hours from August 29 to September 30, 1996. Safety belt, age, and gender observations were conducted when a vehicle came to a stop at a traffic light or a stop sign.

Data Collection Forms

Two forms were used for data collection: a site description form and an observation form. The site description form (see Appendix A) provided descriptive information about the site including the site number, location, site type (freeway exit ramp or local intersection), site choice (primary or alternate), observer number, date, day of week, time of day, weather, and a count of eligible vehicles traveling on the proper traffic leg. A place on the form was also furnished for observers to sketch the intersection and to identify observation locations and traffic flow patterns. Finally, a comments section was available for observers to identify landmarks that might be helpful in characterizing the site (e.g., school, shopping mall) and to discuss problems or issues relevant to the site or study.

The second form, the observation form, was used to record safety belt use, passenger information, and vehicle information (see Appendix A). Each observation form was divided into four boxes with each box having room for the survey of a single vehicle. For each vehicle surveyed, shoulder belt use, gender, and estimated age for the driver as well as vehicle type were recorded on the upper half of the box, while the same information for the front outboard passenger could be recorded in the lower half of the box if there was a front-right passenger present. Children riding in child restraint devices were recorded as belted. Occupants observed with their shoulder belt worn under the arm or behind the back were noted but considered as belted in the analysis. At each site, the observer carried several data collection forms and completed as many as were necessary during the observation period.

Procedures at Each Site

All sites in the sample were visited by single observers for a period of one hour, with the exception of sites in the city of Detroit. To address potential security concerns, Detroit sites were visited by two-person teams of observers for a period of 30 minutes. Because each team member at Detroit sites recorded data for different lanes of traffic, the total amount of data collection time at Detroit sites was equivalent to that at other sites.

Upon arriving at a site, observers determined whether observations were possible at the site. If observations were not possible (e.g., due to construction), observers proceeded to the alternate site. Otherwise, observers completed the site description form and then moved to their observation position near the traffic control device.

Observers were instructed to observe only the lane immediately adjacent to the curb for safety belt use regardless of the number of lanes present. At sites visited by two-person teams, team members observed different lanes of the same traffic leg (either standing with one observer on the curb and one observer on the median, if there was more than one traffic lane and a median, or on diagonally opposite corners of the intersection).

At each site, observers conducted a five-minute count of all eligible vehicles on the designated traffic leg before beginning safety belt observations. Observations began immediately after completion of the count and continued for 50 minutes at sites with one observer and 25 minutes at sites with two observers. During the observation period, observers recorded data for as many eligible vehicles as they could observe. If traffic flow was heavy, observers were instructed to record data for the first eligible vehicle they saw and then look up and record data for the next eligible vehicle they saw, continuing this process for the remainder of the observation period. At the end of the observation period, a second five-minute vehicle count was conducted at single-observer sites (so that time spent at single-observer sites totaled one hour compared to one half hour at two-observer sites).

Observer Training

Prior to data collection, field observers participated in four days of intensive training including both classroom review of data collection procedures and practice field observations. Each observer received a training manual containing detailed information on field procedures for observations, data collection forms, and administrative policies and procedures. Included in the manual was a listing of the sites for the study that identified the location of each site and the traffic leg to be observed (see Appendix B for a listing of the sites), as well as a site schedule identifying the date and time each site was to be observed.

After intensive review of the manual, observers conducted practice observations at several sites chosen to represent the types of sites and situations that would actually be encountered in the field. None of these practice sites were the same as sites observed during the study. Training at each practice site focused on completing the site description form, determining where to stand and which lanes to observe, conducting the vehicle count, recording safety belt use, and estimating age and gender. Observers worked in teams of two, observing the same vehicles, but recording data independently on separate data collection forms. Teams were rotated throughout the training to ensure that each observer was paired with every other observer at least eight times. Each observer pair practiced recording safety belt use, gender, and age until there was an interobserver reliability of at least 85 percent in all measures for both observed drivers and front-right passengers for each pair of observers.

Each observer was provided with an atlas of Michigan county maps and all necessary field supplies. Observers were given time to mark their assigned sites on the appropriate maps and plan travel routes to the sites. After marking the sites on their maps, the marked locations were compared to a master map of locations to ensure that the correct sites had been pinpointed. Field procedures were reviewed for the final time and observers were informed that unannounced site visits would be made by the field supervisor during data collection to ensure adherence to study protocols.

Observer Supervision and Monitoring

During data collection, each observer was spot checked in the field on at least two occasions by the field supervisor. Contact between the field supervisor and field staff was also maintained on a regular basis through staff visits to the UMTRI office to drop off completed forms and through telephone calls from staff to report progress and discuss problems encountered in the field. Field staff were instructed to call the field supervisor at home if problems arose during evening hours or on weekends.

Incoming data forms were examined by the field supervisor and problems (e.g., missing data, discrepancies between the site description form and site listing or schedule) were noted and discussed with field staff. Attention was also given to comments on the site description form about site-specific characteristics that might affect future surveys (e.g., traffic flow patterns, traffic control devices, site access).

Data Processing and Estimation Procedures

The site and data collection forms were keypunched into an electronic format. The accuracy of the data entry was verified in two ways. First, all data were keypunched twice and the data sets were compared for consistency. Second, the data from randomly selected sites were reviewed for accuracy by a second party and all site data were checked for inconsistent codes (e.g., the observation end time occurring before the start time). Errors were corrected after consultation with the original data forms.

For each site, computer analysis programs determined the number of observed vehicles, belted and unbelted drivers, and belted and unbelted passengers. Separate counts were made for each independent variable in the survey (i.e., site type, time of day, day of week, weather, gender, age, and vehicle type). This information was combined with the site information to create a file used for generating study results.

As mentioned earlier, our goal in this safety belt survey was to estimate belt use for the state of Michigan based on VMT. As also discussed, the self-weighting-by-VMT scheme employed is limited by the number of vehicles for which an observer can accurately record information. To correct for this limitation, the vehicle count information was used to weight the observed traffic volumes so they would more accurately reflect VMT.

This weighting was done by first adding each of the two five-minute counts and then multiplying this number by five so that it would represent a 50-minute duration.[7] The resulting number was the estimated number of vehicles passing the site if all eligible vehicles had been included in the survey during the observation period at that site. The estimated count then was divided by the actual vehicle count for each vehicle type to obtain a VMT weighting factor for that site and vehicle type. This weighting factor was

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[7] As mentioned previously, the Detroit sites were visited by pairs of observers for half as long. For these sites, the single five-minute count was multiplied by five to represent the 25-minute observation period.

multiplied by the actual vehicle counts at the site, yielding a weighted N for the number of total drivers and passengers and total number of belted drivers and belted passengers for each vehicle type. Unless otherwise indicated, all analyses reported are based upon the weighted values.

The overall estimate of belt use per VMT and vehicle type in Michigan was determined by first calculating the belt use rate within each stratum for a vehicle type using the following formula:

$$r_i = \frac{TotalNumberofBeltedOccupants,weighted}{TotalNumberofOccupants,weighted}$$

where r_i refers to the belt use rate for a certain vehicle type within any of the four strata. The totals are the sums across all 42 sites within the stratum after weighting, and occupants refers to only front outboard occupants. The overall estimate of belt use by vehicle type was computed by averaging the belt use rates for each stratum. However, comparing total VMT among the strata, one finds that the Wayne County stratum is only 88 percent as large as the total VMT for the other three strata (see Table 1). In order to represent accurately safety belt use for Michigan by VMT, the Wayne County stratum was multiplied by 0.88 during the averaging to correct for its lower total VMT. The overall belt use rate for a vehicle type was determined by the following formula:

$$r_{all} = \frac{r_1 + r_2 + r_3 + (0.88 * r_4)}{3.88}$$

where r_i is the belt use rate for a certain vehicle type within each stratum and r_4 the Wayne County stratum.

The estimates of variance and the calculation of the confidence bands for the belt use estimates are complex. See Appendix C for a detailed description of the formulas and procedures.

RESULTS

The current direct observation survey of safety belt use in Michigan measured safety belt use as a function of four vehicle types: passenger cars, vans, sport-utility vehicles, and pickup trucks. This represents a slight departure from the fifteenth survey in which only passenger cars were observed (Streff, Molnar, Joksch, and Wallace, 1993). Therefore, comparison of the present results with results of the fifteenth survey wave is possible by comparing the current belt use rates for passenger cars only. Comparisons between the current survey results and the sixteenth and seventeenth survey waves can be made for all vehicle types.

