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DIRECT OBSERVATION OF SAFETY BELT USE IN MICHIGAN: DECEMBER 2002

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16. Abstract

A direct observation survey of safety belt use in Michigan was conducted. In this study, 12,690 occupants traveling in four vehicle types (passenger cars, sport-utility vehicles, vans/minivans, and pickup trucks) were surveyed between December 2 and 16, 2002. Belt use was estimated for all commercial/noncommercial vehicle types combined (the statewide safety belt use rate) and separately for each vehicle type. Within and across each vehicle type, belt use rates by age, sex, road type, day of week, time of day, and seating position were calculated. Statewide belt use was 80.5 percent. When compared with the rate observed in September, 2002, the current rate shows that safety belt use in Michigan has remained about the same. A comparison with the highest rate observed before the introduction of standard enforcement shows that the current rate reflects a 10.4 percentage point increase. Belt use was 82.5 percent for passenger cars, 82.6 percent for sport-utility vehicles, 80.8 percent for vans/minivans, and 72.3 percent for pickup trucks. For all vehicle types combined, belt use was higher for females than for males, and higher for drivers than for passengers. In general, belt use was highest during the morning rush hour. Belt use did not vary systematically by day of week. Belt use was lowest among 16-to-29 year olds, followed closely by those in the 30-to-59 year old age group, and highest among the 60-and-older age group. Survey results suggest that the implementation of standard enforcement safety belt use laws and the accompanying enforcement and public information and education efforts have been effective in increasing and maintaining safety belt use in Michigan.

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INTRODUCTION

The correct use of a safety belt reduces the risk of fatal injury to front seat passenger car occupants by 45 percent, and the risk of moderate to critical injury by 50 percent (National Highway Traffic Safety Administration, NHTSA, 1999a). According to the Michigan Office of Highway Safety Planning (OHSP, 2001), occupants involved in automobile crashes in Michigan during 2000 were thirty times more likely to be killed if they were not wearing safety belts. The total economic loss in motor vehicle crashes in Michigan has been estimated at nearly $10 million (OHSP, 2001). NHTSA has suggested that as much as 85 percent of these costs are absorbed by society (1999a) through taxes, insurance premiums, lost wages, and lost productivity (United States General Accounting Office, U.S. GAO, 1992). The cost for an individual can increase by as much as 50 percent when he or she is not wearing a safety belt in a crash (NHTSA, 1999a). In the 424,852 automobile crashes reported in Michigan during 2000, safety belt use was directly related to the level of injury sustained. The substantial decrease, both in loss of life and economics, that would result from higher safety belt use in Michigan underscores the importance of implementing and continuing programs and legislation designed to increase belt use.

In July of 1984, New York enacted the first law mandating safety belt use for motor vehicle occupants. New Jersey, Illinois, and Michigan passed similar legislation the following year (Lund, Pollner, & Williams, 1986). In subsequent years, numerous states followed suit and began writing legislation to mandate statewide safety belt use. By 1999, New Hampshire was the only state without a mandatory safety belt use law for adult motor vehicle occupants (Insurance Institute for Highway Safety, IIHS, 2000). The increase in the national safety belt use rate from around 15 percent in the early 1980s to the current rate of 75 percent (NHTSA, 2002) can be attributed to the introduction of these laws. In general, these laws produced a dramatic increase in safety belt use immediately following implementation, followed by a decline to a level that remained substantially higher than prelaw levels.

Throughout the end of the 1980s and into the 1990s, safety belt use in Michigan continued to gradually increase. These increases were largely attributed to increased police enforcement, media campaigns, and public information and education (PI&E) programs. These policies and programs were successful in educating the public about the necessity and effectiveness of safety belt use. By the end of the 1990s, belt use in Michigan had reached a plateau at around 70 percent. It had been suggested by traffic safety professionals that this was the highest level of safety belt use that could be reached in Michigan without changing the secondary enforcement provision of the law to standard enforcement (Wortham, 1998).

On March 10, 2000, Michigan's safety belt use law was changed to allow for standard enforcement. Immediately following the change to standard enforcement, belt use was observed at 83.5 percent, an increase of 13.4 percentage points over the highest level previously observed in Michigan (Eby, Vivoda, & Fordyce, 2002). While an increase in safety belt use was observed within all groups in the driving population after the change to standard enforcement, the most successful aspect of this change was the increased belt use among the historically low belt use groups in Michigan. These positive changes included decreases in the gaps usually observed between males and females; pickup truck occupants and other vehicle types; young and older motorists; motorists in Wayne County when compared to the rest of the state; and drivers and passengers.

Despite its effectiveness, however, Michigan still had strides to make to ensure that this high belt use rate was maintained and, preferably, increased. In the time since standard enforcement was implemented in Michigan, belt use has varied, but generally remained above the 80 percent level. Since this change occurred, media campaigns, as well as increases in police enforcement of the safety belt law, have been implemented and have been largely responsible for this stabilization. The study reported here represents part of an evaluation of a safety belt campaign, the "Click It Or Ticket Thanksgiving Mobilization," designed to increase belt use in Michigan during the Thanksgiving holiday of 2002. For information regarding the outcome of this evaluation, see Eby & Vivoda (2003). Reported here are the results of a statewide direct observation survey of safety belt use conducted during and after the mobilization intervention in December, 2002.

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 modifications noted.

The goal of this sample design was to select observation sites that accurately represent front-outboard vehicle occupants in eligible commercial and noncommercial vehicles (i.e., passenger cars, vans/minivans, sport-utility vehicles, and pickup trucks) in Michigan, while following federal guidelines for safety belt survey design (NHTSA, 1992, 1998). 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, NHTSA guidelines allow states to omit from their sample space the lowest population counties, provided these counties collectively 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 University of Michigan Transportation Research Institute (UMTRI) surveys (Wagenaar & Molnar, 1989; Wagenaar, Molnar, & Businski, 1987b, 1988). 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 factors have been shown previously

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

to correlate positively with belt use (e.g., Wagenaar, Molnar, & Businski, 1987a). Wayne County was chosen as a separate stratum because of its disproportionately high VMT, and because we wanted to ensure that observation sites were selected within this county. Three other strata were constructed by rank ordering each county by historical belt use rates and then adjusting the stratum boundaries until the total VMT was roughly equal 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 5 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 on 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 for 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), 10 (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, Percent**	**Belt Use Average, Percent**	**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 when 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 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 (*x*) coordinate and a vertical (*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 randomly selected. If more than one intersection was 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 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, there would then 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 southbound traffic and stand next to Main Street. For observer location number two, the observer would watch eastbound 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 upon 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.

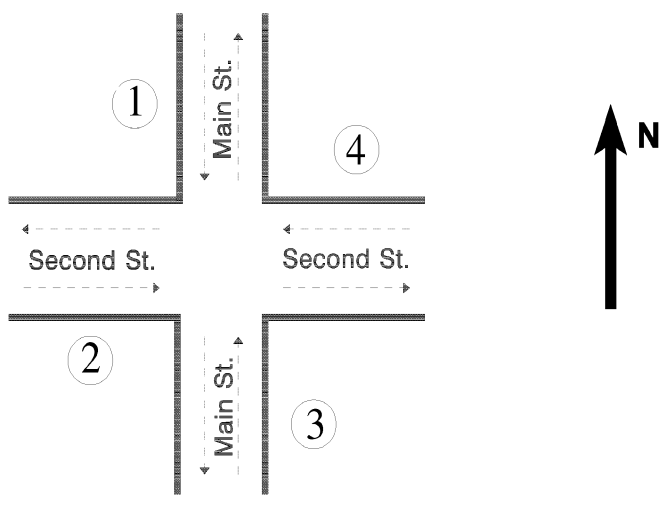

Figure 1. An Example "+" Intersection Showing 4 Possible Observer Locations.

For each 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 10 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 10 numbers between 1 and the number of exit ramps in the stratum. For example, in the high belt use stratum there were a total of 109 exit ramps. To select an exit ramp, a random number between 1 and 109 was generated. This number corresponded to a specific exit ramp. To select the next exit ramp, another random number between 1 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 sides of the 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 if 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 on the selected direction of travel, then a researcher visited the site and randomly picked a travel direction and lane that had such a device.

[4] For those interested in designing a safety belt survey for their county or region, a guidebook and software for selecting and surveying sites for safety belt use is available (Eby, 2000) by contacting UMTRI -SBA, 2901 Baxter Rd., Ann Arbor, MI 48109-2150, or accessing http://www-personal.umich.edu/~eby/sbs.html/.

[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 observations were quasirandomly assigned to sites in such a way that all days of the week and all daylight hours (7:00 am - 7:00 pm) 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 dark, 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 counterclockwise direction (whichever direction left them closest to UMTRI 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 for observations at the sites were not correlated with belt use at a site. This quasirandom 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 vehicles 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/minivans, sport-utility vehicles, and pickup trucks) on the traffic leg

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

under observation was conducted for a set duration (5 minutes) immediately prior to and immediately following the observation period (10 minutes total).

Table 2 shows descriptive statistics for the 168 observation sites of the statewide survey. As shown in this table, the observations were fairly well distributed over day of week. Observations were also well distributed by time of day except for very early and late time periods. During December, daylight hours are generally limited to between 8 a.m. and 5 p.m. 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 every site observed was the primary site and that observations were mostly conducted during sunny and cloudy weather conditions, with a smaller percentage conducted during snow. No observations were conducted during rain.

Table 2. Descriptive Statistics for the 168 Observation Sites

Day of Week		Observation Period		Site Choice		Weather	
Monday	11.9%	7-9 a.m.	10.7%	Primary	100.0%	Sunny	54.2%
Tuesday	14.9%	9-11 a.m.	22.6%	Alternate	0.0%	Cloudy	39.9%
Wednesday	11.9%	11-1 p.m.	19.7%			Rain	0.0%
Thursday	19.0%	1-3 p.m.	23.2%			Snow	5.9%
Friday	16.7%	3-5 p.m.	23.8%				
Saturday	13.7%	5-7 p.m.	0.0%				
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 sex. Trained field staff observed shoulder belt use of drivers and front-right passengers traveling in passenger cars, sport-utility vehicles, vans/minivans, and pickup trucks during daylight hours from December 2 through 16, 2002. Observations of safety belt use, sex, age, vehicle type, and vehicle purpose (commercial or noncommercial) 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 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.

A 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, sex, and estimated age of 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-outboard passenger present. Children riding in child safety seats (CSSs) were recorded but not included in any part of the analysis. Occupants observed with their shoulder belt worn under the arm or behind the back were noted but considered as belted in the analysis. Based upon NHTSA (1999b) guidelines, the observer also recorded whether the vehicle was commercial or noncommercial. A commercial vehicle is defined as a vehicle that is used for business purposes and may or may not contain company logos. This classification includes vehicles marked with commercial lettering or logos, or vehicles with ladders or other tools on them. 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 one observer for a period of 1 hour, with the exception of sites in the city of Detroit. To address potential security concerns, these sites were visited by two-person observer teams for a period of 30 minutes. Observations at other Wayne County sites scheduled to be observed on the same day as Detroit sites were also completed by two observers. Because each team member at these sites recorded data for different lanes of traffic, the total amount of data collection time was equivalent to that at single observer 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 with one observer on the curb and one observer on the median (if there was more than one traffic lane and a median). If no median was present, observers were instructed to stand on diagonally opposite corners of the intersection.

At each site, observers conducted a 5-minute count of all eligible vehicles in 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 5-minute vehicle count was conducted at one-observer sites.

Observer Training

Prior to data collection, field observers participated in five 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. A site schedule identifying the location, date, time, and traffic leg to be observed for each site was included in the manual (see Appendix B for a listing of the sites).

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 the locations of the 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 sex. Observers worked in teams of two, observing the same vehicles, but recording data independently on separate data collection forms. The forms were then compared for accuracy. Teams were rotated throughout the training to ensure that each observer was paired with every other observer. Each observer pair practiced recording safety belt use, sex, and age until there was an interobserver reliability of at least 85 percent for all measures on 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 locate 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's home or cellular phone 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 description form and observation form data were entered into an electronic format. The accuracy of the data entry was verified in two ways. First, all data were entered 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, sex, age, seating position, 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 5-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 through the site if all eligible vehicles had been included in the survey during the observation period at that site. The estimated count for each site is divided by the actual number of vehicles observed there to obtain a volume weighting factor for that site. These weights are then applied to the number of actual vehicles of each type observed at each site to yield the weighted N for the total number of drivers and passengers, and total number of belted drivers and 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 in Michigan was determined by first calculating the belt use rate within each stratum for observed vehicle occupants in all vehicle types using the following formula:

$$r_i ' \frac{\text{Total Number of Belted Occupants, weighted}}{\text{Total Number of Occupants, weighted}}$$

where r_i refers to the belt use rate 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 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 was determined by the following formula:

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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 5-minute count was multiplied by five to represent the 25-minute observation period.

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

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. The same use rate and variance equations were utilized for the calculation of use rates for each vehicle type separately.

RESULTS

As discussed previously, the current direct observation survey of safety belt use in Michigan reports statewide belt use for four vehicle types combined (passenger cars, vans/minivans, sport-utility vehicles, and pickup trucks), in addition to reporting use rates for occupants in each vehicle type separately. Following NHTSA (1999b) guidelines, this survey included commercial vehicles. In the sample, only 5.0 percent of occupants were in commercial vehicles. In order to determine if the inclusion of commercial vehicles significantly changed statewide belt use rates, the statewide rate was calculated separately both with and without commercial vehicles. Analysis showed that there was no difference between the rates. Thus, all rates shown in this report include occupants from both commercial and noncommercial vehicles.

Overall Safety Belt Use

As shown in Figure 2, 80.5 ± 2.0 percent of all front-outboard occupants traveling in either passenger cars, sport-utility vehicles, vans/minivans, or pickup trucks in Michigan between December 2 and 16, 2002 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 78.5 percent and 82.5 percent. When compared with the September, 2002 rate of 82.9 ± 1.6 percent, and the June, 2002 rate of 80.0 ± 1.2 percent, the estimated safety belt use rate observed in December is not statistically different from either of these previous rates. In other words, safety belt use in Michigan has remained about the same over the last six months.

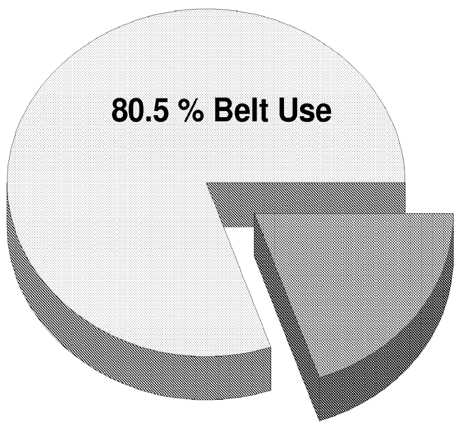

Figure 2. Front-Outboard Shoulder Belt Use in Michigan (All Vehicle Types and Commercial/Noncommercial Combined).

Estimated belt use rates and unweighted numbers of occupants (N) by stratum are shown in Table 3. The same belt use trends that are usually observed in Michigan by stratum are noted. The safety belt use rate for Stratum 1 was the highest in the state. Belt use in Stratum 2 was lower, followed by Strata 3 and 4, respectively. However, the statistical analysis reveals that these numbers are not significantly different from each other. When compared with the September, 2002 stratum belt use rates of 87.0, 82.6, 81.7, and 80.0 percent for Strata 1 through 4, respectively, we find no statistically significant changes in safety belt use by stratum between the two surveys.

Table 3. Percent Shoulder Belt Use by Stratum (All Vehicle Types)

	Percent Use	**Unweighted N**
Stratum 1	82.4 ± 6.0	3,526
Stratum 2	81.2 ± 2.7	2,689
Stratum 3	79.7 ± 3.2	1,958
Stratum 4	78.4 ± 3.3	4,517
STATE OF MICHIGAN	**80.5 ± 2.0 %**	12,690

Estimated belt use rates and unweighted numbers of occupants by stratum and vehicle type are shown in Tables 4a through 4d. Within each vehicle type, we find no systematic differences in safety belt use by stratum. When compared with September's results (Vivoda & Eby, 2002), we find slight decreases in shoulder belt use for occupants of all four vehicle types, but again, these changes are not statistically significant. It is important to note however, that the overall belt use rate of 72.3 ± 3.3 percent for pickup trucks continues to be significantly lower than for any other vehicle type (Table 4d). This finding is consistent with results from previous surveys (e.g., Eby, Molnar, & Olk, 2000; Eby & Vivoda, 2001; Eby, Vivoda, & Fordyce, 2002; Vivoda & Eby, 2002). Thus, enforcement and PI&E programs should continue to target pickup truck occupants.

Table 4a. Percent Shoulder Belt Use by Stratum (Passenger Cars)		
	Percent Use	Unweighted N
Stratum 1	83.3	1,694
Stratum 2	82.8	1,240
Stratum 3	83.2	892
Stratum 4	80.1	2,538
STATE OF MICHIGAN	**82.5 ± 2.4 %**	6,364

Table 4b. Percent Shoulder Belt Use by Stratum (Sport-Utility Vehicles)		
	Percent Use	Unweighted N
Stratum 1	86.0	639
Stratum 2	80.8	449
Stratum 3	82.7	302
Stratum 4	80.7	697
STATE OF MICHIGAN	**82.6 ± 2.6 %**	2,087

Table 4c. Percent Shoulder Belt Use by Stratum (Vans/Minivans)		
	Percent Use	Unweighted N
Stratum 1	83.0	564
Stratum 2	84.7	450
Stratum 3	76.6	303
Stratum 4	78.4	699
STATE OF MICHIGAN	**80.8 ± 3.0 %**	2,016

Table 4d. Percent Shoulder Belt Use by Stratum (Pickup Trucks)		
	Percent Use	Unweighted N
Stratum 1	74.5	629
Stratum 2	74.1	550
Stratum 3	72.1	461
Stratum 4	68.0	583
STATE OF MICHIGAN	**72.3 ± 3.3 %**	2,223

Safety Belt Use by Subgroup

Site Type. Estimated safety belt use by type of site is presented in Table 5 as a function of vehicle type and all vehicles combined. As is typically found in safety belt use surveys in Michigan (Eby, Molnar, & Olk, 2000; Eby, Vivoda, & Fordyce, 2002), use was higher for occupants in vehicles leaving limited access roadways (exit ramps) than for occupants in vehicles on surface streets. This effect was consistent across all vehicle types except for vans/minivans.