Overall Safety Belt Use

As shown in Figure 2, 70.8 percent ± 3.4 percent of all front outboard occupants traveling in passenger cars in Michigan during September 1996 were restrained with shoulder belts. The "±" value following the use rate indicates a 95 percent confidence band around the percentage. This value should be interpreted to mean that we are 95 percent sure that the actual safety belt use rate falls somewhere between 67.4 percent and 74.2 percent. When compared with last year's rate of 66.8 percent, this year's estimated safety belt use rate for passenger cars represents an impressive increase over the last twelve months.

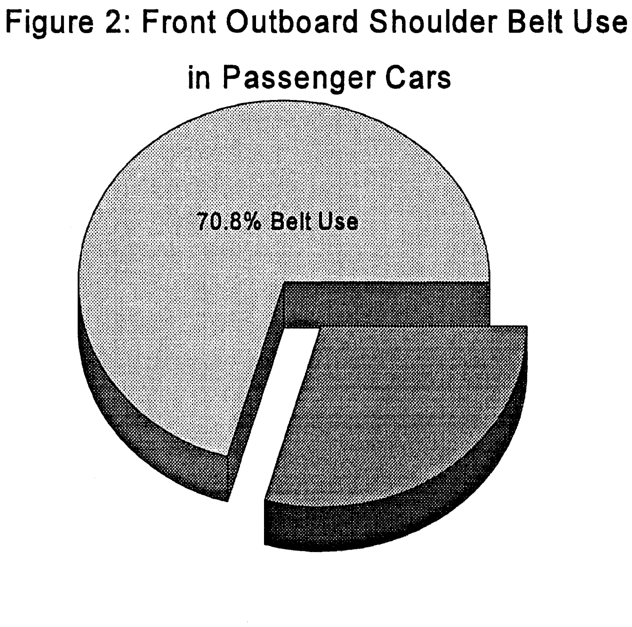

Figure 2. Front Outboard Shoulder Belt Use in Passenger Cars

Estimated belt use rates and unweighted numbers of occupants (N) by strata and vehicle type are shown in Tables 3a to 3d. The strata estimates by passenger cars (Table 3a) show that belt use patterns during September 1996 generally followed the historical trends, except that Stratum 2 had a slightly higher belt use rate than Stratum 1. The Wayne County stratum (Stratum 4) has consistently the lowest overall belt use rate for passenger cars relative to the other three strata. The 65.3 percent estimated belt use rate (passenger cars) for Wayne County, however, represents an increase of 5.5 percentage points from last year. Impressive strides have also been achieved in Stratum 3 where the use rate has increased by seven percentage points since last year. These findings show that efforts to increase belt use statewide are showing effectiveness and should be continued. However, the low belt use rate for Stratum 4, relative to other regions of the state, indicates that measures to increase belt use would still have the greatest potential impact if concentrated in the Wayne County area.

As discovered last year, estimated belt use for front outboard occupants of sport-utility vehicles (Table 3b) was higher than other vehicle types-- overall 71.6 percent. As expected from previous surveys (e.g., Streff, Molnar, & Christoff, 1993; Eby, Streff, & Christoff, 1994), the overall belt use rate of 47.7 percent for pickup trucks was lower than for any other vehicle type (Table 3d). Since these vehicles were the second most common vehicle type observed in the survey, the results suggest that pickup truck drivers and passengers could greatly benefit from belt use programs designed specifically for them.

Table 3a. Percent Shoulder Belt Use by Stratum (Passenger Cars)		
	Percent Use	Unweighted N
Stratum 1	73.3	1,774
Stratum 2	73.4	947
Stratum 3	70.6	840
Stratum 4	65.3	2,232
STATE OF MICHIGAN	**70.8**	5,793

Table 3b. Percent Shoulder Belt Use by Stratum (Sport-Utility Vehicles)		
	Percent Use	Unweighted N
Stratum 1	71.0	207
Stratum 2	73.3	152
Stratum 3	81.5	122
Stratum 4	59.3	222
STATE OF MICHIGAN	**71.6**	703

Table 3c. Percent Shoulder Belt Use by Stratum (Vans/Minivans)		
	Percent Use	Unweighted N
Stratum 1	71.1	304
Stratum 2	66.9	187
Stratum 3	62.7	193
Stratum 4	69.9	367
STATE OF MICHIGAN	**67.6**	1,051

Table 3d. Percent Shoulder Belt Use by Stratum (Pickup Trucks)		
	Percent Use	Unweighted N
Stratum 1	55.7	407
Stratum 2	47.6	282
Stratum 3	36.0	290
Stratum 4	52.1	381
STATE OF MICHIGAN	**47.7**	1,360

Safety Belt Use by Subgroup

Site Type. Estimated safety belt use by type of site is presented in Table 4 as a function of vehicle type. As found in most previous surveys, vehicle occupants observed at freeway exit ramps showed higher safety belt use rates than vehicle occupants observed at local intersections. This effect was consistent for all vehicle types.

Time of Day. Estimated safety belt use by time of day and vehicle type is shown in Table 4. Note that these data were collected only during daylight hours. In general, belt use was highest during the morning commute hours. No other systematic trends were evident.

Day of Week. Estimated safety belt use by day of week and vehicle type is shown in Table 4. Note that the survey was conducted over a four-week period that included Labor Day. Belt use clearly varied from day to day, but no systematic trends were evident. This finding is inconsistent with previous surveys that have shown belt use to be generally highest on Sunday.

Weather. Estimated belt use by prevailing weather conditions is shown in Table 4. No systematic trends were evident.

Gender. Estimated safety belt use by gender and type of vehicle is shown in Table 4. Estimated safety belt use is higher for females than for males in all four vehicle types studied. Such results have been found in every Michigan safety belt survey conducted by UMTRI.

Age. Estimated safety belt use by age and vehicle type is shown in Table 4. For all vehicle types, except sport utility vehicle where only four individuals were observed, the 0-3 year age group had the highest belt use rate, as is typically found. For all vehicle types, the 16-29 age group had the lowest belt use rate. These results are similar to findings in previous UMTRI studies (see e. g., Streff, Molnar, and Christoff, 1993). An interesting finding within all vehicle types is the belt use rate for the 4-15 year old age group. One would expect that individuals in this age group would be belted at nearly the same rate as the youngest age group since parents and other adults would have primary responsibility for ensuring that those in this age group are belted (as with the 0-3 year old age group). However, for all vehicle types except sport-utility vehicles, belt use rates show a decline for the 4-to-15-year-old age group as compared with the younger age group. This decline continues into the next age group (16 to 29 years old). These results show that efforts should be directed toward preventing the decline of belt use that occurs between the ages of 4 and 15. Finally, belt use for the 60 and over age group was high. For all vehicle types, the estimated belt use in this age group was highest among occupants of driving age.

Table 4. Percent Shoulder Belt Use and Unweighted N by Vehicle Type and Subgroup

	Passenger Car		Sport-Utility Vehicle		Van/Minivan		Pickup Truck	
	Percent Use	Unweighted N	Percent Use	Unweighted N	Percent Use	Unweighted N	Percent Use	Unweighted N
Site Type								
Intersection	69.8	4,235	70.8	518	66.3	764	46.2	1074
Exit Ramp	74.3	1,558	76.4	185	71.8	287	53.3	286
Time of Day								
7 - 9 am	70.2	510	76.4	84	76.0	87	53.6	115
9 - 11 am	78.2	580	73.1	105	63.5	115	49.0	195
11 - 1 pm	74.0	889	71.8	90	63.2	158	48.9	205
1 - 3 pm	65.6	1,206	61.9	132	62.4	231	49.2	276
3 - 5 pm	66.8	1,384	63.7	149	66.6	230	46.5	322
5 - 7 pm	66.4	1,224	72.7	143	68.4	230	38.8	247
Day of Week								
Monday	65.7	991	57.8	85	62.7	162	41.3	112
Tuesday	77.7	971	75.4	135	78.7	202	48.4	250
Wednesday	68.4	420	72.7	50	47.4	61	41.5	116
Thursday	68.4	788	65.4	96	77.2	145	48.7	211
Friday	67.2	1,357	79.7	169	62.7	227	46.6	331
Saturday	72.5	662	63.3	82	73.2	138	44.8	203
Sunday	74.4	604	60.6	86	72.5	116	63.3	137
Weather								
Sunny	72.2	4,032	73.1	475	66.4	739	48.2	969
Cloudy	67.3	1,518	71.0	209	69.2	271	45.3	324
Rainy	58.4	167	33.0	12	65.0	35	47.1	38
Gender								
Male	63.6	2,737	65.4	374	60.3	486	44.6	1,093
Female	76.7	2,990	79.3	329	72.7	564	60.1	266
Age								
0 - 3	81.2	32	81.5	4	87.0	7	71.3	8
4 - 15	78.1	165	88.7	25	71.8	70	50.6	31
16 - 29	63.6	1,747	62.9	208	51.7	155	42.5	431
30 - 59	73.0	2,961	73.8	426	68.1	699	49.4	784
60 - Up	73.9	820	76.9	40	79.0	119	54.5	104