Time of Day. Estimated safety belt use by time of day, vehicle type, and all vehicles combined is shown in Table 5. Note that these data were collected only during daylight hours. Due to the limited hours of daylight in December, no observations were conducted after 5:30 p.m. For all vehicles combined, belt use was generally highest during the morning rush hour.

Day of Week. Estimated safety belt use by day of week, vehicle type, and all vehicles combined is shown in Table 5. Note that the survey was conducted over a 3-week period. Belt use clearly varied from day to day, but no systematic differences were evident.

Weather. Estimated belt use by prevailing weather conditions, vehicle type, and all vehicles combined is shown in Table 5. There was essentially no difference in belt use between weather conditions.

Sex. Estimated safety belt use by occupant sex, type of vehicle, and all vehicles combined is shown in Table 5. Estimated safety belt use is higher for females than for males in all four vehicle types studied, and for all vehicle types combined. Similar results have been found in every Michigan safety belt survey conducted by UMTRI (see, e.g., Eby, Molnar, & Olk, 2000; Eby, Vivoda, & Fordyce, 2002).

Age. Estimated safety belt use by age, vehicle type, and all vehicle types combined is shown in Table 5. As there was only one individual in the 0-to-3 year old category observed in the current study, the estimated safety belt use rate for this age group is not meaningful. Excluding the 0-to-3-year-old age group, safety belt use for all vehicles combined is highest for the 4-to-15 and the 60-and-over age groups. Belt use rates for the

16-to-29-year-old age group were the lowest, followed closely by the rates for the 30-to-59-year-old age group. This pattern is consistent with previous UMTRI safety belt studies (see, e.g., Eby, Molnar, & Olk, 2000; Eby, Vivoda, & Fordyce, 2002). Comparing these results with September's safety belt use rates by age, we find that belt use has decreased slightly across all age groups, with the largest decrease noted in the 30-59 year old group.

Seating Position. Estimated safety belt use by position in vehicle, vehicle type, and all vehicles combined is shown in Table 5. This table shows that for all vehicle types combined, and within each vehicle type studied, safety belt use for drivers is slightly higher than for front-right passengers.

Table 5. Percent Shoulder Belt Use and Unweighted N by Vehicle Type and Subgroup

	All Vehicles		Passenger Car		Sport-Utility Vehicle		Van/Minivan		Pickup Truck	
	Percent Use	N	Percent Use	N	Percent Use	N	Percent Use	N	Percent Use	N
Site Type										
Intersection	80.1	8,843	81.6	4,433	82.3	1,456	82.8	1,383	71.1	1,571
Exit Ramp	82.3	3,847	84.8	1,931	83.0	631	80.6	633	77.1	652
Time of Day										
7 - 9 a.m.	85.0	1,198	88.7	574	83.1	212	86.9	222	73.1	190
9 - 11 a.m.	81.5	1,862	83.9	869	83.6	278	79.3	353	77.2	362
11 - 1 p.m.	78.4	2,417	82.8	1,189	83.2	378	70.2	372	70.1	478
1 - 3 p.m.	79.1	3,166	81.6	1,577	80.3	556	80.2	529	68.9	504
3 - 5 p.m.	81.1	4,047	81.5	2,155	82.2	663	85.7	540	75.3	689
5 - 7 p.m.	---	0	---	0	---	0	---	0	---	0
Day of Week										
Monday	83.3	1,792	85.3	1,070	89.4	269	85.2	278	73.8	175
Tuesday	82.8	1,921	86.0	917	84.8	307	81.3	311	75.2	386
Wednesday	82.5	1,065	81.0	491	87.2	189	88.0	183	74.4	202
Thursday	82.9	2,239	86.9	1,090	82.9	313	80.6	373	75.8	463
Friday	79.4	2,540	85.6	1,295	82.5	405	76.3	378	65.2	462
Saturday	86.7	1,630	87.9	779	84.9	329	91.9	229	81.7	293
Sunday	77.7	1,503	78.5	722	81.7	275	78.8	264	67.6	242
Weather										
Sunny	80.2	6,916	81.6	3,464	83.8	1,080	80.7	1,115	72.5	1,257
Cloudy	82.0	4,818	84.7	2,376	81.5	844	83.8	738	72.9	860
Snow	85.2	956	88.0	524	91.7	163	83.9	163	72.0	106
Sex										
Male	75.6	6,901	79.3	3,063	75.2	993	74.5	1,013	70.1	1,832
Female	86.2	5,789	85.3	3,301	89.4	1,094	87.2	1,003	82.7	391
Age										
0 - 3	100.0	1	100.0	1	---	0	---	0	---	0
4 - 15	83.7	364	87.9	162	76.5	71	89.7	77	71.1	54
16 - 29	78.8	4,015	80.2	2,376	80.8	601	78.4	384	71.9	654
30 - 59	79.8	6,723	82.4	2,816	82.9	1,271	80.4	1,295	70.7	1,341
60 - Up	86.9	1,586	86.9	1,009	89.2	144	84.7	259	86.1	174
Position										
Driver	80.6	10,277	82.5	5,164	82.7	1,680	81.2	1,581	72.6	1,852
Passenger	78.9	2,413	82.2	1,200	82.5	407	79.4	435	67.3	371

Age and Sex. Table 6 shows estimated safety belt use rates and unweighted numbers (N) of occupants for all vehicle types combined by age and sex. The belt use rates for the two youngest age groups should be interpreted with caution because the unweighted number of occupants is quite low. Excluding these age groups, belt use for females in all age groups was higher than for males. However, the absolute difference in belt use rates between sexes varied depending upon the age group. The most notable difference is found in the 16-to-29-year-old age group and the 30-to-59-year-old age group, where the estimated belt use rate is 10.9 percentage points and 13.1 percentage points higher respectively, for females than for males. In fact, the female age group that had the lowest belt use rate (16-to-29 year olds) was about the same as the male age group that had the highest belt use rate (60-up age group).

When compared with the rates observed in the statewide survey conducted in September, 2002, we find slight decreases among females of all age groups (Vivoda & Eby, 2002). However, among males in the survey, belt use for the 16-to-29 and 60-up age groups stayed about the same. For males in the 30-to-59 year old age group, belt use decreased by 4.6 percentage points. While efforts should continue to focus on getting young males to buckle up, these results strongly suggest that males in general should not be ignored in these efforts.

Table 6. Percent Shoulder Belt Use and Unweighted N by Age and Sex (All Vehicle Types Combined)

Age Group	Male		Female	
	Percent Use	Unweighted N	Percent Use	Unweighted N
0 - 3	---	0	100.0	1
4 - 15	84.6	209	82.4	155
16 - 29	73.4	2,109	84.3	1,906
30 - 59	74.0	3,744	87.1	2,979
60 - Up	85.1	839	88.5	747

Historical Trends

The current direct observation survey is the fifteenth statewide survey that utilizes the sampling design and procedures implemented in 1993 (Streff, Eby, Molnar, Joksch, & Wallace, 1993). As such, it is possible to investigate safety belt use trends over the last several years. The annual survey in 1993, however, only included passenger vehicles, so that survey is only included for historical trends by vehicle type.

Overall Belt Use Rate. Figure 3 shows the statewide safety belt use rate for all vehicles combined over the last 9 years. The safety belt use rate has shown a consistent increase over this time. Since 1994, the safety belt use rate has increased by 17.8 percentage points, with an increase of 10.4 percentage points over the highest rate observed before the introduction of standard enforcement. This finding indicates that efforts to increase safety belt use in Michigan, have been effective and should be continued.

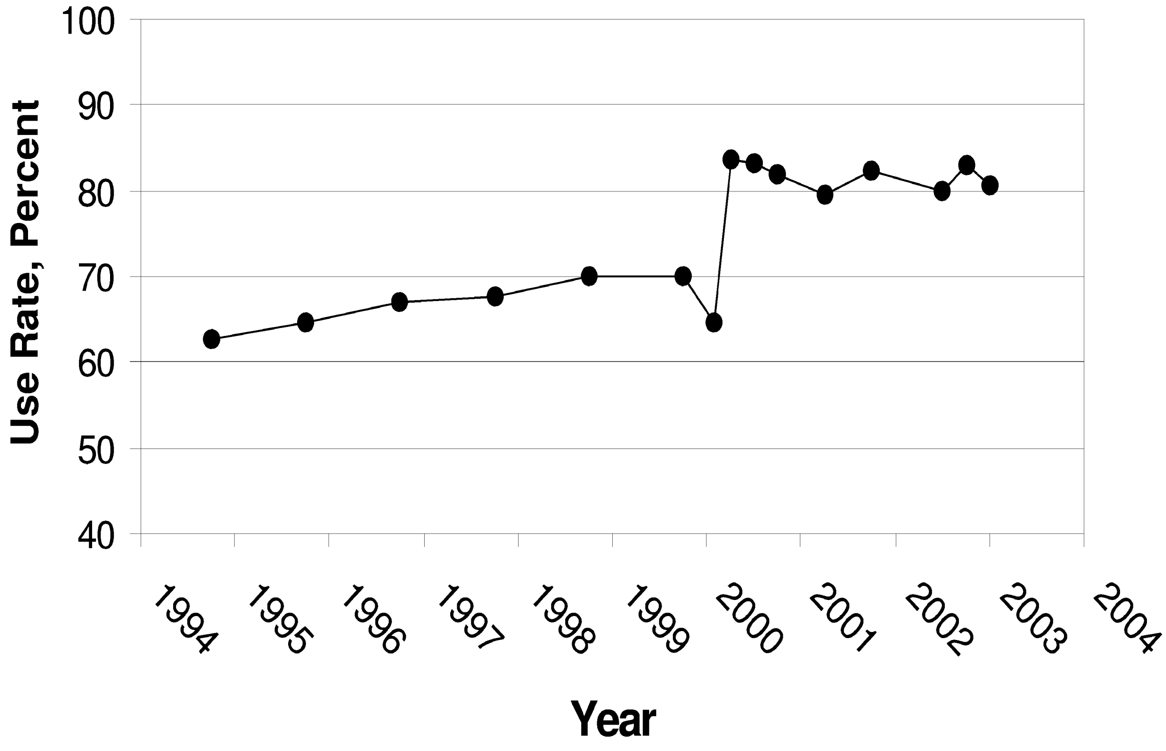

Figure 3. Front-Outboard Shoulder Belt Use by Year (All Vehicle Types Combined).

Overall Belt Use Rate by Stratum. Figure 4 shows the statewide safety belt use rate for all vehicles combined since 1994 by stratum. For all strata, there is a general upward trend in safety belt use from 1994 to 2002, with the greatest increase in use (23.2 percentage points) found in Stratum 4. Similarly, Stratum 4 experienced the largest increase in belt use immediately following the implementation of standard enforcement. Since the implementation of standard enforcement, belt use within each stratum has experienced slight variations, but remained fairly steady. However, continued programs are necessary in order to maintain and increase current rates.

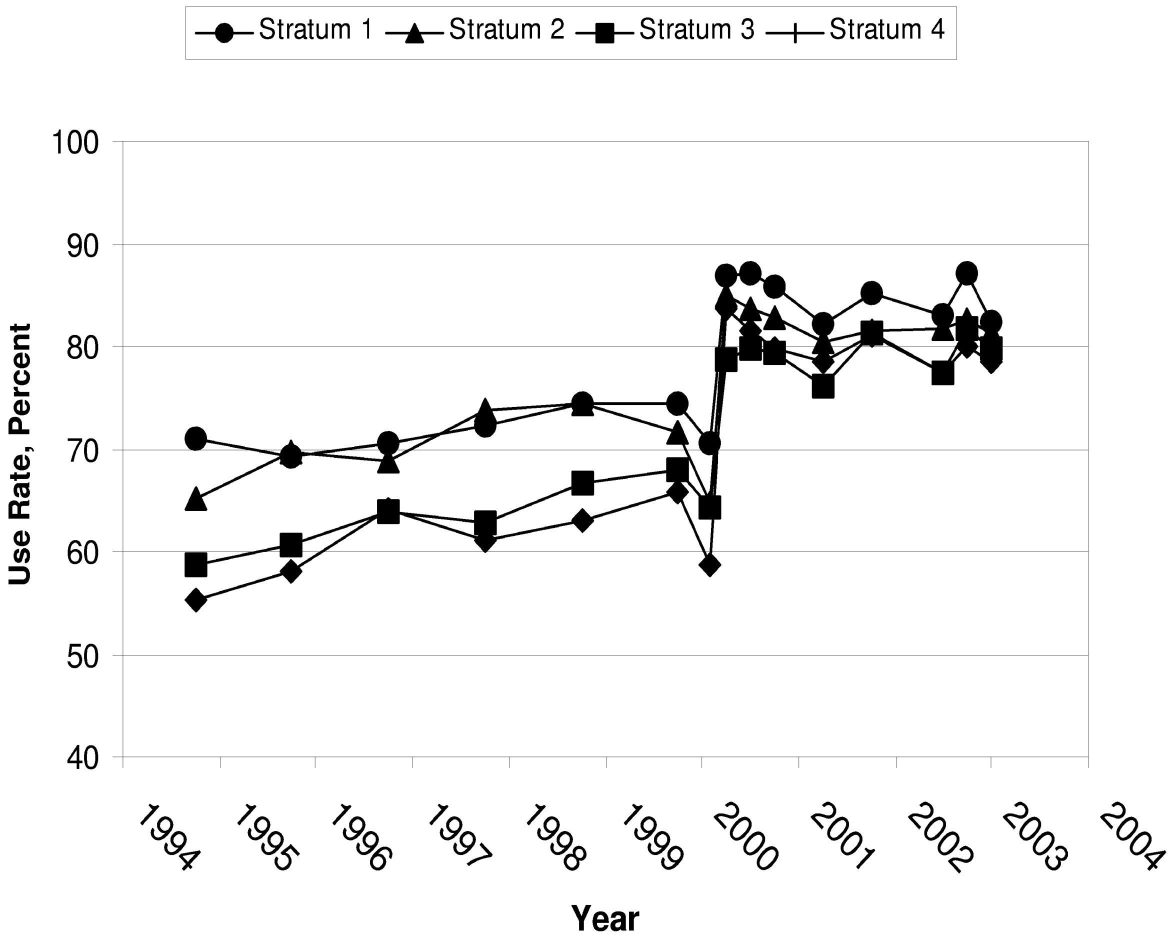

Figure 4. Front-Outboard Shoulder Belt Use by Year and Stratum (All Vehicle Types Combined).

Belt Use by Site Type. Figure 5 shows the estimated safety belt use rates for all vehicles combined as a function of whether the site was a freeway exit ramp or a local intersection. The difference in use rates between motorists on these roadway types has remained fairly consistent since 1994, with the use rate for freeway exit ramps higher than for local intersections.

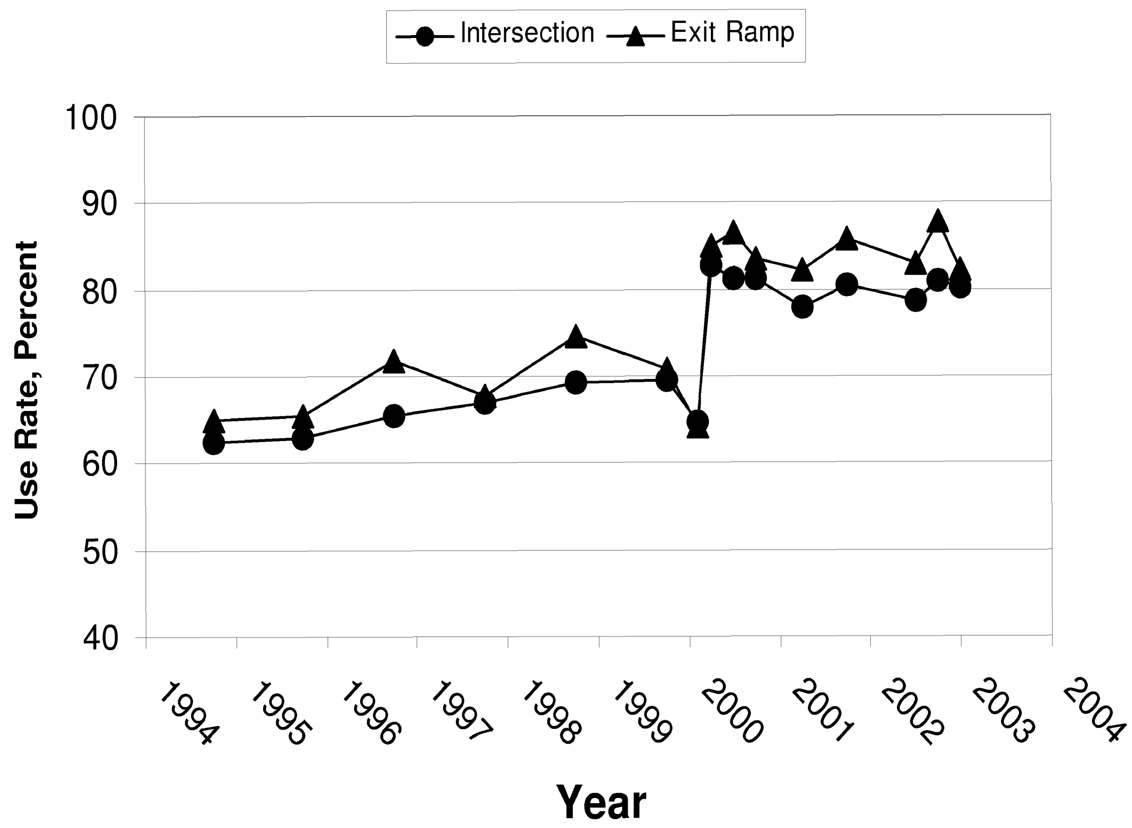

Figure 5. Front Outboard Shoulder Belt Use by Site Type and Year (All Vehicle Types Combined).