Age and Gender. Table 5 shows estimated safety belt use rates and unweighted numbers (N) of occupants for passenger cars only. An analysis of belt use by age and gender was not possible for the other vehicle types because there would have been too few occupants observed in each category to be able to make meaningful estimates. For passenger cars, the belt use rates for the two youngest age groups should be interpreted with caution since the unweighted number of occupants is quite low. As expected, belt use for females in all age groups was generally higher than for males. However, the absolute difference in belt use rates between genders varied greatly depending upon the age group. The most notable difference is found in the 16-to-29-year-old group, where the estimated belt use rate is 21.1 percentage points higher for females than for males. The belt use rate disparity between genders diminishes as age increases, with an 8.9 percentage point differences found for the sixty-and-over age group. These results argue strongly for statewide efforts to be directed at getting young males to wear their safety belts.

Table 5. Percent Front Outboard Shoulder Belt Use and Unweighted N by Age and Gender (Passenger Cars)

	Male		Female	
	Percent Use	Unweighted N	Percent Use	Unweighted N
0 - 3	86.4	16	63.3	16
4 - 15	75.6	73	80.2	92
16 - 29	51.5	848	72.6	898
30 - 59	67.2	1397	78.3	1564
60 - Up	69.0	400	77.9	419

Historical Trends (1993-1996)

The current direct observation survey is the fourth survey in a row that utilizes the sampling design and procedures implemented in 1993 (Streff, Eby, Molnar, Joksch, and Wallace, 1993). As such, it is now possible to investigate safety belt use trends over the last four years for passenger car occupants (note that only passenger cars were observed in the 1993 study).

Overall Belt Use Rate. Figure 3 shows the statewide safety belt use rate for passenger cars over the last four years. The use rate has shown a consistent increase over the last four years.

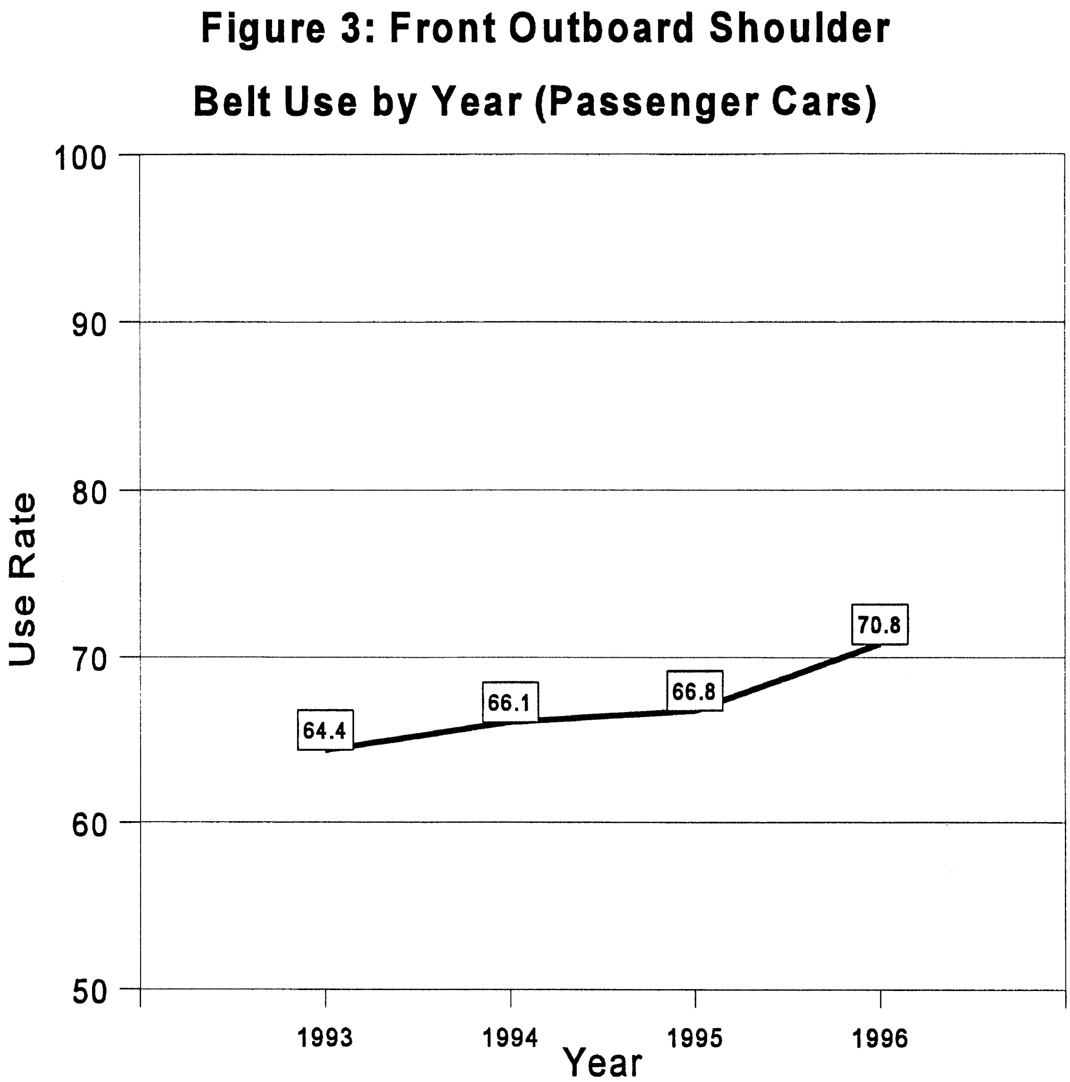

Figure 3. Front Outboard Shoulder Belt Use by Year.

Belt Use by Site Type. Figure 4 shows the estimated safety belt use rates as a function of whether the site was a freeway exit ramp or a local intersection. The difference in use rates has remained fairly consistent over the last four years, with the use rate for freeway exit ramps two to three percentage points higher than local intersections.