Belt Use By Sex. Figure 6 shows front-outboard safety belt use by sex since 1994. Safety belt use by females for every survey is significantly higher than for males. Significant increases in belt use, related to the introduction of standard enforcement legislation, were observed within each sex.

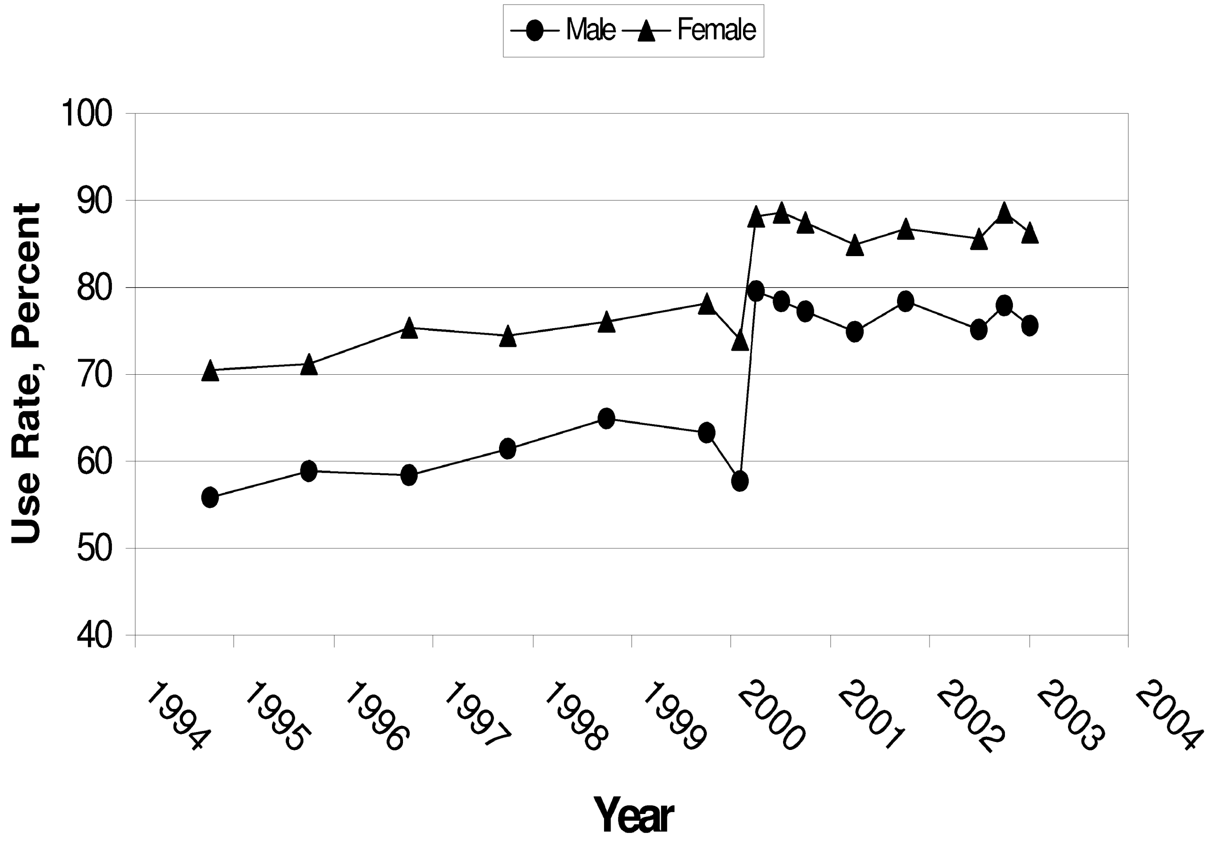

Figure 6. Front-Outboard Shoulder Belt Use by Sex and Year (All Vehicle Types Combined).

Belt Use By Seating Position. Figure 7 shows front-outboard safety belt use by seating position and year. Safety belt use by drivers has been consistently higher than for front-outboard passengers since 1994.

Figure 7. Front-Outboard Shoulder Belt Use by Seating Position (All Vehicle Types Combined).

Belt Use by Age. Figure 8 shows front-outboard safety belt use by age group since 1994 for all vehicles combined. The youngest age group is typically excluded from comparisons due to the very small numbers in our sample. Conclusions about the 4-to-15-year-old age group should also be made with caution as the number of occupants within this age group is quite low. Excluding these age groups, the use rates by age have been ordered consistently each year with the 16-to-29-year-old age group having the lowest safety belt use rates, followed by the 30-to-59 year olds. The highest belt use is observed within the 60-up age group. Significant increases were noted among all of the age groups when standard enforcement was introduced.

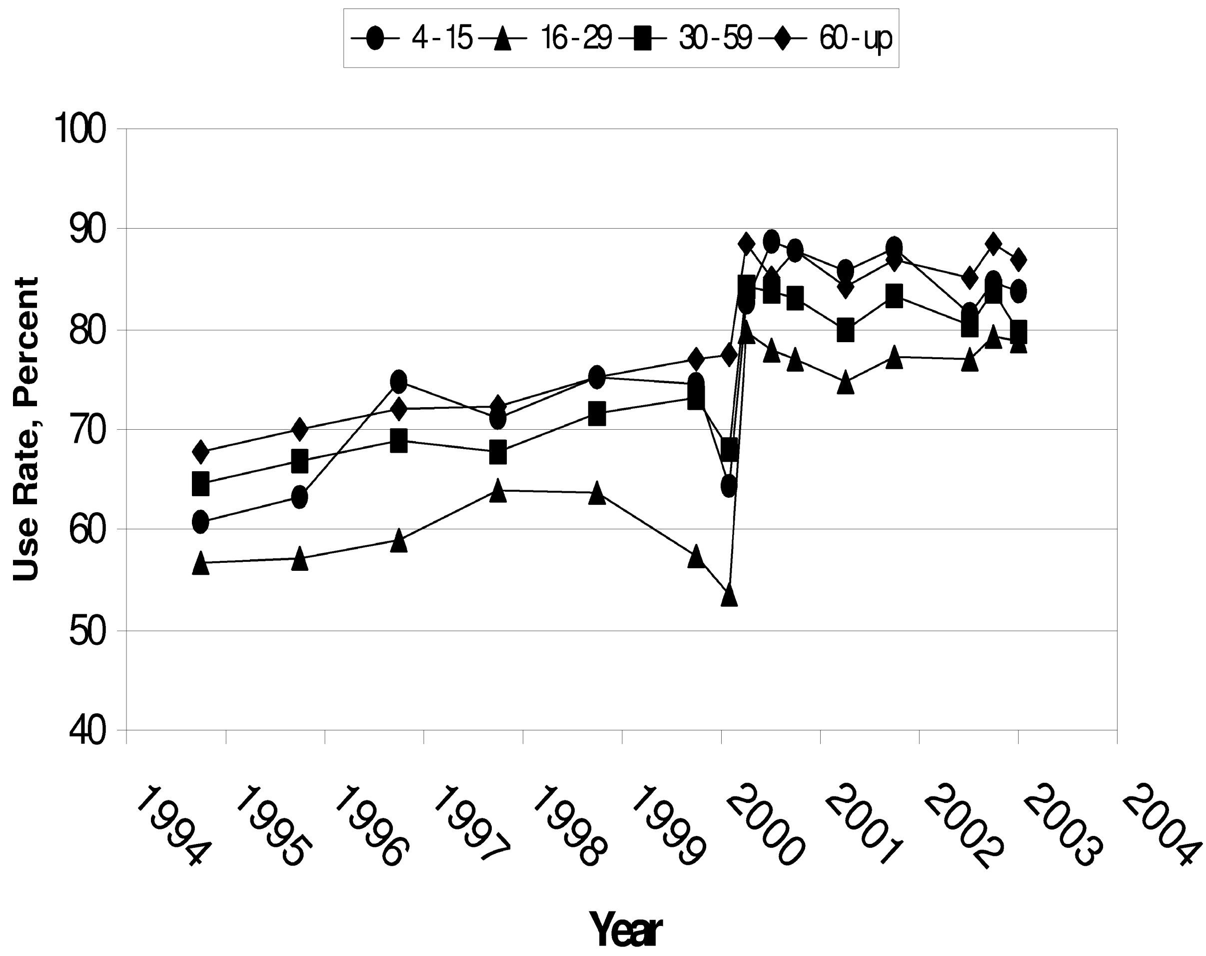

Figure 8. Front-Outboard Shoulder Belt Use by Age and Year (All Vehicle Types Combined).

Belt Use by Vehicle Type and Year. Figure 9 shows motor vehicle occupant belt use by the type of vehicle since 1993. Belt use for 1993 only shows passenger vehicles because only this vehicle type was observed in that year. Figure 9 reveals that significant increases have been observed in safety belt use rates for occupants in all vehicle types. The most notable increase (27.4 percentage points since 1994) has been observed in the belt use rates of pickup truck occupants. However, these occupants continue to be less likely to use a safety belt than occupants in other vehicle types.

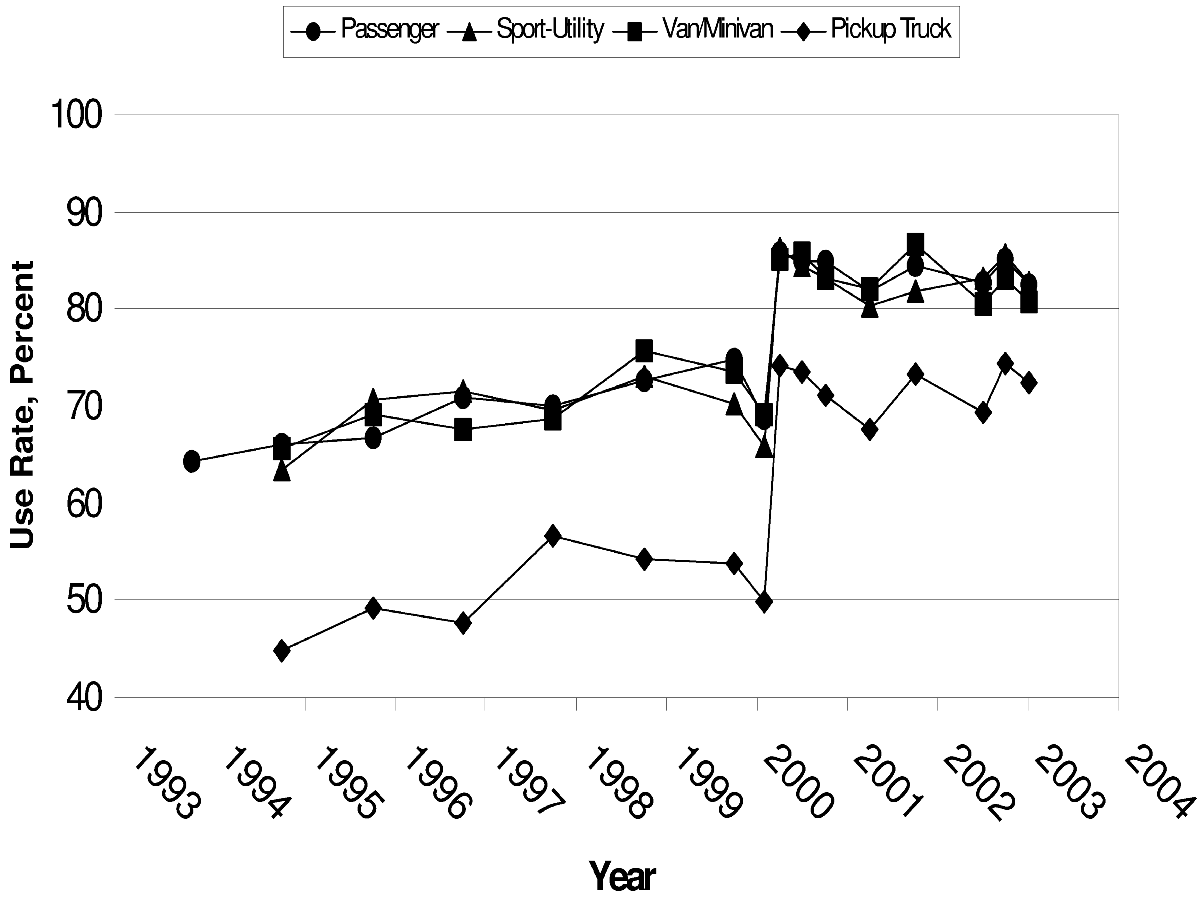

Figure 9. Front-Outboard Shoulder Belt Use by Vehicle Type and Year.

DISCUSSION

The estimated statewide safety belt use rate in December, 2002, for front-outboard occupants of passenger cars, sport-utility vehicles, vans/minivans, and pickup trucks combined was 80.5 ± 2.0 percent. Belt use in Michigan has not significantly changed when compared with the September, 2002, and June, 2002, belt use rates. A comparison with the highest rate observed before the introduction of standard enforcement (70.1 ± 2.2 percent; Eby, Vivoda, & Fordyce, 1999) reveals that the current rate reflects a 10.4 percentage point increase. Furthermore, the safety belt use rate from 1994 to present (see Figure 3), shows that belt use in Michigan has increased by 17.8 percentage points. These findings indicate that efforts to increase safety belt use in Michigan over the past nine and a half years, particularly the implementation of standard enforcement legislation in March, 2000, have been effective.

Comparing results over survey years indicates that progress has been made in increasing safety belt use among segments of Michigan's population least likely to buckle up; 16-to-29 year olds, pickup truck occupants, residents of Wayne County, and males. Since the introduction of standard enforcement, safety belt use among each of these groups reflects larger increases than their comparison groups. Belt use among motorists in these groups also reflects the largest increases since 1994. However, even with such substantial increases, these groups continue to display lower belt use than the rest of the motoring public. These results suggest that efforts to increase belt use should continue to focus on these populations. In addition, efforts to understand why these groups wear safety belts less often would be helpful in the development of programs designed to increase safety belt use.

In the current survey, belt use by many of the subcategories showed the usual trends that have been observed in Michigan over the past nine and a half years (see e.g., Eby, Molnar, & Olk, 2000; Eby, Vivoda, & Fordyce, 2002). Belt use was higher for motorists driving on freeway exit ramps than at local intersections. There were no consistent differences in belt use by time of day, day of week, or weather. Belt use was lower for passengers than drivers, for occupants of pickup trucks than other vehicle types, and for males than females.

Belt use also continued to be low for motorists between the ages of 16 and 29. However, the belt use rate for those in the 30-to-59 year old age group was also quite low. This finding is not consistent with most safety belt use surveys that have been conducted in Michigan (Eby, Molnar, & Olk, 2000; Eby, Vivoda, & Fordyce, 2002). A further analysis of this difference reveals that low belt use is observed only among males within this age group. Among 30-to-59 year olds, female belt use was observed at 87.1 percent while male belt use was only 74.0 percent. This belt use rate for 30-to-59 year old males is nearly the same as the rate of 73.4 percent for 16-to-29 year old males. Among all age/sex combinations, the group of 30-to-59 year old males reflects the largest decrease in belt use from the study conducted in September, 2002. In that survey wave, 30-to-59 year old males had 78.6 percent belt use compared to 74.0 percent in the current survey, a decrease of 4.6 percentage points.

It is also worth noting that although safety belt use remained statistically the same among pickup truck occupants from September, 2002 to the current survey, the largest decline among motorists in pickups was also observed within the 30-to-59 year old age group. In September, 2002, belt use for these motorists was 76.1 percent, compared to 70.7 percent in the current survey. Overall, 16-to-29 year old motorists continue to have lower safety belt use than the other age groups. However, there is usually a substantial difference in belt use between the 16-to-29 and 30-to-59 year old age groups, that was not observed in the current survey.

There are several possibilities that could explain this difference. For example, there is some evidence that belt use tends to decrease somewhat in the cold winter months (seasonal effect) (see e.g., Eby, Vivoda, & Fordyce, 2002). If this is the case, the seasonal effect may influence each age group in different ways. For example, drivers between the ages of 30 and 59 may buckle up less often in cold weather, while younger drivers may not be affected by seasonal changes. A similar effect was observed during a winter safety belt study conducted in January, 2000 (Eby, Vivoda, & Fordyce, 2002), when compared to the study conducted several months prior, in September, 1999 (Eby, Vivoda, & Fordyce, 1999). Between these two studies, overall belt use declined from 70.1 percent to 64.7 percent. Once again, the largest decline by age and sex was noted within the group of 30-to-59 year old males (6.3 percentage points).

Another possible explanation for these results is that the current safety belt survey was conducted as part of an evaluation of the "Click It Or Ticket" Thanksgiving Mobilization safety belt campaign. This campaign attempted to increase belt use by using media messages combined with increased police enforcement during the Thanksgiving holiday of 2002.[8] One focus of this mobilization was to target young drivers (16-to-29 year olds), a historically low belt use group. Between November and December, 2002, overall belt use did not change significantly, but due to limitations in sample size in the November study, changes in belt use by demographic characteristics could not be evaluated. It is possible that there would have been an overall decline in safety belt use had it not been for this program. Since one of the targets of the mobilization campaign was 16-to-29 year old drivers, and belt use for that group remained the same (rather than declining like the other age groups), the mobilization may have been successful among these young motorists. The decline in belt use noted for 30-to-59 year old drivers may reflect a general decline for those who were not a specific focus of the mobilization.

Collectively, these findings suggest that the change in the safety belt law to standard enforcement, PI&E programs, statewide enforcement campaigns, as well as other local programs, have been effective in increasing belt use in Michigan over the last nine and a half years. To continue to increase and maintain safety belt use, these programs should remain focused on the historically low belt use groups, while still addressing the other groups within the driving population, specifically males motorists in general. The national and state goal of 90 percent belt use (OHSP, 2002; NHTSA, 1997) has not yet been met, and these programs, as well as other innovative programs, must continue in order for Michigan to reach this goal.