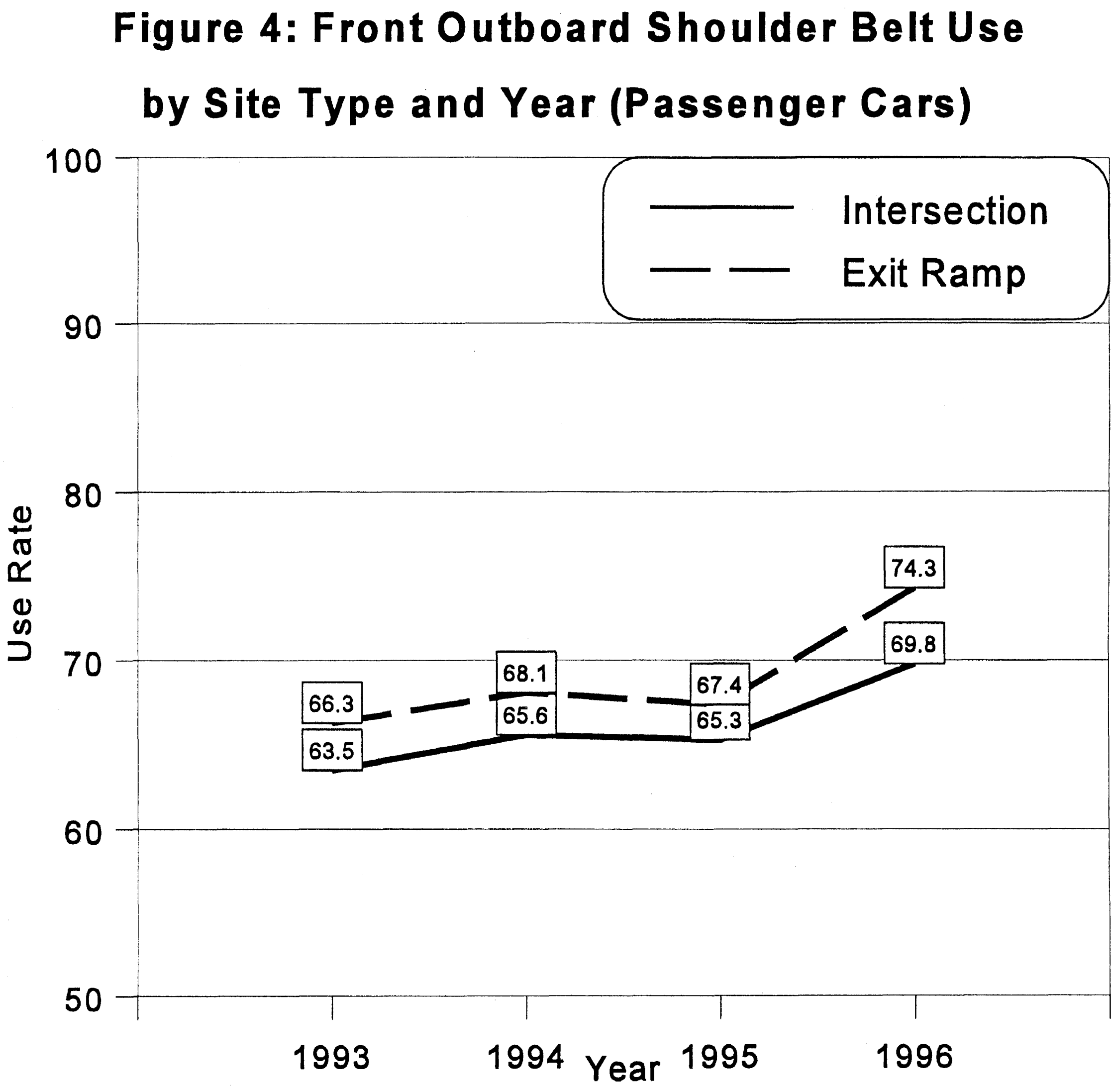

Figure 4. Front Outboard Shoulder Belt Use by Site Type and Year.

Belt Use By Gender. Figure 5 shows front outboard safety belt use over the last three years by gender. (Note that the 1993 survey did not include data about the gender of vehicle occupants.) The difference in use rates by gender does not show a systematic trend, although in the current survey year the difference is greater than the other two years. There are too few survey years to determine if this trend is likely to continue.

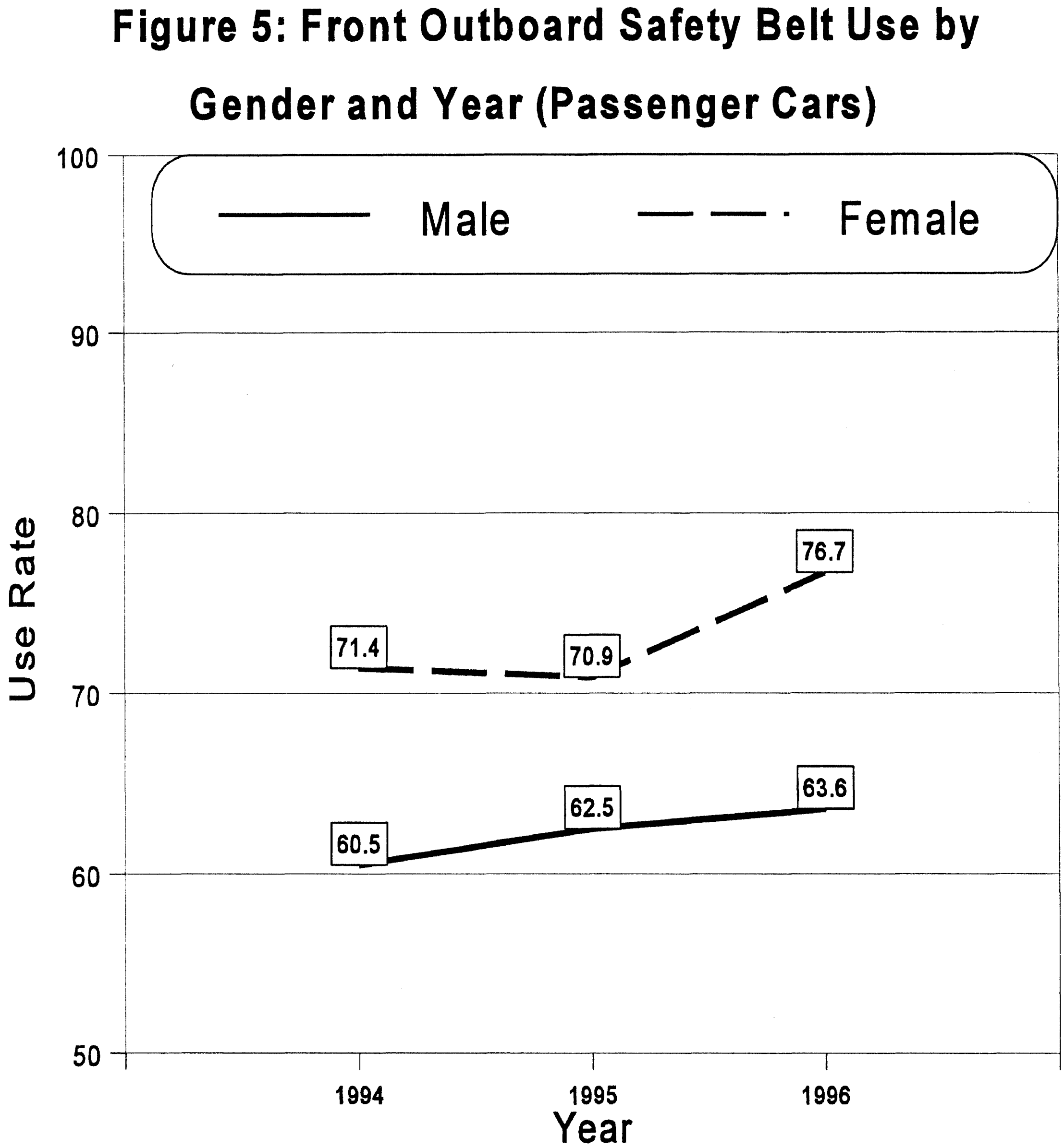

Figure 5. Front Outboard Shoulder Belt Use by Gender and Year.

Belt Use by Age. Figure 6 shows front outboard safety belt use over the last three years by age group for passenger cars. As shown in this figure, the use rates by age have been consistently ordered each year except for the 4-to-15-year-old age group.