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[8] For a full description of the "Click It Or Ticket" Thanksgiving Mobilization evaluation, see Eby & Vivoda, 2003.

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APPENDIX A

Data Collection Forms

SITE DESCRIPTION - DECEMBER 2002

SITE # __ __ __ (1 2 3) SITE LOCATION________________________

SITE TYPE	SITE CHOICE	TRAFFIC CONTROL
1 Intersection	1 Primary	1 Traffic Light
2 Freeway	2 Alternate	2 Stop sign
4	5	3 None
Exit No. ________		4 Other ____________
		6

DATE (month/day): __ __/__ __/2002
7 8 9 10

OBSERVER	DAY OF WEEK	WEATHER
1 Dave J.	1 Monday	1 Mostly Sunny
2 Dave S.	2 Tuesday	2 Mostly Cloudy
3 Mark	3 Wednesday	3 Rain
4 Steve	4 Thursday	4 Snow
5 Jonathon	5 Friday	13
6 Dave E.	6 Saturday	
11	7 Sunday	
	12	

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

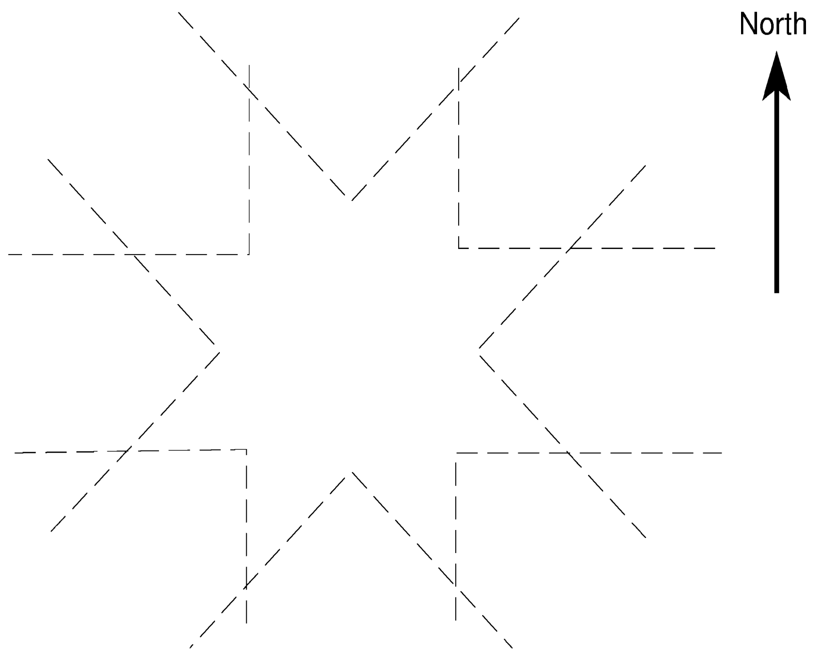
INTERRUPTION (total number of minutes during observation period): __ __
22 23

MEDIAN: 1 Yes
2 No
24

TRAFFIC COUNT 1: __ __ __
25 26 27

TRAFFIC COUNT 2:__ __ __
28 29 30

COMMENTS:



SITE # ___ ___ ___

1 2 3

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	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	Office Use Only: ___ ___ ___ 11 12 13	COMM. VEHICLE 1 No 2 Yes 14

DRIVER	1 Not belted 2 Belted 3 B Back 4 U Arm 4	1 Male 2 Female 5	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	Office Use Only: ___ ___ ___ 11 12 13	COMM. VEHICLE 1 No 2 Yes 14

DRIVER	1 Not belted 2 Belted 3 B Back 4 U Arm 4	1 Male 2 Female 5	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	Office Use Only: ___ ___ ___ 11 12 13	COMM. VEHICLE 1 No 2 Yes 14

DRIVER	1 Not belted 2 Belted 3 B Back 4 U Arm 4	1 Male 2 Female 5	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	Office Use Only: ___ ___ ___ 11 12 13	COMM. VEHICLE 1 No 2 Yes 14

APPENDIX B

Site Listing

Survey Sites By Number

No.	County	Site Location	Type	Str
001	Oakland	EB Whipple Lake Rd. & Eston Rd.	I	1
002	Kalamazoo	EB S Ave. & 29th St.	I	1
003	Oakland	SB Pontiac Trail & 10 Mile Rd.	I	1
004	Washtenaw	SB Moon Rd. & Ann Arbor-Saline Rd./Saline-Milan Rd.	I	1
005	Oakland	WB Drahner Rd. & Baldwin Rd.	I	1
006	Oakland	SB Rochester Rd. & 32 Mile Rd./Romeo Rd.	I	1
007	Oakland	SB Williams Lake Rd. & Elizabeth Lake Rd.	I	1
008	Ingham	SB Searles Rd. & Iosco Rd.	I	1
009	Kalamazoo	WB D Ave. & Riverview Dr.	I	1
010	Washtenaw	EB N. Territorial Rd. & Dexter-Pinckney Rd.	I	1
011	Washtenaw	NB Schleeweis Rd./Macomb St. & W. Main St.	I	1
012	Ingham	NB Shaftsburg Rd. & Haslett Rd.	I	1
013	Oakland	NB Middlebelt Rd. & 9 Mile Rd.	I	1
014	Washtenaw	WB Packard Rd. & Carpenter Rd.	I	1
015	Ingham	EB Haslett Rd. & Marsh Rd.	I	1
016	Washtenaw	NB Jordan Rd./Monroe St. & US-12/Michigan Ave.	I	1
017	Washtenaw	SB M-52/Main St. & Old US-12	I	1
018	Kalamazoo	SB 8th St. & Q Ave.	I	1
019	Washtenaw	WB 8 Mile Rd. & Pontiac Trail	I	1
020	Oakland	SB Lahser Rd. & 11 Mile Rd.	I	1
021	Kalamazoo	NB Ravine Rd. & D Ave.	I	1
022	Washtenaw	EB Glacier Way/Glazier Way & Huron Pkwy.	I	1
023	Washtenaw	WB Bethel Church Rd. & M-52	I	1
024	Washtenaw	SB Platt Rd. & Willis Rd.	I	1
025	Ingham	WB Fitchburg Rd. & Williamston Rd.	I	1
026	Washtenaw	EB Merritt Rd. & Stoney Creek Rd.	I	1
027	Oakland	SB Hickory Ridge Rd. & M-59/Highland Rd.	I	1
028	Kalamazoo	SB Douglas Ave. & D Ave.	I	1
029	Oakland	WB Walnut Lake Rd. & Haggerty Rd.	I	1
030	Oakland	NB Jossman Rd. & Grange Hall Rd.	I	1
031	Kalamazoo	EB H Ave. & 3rd St.	I	1
032	Kalamazoo	EB TU Ave. & 24th St./Sprinkle Rd.	I	1
033	Oakland	WBD I-96 & Milford Rd.. (Exit 155B)	ER	1
034	Washtenaw	WBP I-94 & Whittaker Rd./Huron St. (Exit 183)	ER	1
035	Kalamazoo	SBP US-131 & M-43 (Exit 38B)	ER	1
036	Washtenaw	SBD US-23 & N. Territorial Rd.	ER	1
037	Kalamazoo	EBP I-94 & Portage Rd.	ER	1
038	Oakland	EBP I-696 & Orchard Lake Rd. (Exit 5)	ER	1
039	Kalamazoo	WBP I-94 & 9th St. (Exit 72)	ER	1
040	Washtenaw	WBD I-94 & Jackson Rd.	ER	1
041	Kalamazoo	NBD US-131 & Stadium Dr./Business I-94	ER	1
042	Kalamazoo	NBP US-131 & Q Ave./Centre Ave.	ER	1
043	Livingston	SB County Farm Rd. & Coon Lake Rd.	I	2
044	Bay	WB Nebodish Rd. & Knight Rd.	I	2