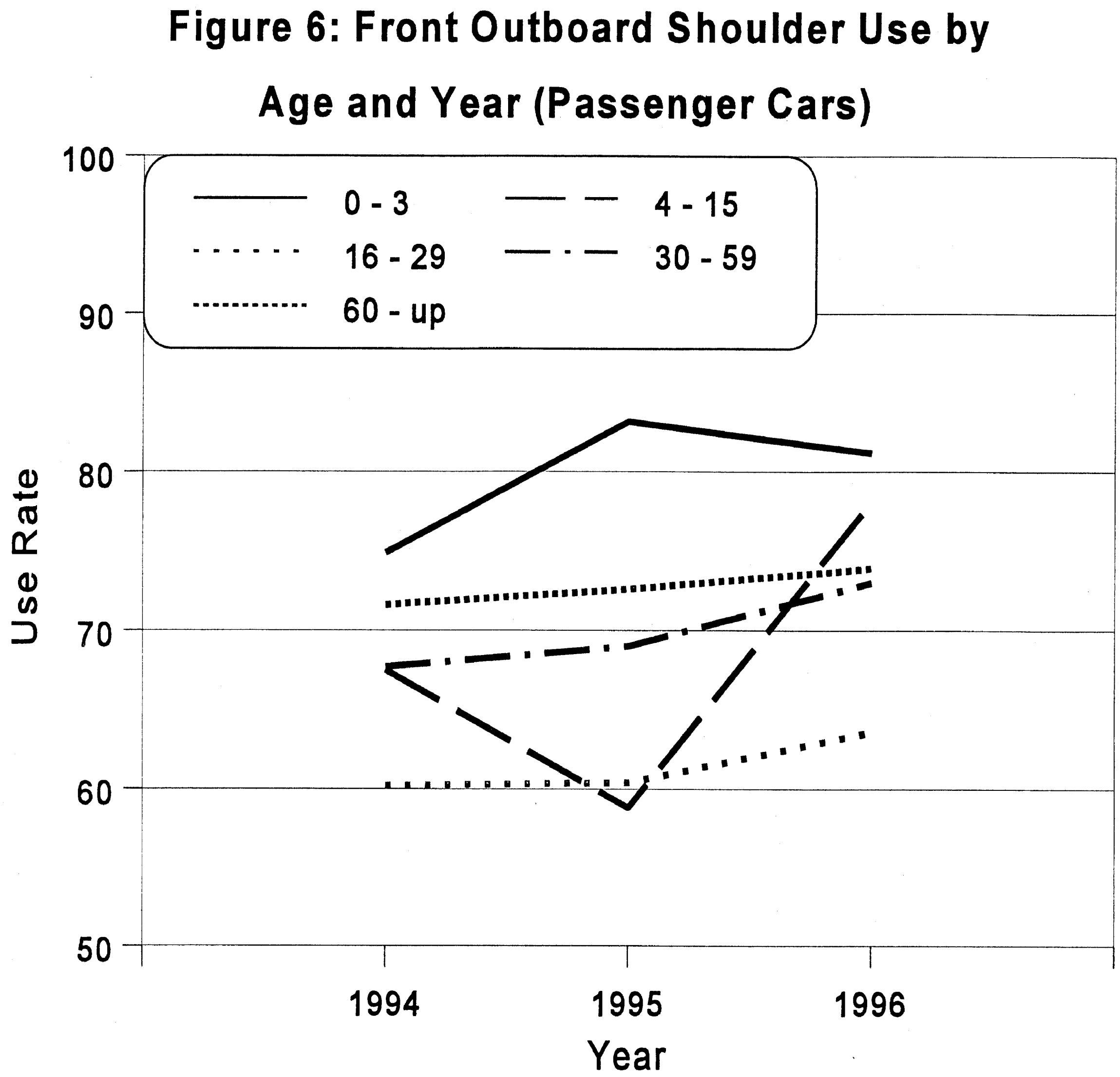

Figure 6. Front Outboard Shoulder Belt Use by Age and Year.

DISCUSSION

The estimated statewide belt use rate for front outboard occupants of passenger cars was 70.8 ± 3.4 percent. When compared with last year's use rate of 66.8 ± 2.4 percent (Eby, Streff, and Christoff, 1994), the current rate shows that front outboard shoulder belt use in Michigan has increased impressively over the last twelve months and represents one of the largest yearly increases in belt use Michigan has ever experienced.

Comparing results over survey years shows that promising progress has been made in increasing safety belt use among the Michigan population most likely not to be wearing a safety belt. In particular, this year's results showed good increases in belt use for Wayne County and for passenger car occupants 16 to 29 years of age, categories that have traditionally shown low use rates.

These findings show that the enforcement and public information and education (PI&E) programs by the Michigan Department of State Police Office of Highway Safety Planning, and other local programs, have been effective in increasing belt use among the majority of the Michigan population. However, a national goal of 75 percent belt use has been set for 1997. As the effectiveness of current programs is realized, those residents who remain unbelted will be the most difficult to get to wear safety belts and will likely require programs not yet utilized. Therefore, In order to reach this goal for Michigan we must maintain the current efforts and begin new activities to increase safety belt use.

One activity that could be effective in increasing safety belt use would be to change the specific provisions of Michigan's safety belt law. Specifically, compliance with Michigan's safety belt law would be facilitated if the law permitted primary enforcement. Findings from a study by Campbell (1987), as well as our own calculations, indicate that statewide belt use rates are higher in states with primary enforcement than in states with secondary enforcement. Further support for this claim comes from California, where primary enforcement has recently been implemented. An evaluation of belt use both before and after implementation of a primary enforcement law showed that belt use increased from 58 to 76 percent in the first few months after switching to primary enforcement (Ulmer, Preusser, and Preusser, 1994).

Even without such new legislation, stricter enforcement of the current law, coupled with major publicity campaigns, can be effective in increasing belt use. Issuing safety belt citations regularly to motorists being cited for another violation can be particularly effective in increasing safety belt use because traffic law offenders, in particular drinking drivers, are less likely to use safety belts than nonoffenders (e.g., Foss, Bierness, and Sprattler, 1994, Evans, 1991). In an effort to facilitate secondary enforcement of safety belt laws, the Michigan Office of Highway Safety Planning has supported a project to test the effectiveness of a new UD-8 citation form that allows an officer to write up to three violations on a single form. Results of this study show that use of the new UD-8 led to an increase in verbal warnings of safety belt violations, safety belt citations issued, and guilty dispositions of these cases (Streff, Lang, and Christoff, 1994). Thus, even with secondary enforcement, police have many opportunities to affect the segment of the population at greatest risk for nonuse. It is important to remember, however, that many police officers perceive significant disincentives for issuing secondary belt citations. Consideration should be given to including incentives for officers and their commanders in programs targeting increased belt law enforcement.

Finally, even if enforcement and PI&E programs are being conducted, statewide belt use may not increase dramatically because these programs may be reaching only audiences that already have high belt use rates. The current study reports belt use rates separated into several important demographic categories. These categorical belt use rates suggest that certain populations could benefit particularly from a safety belt enforcement and PI&E program. For example, based upon the present survey results, the person most likely to be violating Michigan's safety belt law is a male, age 16 to 29, traveling in a pickup truck on a local road in Wayne County (Stratum 4). By targeting programs designed to increase safety belt use at those populations most likely to benefit, one can maximize belt use increases while spending the least amount of money.

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APPENDIX A

Data Collection Forms

1996 SITE DESCRIPTION FORM

SITE # __ __ __ SITE LOCATION ______________________________
1 2 3

SITE TYPE
1☐ Intersection
2☐ Freeway
4

Exit no. ________

SITE CHOICE
1☐ Primary
2☐ Alternate
5

TRAFFIC CONTROL
1☐ Traffic Light
2☐ Stop sign
3☐ None
4☐ Other ________________
6

DATE (month/day): __ __/__ __/1996
7 8 9 10

OBSERVER
1☐ TERRY
2☐ CLAIRE
3☐ GARY
4☐ JENNIFER
5☐ DAVID
6☐ FRED
7☐ CARL
11

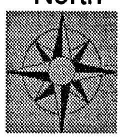
DAY OF WEEK
1☐ Monday
2☐ Tuesday
3☐ Wednesday
4☐ Thursday
5☐ Friday
6☐ Saturday
7☐ Sunday
12

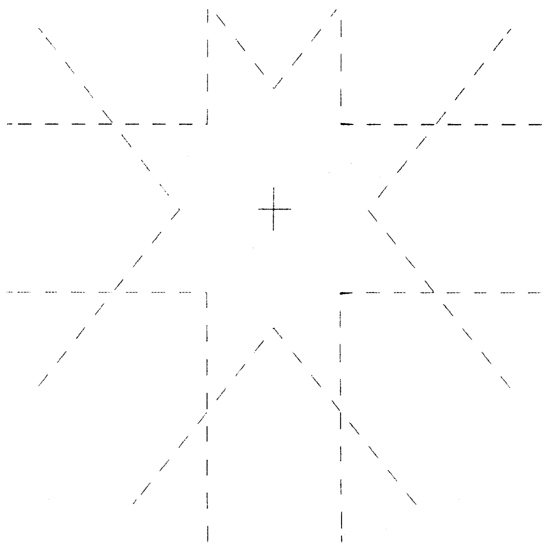
WEATHER
1☐ Mostly Sunny
2☐ Mostly Cloudy
3☐ Rain
4☐ Snow
13

START TIME: __ __:__ __ (24 hour clock) END TIME: __ __:__ __ (24 hr clock)
14 15 16 17 18 19 20 21

INTERRUPTION (total number of minutes during observation period): __ __
22 23

North





Median: 1☐ Yes
2☐ No
24

Traffic Count 1: _______

Traffic Count 2: _______

COMMENTS:

SITE # ___ ___ ___
1 2 3

PAGE #________

ATTENTION CODING: DUPLICATE COL 1 - 3 FOR ALL VEHICLES

DRIVER	1☐ Not belted 2☐ Belted 3☐ B Back 4☐ U Arm 4	1☐ Male 2☐ Female 5	1☐ 0 - 3 2☐ 4 - 15 3☐ 16 - 29 4☐ 30 - 59 5☐ 60+ 6	VEHICLE TYPE 1☐ Passenger car 2☐ Van 3☐ Utility 4☐ Pick-up 7
FRONT-RIGHT PASSENGER	1☐ Not belted 2☐ Belted 3☐ B Back 4☐ U Arm 5☐ CRD 8	1☐ Male 2☐ Female 9	1☐ 0 - 3 2☐ 4 - 15 3☐ 16 - 29 4☐ 30 - 59 5☐ 60+ 10	

DRIVER	1☐ Not belted 2☐ Belted 3☐ B Back 4☐ U Arm 4	1☐ Male 2☐ Female 5	1☐ 0 - 3 2☐ 4 - 15 3☐ 16 - 29 4☐ 30 - 59 5☐ 60+ 6	VEHICLE TYPE 1☐ Passenger car 2☐ Van 3☐ Utility 4☐ Pick-up 7
FRONT-RIGHT PASSENGER	1☐ Not belted 2☐ Belted 3☐ B Back 4☐ U Arm 5☐ CRD 8	1☐ Male 2☐ Female 9	1☐ 0 - 3 2☐ 4 - 15 3☐ 16 - 29 4☐ 30 - 59 5☐ 60+ 10	

DRIVER	1☐ Not belted 2☐ Belted 3☐ B Back 4☐ U Arm 4	1☐ Male 2☐ Female 5	1☐ 0 - 3 2☐ 4 - 15 3☐ 16 - 29 4☐ 30 - 59 5☐ 60+ 6	VEHICLE TYPE 1☐ Passenger car 2☐ Van 3☐ Utility 4☐ Pick-up 7
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FRONT-RIGHT PASSENGER	1☐ Not belted 2☐ Belted 3☐ B Back 4☐ U Arm 5☐ CRD 8	1☐ Male 2☐ Female 9	1☐ 0 - 3 2☐ 4 - 15 3☐ 16 - 29 4☐ 30 - 59 5☐ 60+ 10	

APPENDIX B
Site Listing

1996 Direct Observation Sites

No.	County	Primary Site Location	Alternate Site Location	Type	Str
001	Oakland	EB Whipple Lake Rd. & Eston Rd.	EB Clarkston Rd. & Joslyn Rd.	I	1
002	Kalamazoo	EB S Ave. & 29th St.	NB 34th St. & V Ave.	I	1
003	Oakland	SB Pontiac Trail & 10 Mile Rd.	EB 12 Mile Rd. & South Hill Rd.	I	1
004	Washtenaw	SB Moon Rd. & Ann Arbor-Saline Rd./Saline-Milan Rd.	SB Moon Rd. & Willis Rd.	I	1
005	Oakland	WB Drahner Rd. & Baldwin Rd.	WB Waldon Rd. & Clintonville Rd.	I	1
006	Oakland	SB Rochester Rd. & 32 Mile Rd./Romeo Rd.	NB Townsend Rd. & Romeo Rd.	I	1
007	Oakland	SB Williams Lake Rd. & Elizabeth Lake Rd.	EB Davisburg Rd. & Bigelow Rd.	I	1
008	Ingham	SB Searles Rd. & Iosco Rd.	EB Grand River Rd. & Elm Rd.	I	1
009	Kalamazoo	WB D Ave. & Riverview Dr.	EB DE Ave. & 32nd St.	I	1
010	Washtenaw	EB N. Territorial Rd. & Dexter-Pinckney Rd.	SB Jennings Rd. & N. Territorial Rd.	I	1
011	Washtenaw	NB Schleeweis Rd./Macomb St. & W. Main St.	SB Sharon Rd. & Ely Rd.	I	1
012	Ingham	NB Shaftsburg Rd. & Haslett Rd.	EB Rowley Rd. & Webberville Rd.	I	1
013	Oakland	NB Middlebelt Rd. & 9 Mile Rd.	SB Evergreen Rd. & 9 Mile Rd.	I	1
014	Washtenaw	WB Packard Rd. & Carpenter Rd.	NB Newport Rd. & Miller Rd.	I	1
015	Ingham	EB Haslett Rd. & Marsh Rd.	EB Bell Oak Rd. & Morrice Rd.	I	1
016	Washtenaw	NB Jordan Rd./Monroe St. & US-12/Michigan Ave.	NB Stoney Creek & Day Rd.	I	1
017	Washtenaw	SB M-52/Main St. & Old US-12	EB Scio Church Rd. & Fletcher Rd.	I	1
018	Kalamazoo	SB 8th St. & Q Ave.	WB Centre Ave. & Cox's Dr.	I	1
019	Washtenaw	WB 8 Mile Rd. & Pontiac Trail	NB Pontiac Trail & 7 Mile Rd.	I	1
020	Oakland	SB Lahser Rd. & 11 Mile Rd.	EB 10 Mile Rd. & Livernois Rd.	I	1
021	Kalamazoo	NB Ravine Rd. & D Ave.	NB Westnedge Ave. & F Ave.	I	1
022	Washtenaw	EB Glacier Way/Glazier Way & Huron Pkwy.	SB Main St. & Stadium Blvd.	I	1
023	Washtenaw	WB Bethel Church Rd. & M-52	SB Clinton Rd. & Austin Rd.	I	1
024	Washtenaw	SB Platt Rd. & Willis Rd.	WB Textile Rd. & Maple Rd.	I	1

025	Ingham	WB Fitchburg Rd. & Williamston Rd.	NEB Kirby Rd. & Race Rd.	I	1
026	Washtenaw	EB Merritt Rd. & Stoney Creek Rd.	SB Ridge Rd. & Mott Rd.	I	1
027	Oakland	SB Hickory Ridge Rd. & M-59/Highland Rd.	WB Commerce Rd. & Duck Lake Rd.	I	1
028	Kalamazoo	SB Douglas Ave. & D Ave.	NB 5th St. & D Ave.	I	1
029	Oakland	WB Walnut Lake Rd. & Haggerty Rd.	EB Grand River Rd. & Taft Rd.	I	1
030	Oakland	NB Jossman Rd. & Grange Hall Rd.	NWB Groveland Rd. & Dixie Hwy.	I	1
031	Kalamazoo	EB H Ave. & 3rd St.	WB G Ave. & 7th St.	I	1
032	Kalamazoo	EB TU Ave. & 24th St./Sprinkle Rd.	EB RS Ave. & 26th St.	I	1
033	Oakland	EBR I-96 & Wixom Rd. (Exit 159)	WBR I-96 & Milford Rd.	ER	1
034	Washtenaw	WBL I-94 & Whittaker Rd./Huron St. (Exit 183)	EBL I-94 & US-12/Michigan Ave.	ER	1
035	Kalamazoo	SBR US-131 & M-43	SBL US-131 & Stadium Dr.	ER	1
036	Washtenaw	SBR US-23 & N. Territorial Rd.	NBL US-23 & Whitmore Lake Rd.	ER	1
037	Kalamazoo	EBL I-94 & Portage Rd.	EBR I-94 & Sprinkle Rd.	ER	1
038	Oakland	EBL I-696 & Orchard Lake Rd.	EBL I-696 & Novi Rd.	ER	1
039	Kalamazoo	WBL I-94 & 9th St. (Exit 72)	EBL I-94 & Westnedge Ave.	ER	1
040	Washtenaw	WBR I-94 & Jackson Rd.	EBR I-94 & Ann Arbor-Saline Rd.	ER	1
041	Kalamazoo	NBL US-131 & W Ave./Eliza St.	SBL US-131 & VW Ave.	ER	1
042	Kalamazoo	NBR US-131 & U Ave.	NBL US-131 & Q Ave.	ER	1
043	Livingston	SB County-Farm Rd. & Coon Lake Rd.	NB Pettysville Rd. & Rush Lake Rd.	I	2
044	Bay	WB Nebodish Rd. & Knight Rd.	SB Bangor Rd. & Marquette Ave.	I	2
045	Macomb	SB Camp Ground Rd. & 31 Mile Rd.	EB Irwin Rd. & Capac Rd.	I	2
046	Jackson	SB Benton Rd./Moon Lake Rd. & M-50/ Brooklyn Rd.	SB Meridan Rd. & White Rd.	I	2
047	Allegan	SB 6th St. & M-89	SB 7th St. & 109th Ave.	I	2
048	Kent	EB 36th St. & Snow Ave.	WB Conservation St. & Honey Creek	I	2
049	Livingston	EB Chase Lake Rd. & Fowlerville Rd.	SB Robb Rd. & Hayner Rd.	I	2
050	Allegan	WB 144th Ave. & 2nd St.	NB 14th St. & 142nd Ave.	I	2