045	Macomb	SB Camp Ground Rd. & 31 Mile Rd.	I	2
046	Jackson	SB Benton Rd./Moon Lake Rd. & M-50/ Brooklyn Rd.	I	2
047	Allegan	SB 6th St. & M-89	I	2
048	Kent	EB 36th St. & Snow Ave.	I	2
049	Livingston	EB Chase Lake Rd. & Fowlerville Rd.	I	2
050	Allegan	WB 144th Ave. & 2nd St.	I	2
051	Livingston	SB Cedar Lake Rd. & Coon Lake Rd.	I	2
052	Jackson	NB Mt. Hope Rd. & Waterloo-Munith Rd.	I	2
053	Kent	WB Cascade Rd. & Thornapple River Dr.	I	2
054	Allegan	NB 62nd St. & 102nd Ave.	I	2
055	Kent	SB Meddler Ave. & 18 Mile Rd.	I	2
056	Eaton	SB Houston Rd. & Kinneville Rd.	I	2
057	Macomb	SB M-19/Memphis Ridge Rd. & 32 Mile Rd./ Division Rd.	I	2
058	Allegan	NB 66th St. & 118th Ave.	I	2
059	Grn Traverse	NB Silver Lake Rd./County Rd. 633 & US-31	I	2
060	Grn Traverse	EB Riley Rd./Tenth St. & M-137	I	2
061	Bay	SB 9 Mile Rd. & Beaver Rd.	I	2
062	Kent	SB Ramsdell Dr. & M-57/14 Mile Rd.	I	2
063	Eaton	NB Ionia Rd. & M-50/Clinton Trail	I	2
064	Macomb	EB 23 Mile Rd. & Romeo Plank Rd.	I	2
065	Livingston	NB Old US-23/Whitmore Lake Rd. & Grand River Rd.	I	2
066	Jackson	SWB Horton Rd. & Badgley Rd.	I	2
067	Kent	SB Belmont Ave. & West River Dr.	I	2
068	Eaton	EB 5 Point Hwy. & Ionia Rd.	I	2
069	Allegan	WB 129th Ave. & 10th St.	I	2
070	Eaton	EB M-43 & M-100	I	2
071	Ottawa	WB Taylor St. & 72nd Ave.	I	2
072	Bay	EB Cass Rd. & Farley Rd.	I	2
073	Allegan	EB 126th Ave. & 66th St.	I	2
074	Bay	NB Mackinaw Rd. & Cody-Estey Rd.	I	2
075	Jackson	EBD I-94 & Elm Ave. (Exit 141)	ER	2
076	Kent	NBD US-131 & 100th St. (Exit 72)	ER	2
077	Ottawa	NBD I-196 & Byron Rd.	ER	2
078	Kent	SBP US-131 & Hall St.	ER	2
079	Macomb	SBP M-53 & 26 Mile Rd.	ER	2
080	Bay	NBD I-75 & Wilder Rd. (Exit 164)	ER	2
081	Livingston	EBD I-96 & Fowlerville Rd. (Exit 129)	ER	2
082	Macomb	EBP I-94 & 12 Mile Rd. (Exit 231)	ER	2
083	Jackson	WBD I-94 & Sargent Rd. (Exit 145)	ER	2
084	Allegan	NBP US-31/I-196 & Washington Rd./ Blue Star Hwy (Exit 47A)	ER	2
085	Genesee	SB Van Slyke Rd. & Maple Ave.	I	3
086	Monroe	WB Ida Center Rd. & Summerfield Rd.	I	3
087	Saginaw	WB Baldwin Rd. & Fowler Rd.	I	3
088	Calhoun	NB 23 Mile Rd. & V Drive N.	I	3
089	Saginaw	WB Wadsworth Rd. & Portsmouth Rd.	I	3
090	Lenawee	WB Slee Rd. & US-223	I	3
091	Van Buren	WB 36th Ave. & M-40	I	3

092	Van Buren	EB 63rd Ave. & County Rd. 652	I	3
093	Lapeer	WB McKeen Lake Rd. & Flint River Rd.	I	3
094	St. Joseph	NB Thomas Rd. & US-12	I	3
095	Saginaw	WB Rathbun Rd. & Moorish Rd.	I	3
096	Berrien	NB Fikes Rd. & Coloma Rd.	I	3
097	Genesee	WB Hegal Rd. & M-15/State Rd.	I	3
098	Lapeer	EB M-90 & M-90/M-53	I	3
099	Saginaw	NB Thomas Rd. & Swan Creek Rd.	I	3
100	Lenawee	WB Pixley Rd. & Deer Field Rd./Beaver Rd.	I	3
101	Van Buren	NB County Rd. 665 & M-40	I	3
102	Van Buren	WB County Rd. 374 & Red Arrow Hwy./St Joseph Rd..	I	3
103	Calhoun	SEB Michigan Ave./Austin Rd. & 28 Mile Rd./N. Eaton Rd.	I	3
104	St. Clair	WB Norman Rd. & M-19/Emmett Rd.	I	3
105	Monroe	EB Oakville-Waltz Rd. & Sumpter Rd.	I	3
106	Berrien	WB Glenlord Rd. & Washington Ave.	I	3
107	Muskegon	NB Whitbeck Rd. & Fruitvale Rd.	I	3
108	Monroe	SB Petersburg Rd. & Ida West Rd./Division Rd.	I	3
109	St. Clair	WB Masters Rd. & M-19	I	3
110	St. Joseph	SB Zinmaster Rd. & M-60	I	3
111	Shiawassee	NB State Rd. & Lansing Rd.	I	3
112	Van Buren	EB Celery Center Rd. & M-51	I	3
113	Shiawassee	SB Geeck Rd. & M-21	I	3
114	Muskegon	SB Holton Duck Lake Rd. & Ryerson Rd./ Fourth St.	I	3
115	Berrien	WB Glenlord Ave. & Hollywood Rd.	I	3
116	Lenawee	SB S. Piotter Hwy & Deer Field Rd.	I	3
117	Monroe	SBP I-75 & Front St./Monroe St. (Exit 13)	ER	3
118	Lapeer	WBD I-96 & Nepessing Rd. (Exit 153)	ER	3
119	Lapeeer	EBP I-69 & Lake Pleasant Rd. (Exit 163)	ER	3
120	Berrien	WBD I-94 & US-33/M-63/Niles Rd. (Exit 27)	ER	3
121	Van Buren	EBP I-94 & 64th St. (Exit 46, Hartford)	ER	3
122	Van Buren	EBD I-94 & County Rd. 652/Main St.(Exit 66)	ER	3
123	Muskegon	NBD US-31 & M-46/Apple St.	ER	3
124	Van Buren	NBP I-196 & M-140 (Exit 18)	ER	3
125	Calhoun	WBD I-94 & 26 Mile Rd.	ER	3
126	Monroe	NBP US-23 & Ida-West Rd. (Exit 13)	ER	3
127	Wayne	WB 8 Mile Rd. & Beck Rd.	I	4
128	Wayne	EB Warren Rd. & Wayne Rd.	I	4
129	Wayne	EB McNichols Rd. & Woodward Ave.	I	4
130	Wayne	NB Canton Center Rd. & Cherry Hill Rd.	I	4
131	Wayne	WB Ecorse Rd. & Pardee Rd.	I	4
132	Wayne	EB Michigan Ave. & Sheldon Rd.	I	4
133	Wayne	EB Ecorse Rd. & Middlebelt Rd.	I	4
134	Wayne	NB M-85/Fort Rd. & Emmons Rd.	I	4
135	Wayne	WB Glenwood Rd. & Wayne Rd.	I	4
136	Wayne	NB Haggerty Rd. & 7 Mile Rd.	I	4
137	Wayne	WB 6 Mile Rd. & Inkster Rd.	I	4
138	Wayne	SB Inkster Rd. & Goddard Rd.	I	4

139	Wayne	SB Merriman Rd. & Cherry Hill Rd.	I	4
140	Wayne	SEB Outer Dr. & Pelham Rd.	I	4
141	Wayne	NB Meridian Rd. & Macomb Rd.	I	4
142	Wayne	WB Ford Rd. & Venoy Rd.	I	4
143	Wayne	SWB Vernor Rd. & Gratiot Rd.	I	4
144	Wayne	WB 5 Mile Rd. & Beck Rd.	I	4
145	Wayne	EB 7 Mile Rd. & Livernois Rd.	I	4
146	Wayne	NB Gunston/Hoover Rd. & McNichols Rd.	I	4
147	Wayne	SB W. Jefferson/ Biddle Ave. & Southfield Rd.	I	4
148	Wayne	EB Goddard Rd. & Wayne Rd.	I	4
149	Wayne	WB 8 Mile Rd. & Kelly Rd.	I	4
150	Wayne	SB Merriman Rd. & US-12/Michigan Ave.	I	4
151	Wayne	SB Telegraph Rd. & Plymouth Rd.	I	4
152	Wayne	WB Sibley Rd. & Inkster Rd.	I	4
153	Wayne	NEB Mack Rd. & Moross Rd.	I	4
154	Wayne	WB Annapolis Rd. & Inkster Rd.	I	4
155	Wayne	SB Greenfield Rd. & Grand River Rd.	I	4
156	Wayne	EB Joy Rd. & Livernois Rd.	I	4
157	Wayne	SEB Conner Ave. & Gratiot Rd.	I	4
158	Wayne	NWB Grand River Rd. & Wyoming Ave.	I	4
159	Wayne	WBP I-96 & Evergreen Rd.	ER	4
160	Wayne	WBP I-94 & Haggerty Rd. (Exit 192)	ER	4
161	Wayne	NBD I-75 & Gibralter Rd. (Exit 29)	ER	4
162	Wayne	SBP I-75 & Southfield Rd.	ER	4
163	Wayne	NBD I-275 & 6 Mile Rd. (Exit 170)	ER	4
164	Wayne	NBP I-275 & M-153/Ford Rd. (Exit 25)	ER	4
165	Wayne	NBD I-275 & Eureka Rd. (Exit 15)	ER	4
166	Wayne	NBP I-75 & Springwells Ave. (Exit 45)	ER	4
167	Wayne	WBD I-94 & Pelham Rd. (Exit 204)	ER	4
168	Wayne	SBD I-75 & Sibley 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 x 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:

$$95\%\ Confidence\ Band = r_{all} \pm 1.96 \times \sqrt{Variance}$$

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 (NHTSA, 1992, 1998) stipulate that the relative error of the belt use estimate must be under 5 percent.