051	Livingston	SB Cedar Lake Rd. & Coon Lake Rd.	EB Swartout Rd. & Chilson Rd.	I	2
052	Jackson	NB Mt. Hope Rd. & Waterloo-Munith Rd.	SB Coon Hill Rd. & Kennedy Rd.	I	2
053	Kent	WB Cascade Rd. & Thornapple River Dr.	WB 68th St. & Cherry Valley Rd.	I	2
054	Allegan	NB 62nd St. & 102nd Ave.	SB 52nd St. & 103 Ave.	I	2
055	Kent	SB Meddler Ave. & 18 Mile Rd.	NB Myers Lake Ave. & 15 Mile Rd.	I	2
056	Eaton	SB Houston Rd. & Kinneyville Rd.	SB Royston Rd. & 5 Point Hwy.	I	2
057	Macomb	SB M-19/Memphis Ridge Rd. & 32 Mile Rd./ Division Rd.	WB 32 Mile Rd. & Pashalk Rd.	I	2
058	Allegan	NB 66th St. & 118th Ave.	WB 124th Ave. & 58th St.	I	2
059	Grn Traverse	NB Silver Lake Rd./County Rd. 633 & US-31	EB Cedar Run Rd. & Barney Rd.	I	2
060	Grn Traverse	EB Riley Rd./Tenth St. & M-137	WB M-113 & Hanna Rd.	I	2
061	Bay	SB 9 Mile Rd. & Beaver Rd.	WB Prevo Rd. & Fraser Rd.	I	2
062	Kent	SB Ramsdell Dr. & M-57/14 Mile Rd.	NB Lincoln Lake Dr. & 18 Mile Rd.	I	2
063	Eaton	NB Ionia Rd. & M-50/Clinton Trail	NB Dow Rd. & Eaton Hwy.	I	2
064	Macomb	EB 23 Mile Rd. & Romeo Plank Rd.	NEB M-97 & Harrington Rd.	I	2
065	Livingston	NB Old US-23/Whitmore Lake Rd. & Grand River Rd.	NB Hamburg Rd. & M-36	I	2
066	Jackson	SWB Horton Rd. & Badgley Rd.	NB Chapel Rd. & Michigan Ave.	I	2
067	Kent	SB Belmont Ave. & West River Dr.	EB Knapp St. & Honey Creek Ave.	I	2
068	Eaton	EB 5 Point Hwy. & Ionia Rd.	NB Stine Dr. & Kinsel Hwy.	I	2
069	Allegan	WB 129th Ave. & 10th St.	EB 135th Ave. & 12th St.	I	2
070	Eaton	EBR M-43 & M-100	SB Dow Rd. & M-50	I	2
071	Ottawa	WB Taylor St. & 72nd Ave.	SB 104th Ave. & Felch St.	I	2
072	Bay	EB Cass Rd. & Farley Rd.	SB Madison Ave. & Youngs Ditch Rd.	I	2
073	Allegan	EB 126th Ave. & 66th St.	EB 138th Ave. & 52nd St.	I	2
074	Bay	NB Mackinaw Rd. & Cody-Estey Rd.	NB 7 Mile Rd. & Newburg Rd.	I	2
075	Jackson	EBR I-94 & Elm Ave.	SBL US-127 & Country Farm Rd. /Springport Rd.	ER	2

076	Kent	NBR US-131 & 100th St. (Exit 74)	NBL US-131 & 84th St.	ER	2
077	Ottawa	NBR I-196 & Byron Rd.	NBR I-196 & 32nd Ave.	ER	2
078	Kent	NBL US-131 & Hall St.	SBL US-131 & Burton St.	ER	2
079	Macomb	SBL M-53 & 26 Mile Rd.	NBR M-53 & 23 Mile Rd.	ER	2
080	Bay	NBR I-75 & Wilder Rd. (Exit 164)	SBL I-75 & Beaver Rd.	ER	2
081	Livingston	EBR I-96 & Fowlerville Rd. (Exit 129)	EBL I-96 & M-59/Highland Rd.	ER	2
082	Macomb	EB I-94 & 12 Mile Rd. (Exit 231)	EB I-94 & Little Mack Rd. (Exit 232)	ER	2
083	Jackson	WBR I-94 & Sargent Rd. (Exit 145)	WBL I-94 & Mt. Hope Rd.	ER	2
084	Allegan	NBL US-31/I-196 & Washington Rd./Blue Star Hwy.	NBL US-31/I-196 & Old US-31/68th St.	ER	2
085	Genesee	SB Van Slyke Rd. & Maple Ave.	EB Hill Rd. & Center Rd.	I	3
086	Monroe	WB Ida Center Rd. & Summerfield Rd.	SEB Teal Rd. & Summerfield Rd.	I	3
087	Saginaw	WB Baldwin Rd. & Fowler Rd.	NB Carr Rd. & Marion Rd.	I	3
088	Calhoun	NB 23 Mile Rd. & V Drive N.	WB V Dr. N. & Old US-23	I	3
089	Saginaw	WB Wadsworth Rd. & Portsmouth Rd.	SB Michigan Rd. & Crane Rd.	I	3
090	Lenawee	WB Slee Rd. & US-223	WB Sandy Beach Rd. & Hallenbeck Hyw.	I	3
091	Van Buren	WB 36th Ave. & M-40	NEB Red Arrow Hwy. & County Rd. 657	I	3
092	Van Buren	EB 63rd Ave. & County Rd. 652	NB County Rd. 657 & County Rd. 358	I	3
093	Lapeer	WB McKeen Lake Rd. & Flint River Rd.	NB Booth Rd. & M-90	I	3
094	St. Joseph	NB Thomas Rd. & M-12	WB Millers Mill Rd. & Quarterline Rd.	I	3
095	Saginaw	WB Rathbun Rd. & Moorish Rd.	EB Birch Run Rd. & Moorish Rd.	I	3
096	Berrien	NB Fikes Rd. & Coloma Rd.	SB Yore Ave. & Meadowbrook Rd.	I	3
097	Genesee	WB Hegal Rd. & M-15/State Rd.	WB Bristol Rd. & Atlas Rd.	I	3
098	Lapeer	EB M-90 & M-90/M-53	WB M-90 & M-90/M-53	I	3
099	Saginaw	NB Thomas Rd. & Swan Creek Rd.	EB Shatuck Rd. & Center Rd.	I	3
100	Lenawee	WB Pixley Rd. & Deer Field Rd./Beaver Rd.	EB Moore Rd. & M-52	I	3
101	Van Buren	NB County Rd. 665 & M-40	EB 46th Ave. & M-40	I	3

102	Van Buren	WB County Rd. 374 & Red Arrow Hyw.	EB 40th Ave. & 52nd St.	I	3
103	Calhoun	SEB Michigan Ave./Austin Rd. & 28 Mile Rd./ N. Eaton Rd.	WB M Dr. N & 21.5 Mile Rd.	I	3
104	St. Clair	WB Norman Rd. & M-19/Emmett Rd.	WB Donald Rd. & Martin Rd.	I	3
105	Monroe	EB Oakville-Waltz Rd. & Sumpter Rd.	NB Grafton Rd. & Carleton-Rockwood Rd.	I	3
106	Berrien	WB Glenlord Rd. & Lincoln Ave.	NB Riverview Rd. & Brittan Ave.	I	3
107	Muskegon	NB Whitbeck Rd. & Fruitvale Rd.	EB Hancock Rd. & Indian Bay Rd.	I	3
108	Monroe	SB Petersburg Rd. & Ida West Rd./ N. Division St.	SWB Dixon Rd. & Ida West Rd.	I	3
109	St. Clair	WB Masters Rd. & M-19	EB Lambs Rd. & Wales Center Rd.	I	3
110	St. Joseph	SB Zinsmaster Rd. & M-60	NB Anglevine & River Run Rd.	I	3
111	Shiawassee	NB State Rd. & Lansing Rd.	WB Cole Rd. & Reed Rd.	I	3
112	Van Buren	EB Celery Center Rd. & M-51	SB 39th St. & 72nd Ave.	I	3
113	Shiawassee	SB Geeck Rd. & M-21	SB New Lothrup Rd. & Easton Rd.	I	3
114	Muskegon	SB Holton Duck Lake Rd. & Ryerson Rd./ Fourth St.	SB Brickyard Rd./200th Ave. & Ryerson Rd./Fourth St.	I	3
115	Berrien	WB Glenlord Ave. & Hollywood Rd.	NB Kirk Rd. & Shanghai Rd.	I	3
116	Lenawee	SB S. Piotter Hwy & Deer Field Rd.	NWB Cemetary Rd. & Silberhorn Hwy.	I	3
117	Monroe	SBR I-75 & Front St./Monroe St.	NBL I-75 & Plaisance Rd.	ER	3
118	Lapeer	WBR I-96 & Nepessing Rd.	WBR I-69 & Elba Rd.	ER	3
119	Lapeeer	EBL I-69 & Lake Pleasant Rd.	WBL I-69 Five Lakes Rd.	ER	3
120	Berrien	EBR I-94 & US-33/M-63	EBR I-94 & Pipestone Rd.	ER	3
121	Van Buren	EBL I-94 & 64th St. (Exit 46, Hartford)	EBR I-94 & County Rd. 365	ER	3
122	Van Buren	EBR I-94 & County Rd. 652/Main St. Exit 66)	WBR I-94 & M-40	ER	3
123	Muskegon	NBR US-31 & M-46/Apple St.	SBL US-31 & Marquette Ave.	ER	3
124	Van Buren	NBR I-196 & M-140 (Exit 18)	SBL I-196 & County Rd. 378	ER	3
125	St. Joseph	NB US-131 & WB M-60/ Bus. Rte. US-131	SB US-131 & Hoffman Rd./County Rd. 105	I	3
126	Monroe	NBL US-23 & Ida-West Rd.	NBL US-23 & Ida Dixon Rd.	ER	3

127	Wayne	WB 8 Mile Rd. & Beck Rd.	WB Warren Rd. & Canton Center Rd.	I	4
128	Wayne	EB Warren Rd. & Wayne Rd.	NB Newburgh Rd. & Warren Rd.	I	4
129	Wayne	EB McNichols Rd. & Woodward Ave.	EB 7 Mile & John R.	I	4
130	Wayne	NB Canton Center Rd. & Cherry Hill Rd.	NB Huron River Dr. & Goddard Rd.	I	4
131	Wayne	WB Ecorse Rd. & Pardee Rd.	WB Palmer Rd. & Venoy Rd.	I	4
132	Wayne	EB Michigan Ave. & Sheldon Rd.	WB Palmer Rd. & Lilley Rd.	I	4
133	Wayne	EB Ecorse Rd. & Middlebelt Rd.	SB Otter Rd. & Judd Rd.	I	4
134	Wayne	NB M-85/Fort Rd. & Emmons Rd.	EB Wick Rd. & Morten View Rd.	I	4
135	Wayne	WB Glenwood Rd. & Wayne Rd.	WB Joy Rd. & Middlebelt Rd.	I	4
136	Wayne	NB Haggerty Rd. & 7 Mile Rd.	WB Ford Rd. & Ridge Rd.	I	4
137	Wayne	WB 6 Mile Rd. & Inkster Rd.	EB 8 Mile Rd. & Evergreen Rd.	I	4
138	Wayne	SB Inkster Rd. & Goddard Rd.	SB Beech-Daly Rd. & Goddard Rd.	I	4
139	Wayne	SB Merriman Rd. & Cherry Hill Rd.	SB Middlebelt Rd. & Cherry Hill Rd.	I	4
140	Wayne	SEB Outer Dr. & Pelham Rd.	WB Joy Rd. & Greenfield Rd.	I	4
141	Wayne	NB Meridian Rd. & Macomb Rd.	EB Eureka Rd. & M-85	I	4
142	Wayne	WB Ford Rd. & Venoy Rd.	SB Shelden Rd. & 6 Mile Rd.	I	4
143	Wayne	SWB Vernor Rd. & Gratiot Rd.	SEB Woodward Rd. & Caniff Rd.	I	4
144	Wayne	WB 5 Mile Rd. & Beck Rd.	WB Plymouth Rd. & Wayne Rd.	I	4
145	Wayne	EB 7 Mile Rd. & Livernois Rd.	NWB Dexter Rd. & Chicago Rd.	I	4
146	Wayne	NB Gunston/Hoover Rd. & McNichols Rd.	SB Van Dyke/M-53 & 7 Mile Rd.	I	4
147	Wayne	SB W. Jefferson/SB Biddle Ave. & Southfield Rd.	SB Warren Rd. & Evergreen Rd.	I	4
148	Wayne	EB Goddard Rd. & Wayne Rd.	NB Howe Rd. & Annapolis Rd.	I	4
149	Wayne	WB 8 Mile Rd. & Kelly Rd.	NEB Jefferson Rd. & Whittier Rd.	I	4
150	Wayne	SB Merriman Rd. & US-12/Michigan Ave.	EB Cherry Hill Rd. & John Hix Rd.	I	4
151	Wayne	SB Telegraph Rd. & Plymouth Rd.	WB Oakwood Rd. & Schaeffer Rd.	I	4

152	Wayne	WB Sibley Rd. & Inkster Rd.	EB Grosse Ile Pkwy. & Meridian Rd.	I	4
153	Wayne	NEB Mack Rd. & Moross Rd.	EB 7 Mile Rd. & Mound Rd.	I	4
154	Wayne	WB Annapolis Rd. & Inkster Rd.	SB Vining Rd. & West Rd.	I	4
155	Wayne	SB Greenfield Rd. & Grand River Rd.	EB McNichols Rd. & Wyoming Ave.	I	4
156	Wayne	EB Joy Rd. & Livernois Rd.	SB Schaefer Rd. & Schoolcraft Rd.	I	4
157	Wayne	SEB Conner Ave. & Gratiot Rd.	Eb Michigan Ave. & W. Grand Blvd.	I	4
158	Wayne	NWB Grand River Rd. & Wyoming Ave.	NEB Rotunda Dr. & Oakwood Rd.	I	4
159	Wayne	WBL I-96 & Evergreen Rd.	EBR I-96 & Greenfield Rd.	ER	4
160	Wayne	WBL I-94 & Haggerty Rd. (Exit 192)	EBR I-94 & Belleville Rd. (Exit 190)	ER	4
161	Wayne	NBR I-75 & Gibralter Rd. (Exit 29)	SBL I-75 & North Huron River Dr. (Exit 27)	ER	4
162	Wayne	NBR I-75/Lafayette St. & Outer Drive	SBL I-75 & Southfield Rd.	ER	4
163	Wayne	NBR I-275 & 6 Mile Rd.	NBL I-275 & 7 Mile Rd.	ER	4
164	Wayne	NBL I-275 & M-153/Ford Rd. (Exit 25)	NBL I-275 & US-12/Michigan Ave. (Exit 22)	ER	4
165	Wayne	NBR I-275 & Eureka Rd. (Exit 15)	SBR I-275 & Sibley Rd. (Exit 13)	ER	4
166	Wayne	NBL I-75 & Springwells Ave. (Exit 45)	SBL I-75 & Clark Rd.	ER	4
167	Wayne	WBR I-94 & Pelham Rd. (Exit 204)	EB I-94 & Middlebelt Rd.	ER	4
168	Wayne	SBR I-75 & Sibley Rd.	SBL I-75 & West Rd.	ER	4

APPENDIX C
Calculation of Variances, Confidence Bands, and Relative Error

The variances for the belt use estimates were calculated using an equation derived from Cochran's (1977) equation 11.30 from section 11.8. The resulting formula was:

$$var(r) \approx \frac{n}{n-1} \sum_i \left(\frac{g_i}{\sum g_k}\right)^2 (r_i - r)^2 + \frac{n}{N} \sum_i \left(\frac{g_i}{\sum g_k}\right)^2 \frac{s_i^2}{g_i}$$

where $var(r_i)$ equals the variance within a stratum and vehicle type, n is the number of observed intersections, g_i is the weighted number of vehicle occupants at intersection I, g_k is the total weighted number of occupants for a certain vehicle type at all 42 sites within the stratum, r_i is the weighted belt use rate at intersection I, r is the stratum belt use rate, N is the total number of intersections within a stratum, and $s_i = r_i(1-r_i)$. In the actual calculation of the stratum variances, the second term of this equation is negligible. If we conservatively estimate N to be 2000, the second term only adds 2.1×10^{-6} units to the largest variance (Stratum 4). This additional variance does not significantly add to the variance captured in the first term. Therefore, since N was not known exactly, the second term was dropped in the variance calculations. The overall estimated variance for each vehicle type was calculated using the formula:

$$var(r_{all}) = \frac{var(r_1) + var(r_2) + var(r_3) + 0.88^2 \times var(r_4)}{3.88^2}$$

The Wayne County stratum variance was multiplied by 0.88 to account for the similar weighting that was done to estimate overall belt use. The 95 percent confidence bands were calculated using the formula:

$$95\%\,ConfidenceBand = r_{all} \pm 1.96 \times \sqrt{Variance}$$

where r is the belt use of interest. This formula is used for the calculation of confidence bands for each stratum and for the overall belt use estimate.

Finally, the relative error or precision of the estimate was computed using the formula:

$$RelativeError = \frac{StandardError}{r_{all}}$$

The federal guidelines (National Highway Traffic Safety Administration, 1992) stipulate that the relative error of the belt use estimate must be under five percent.