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16. Abstract

Reported here are the results of a direct observation survey of safety belt use conducted in January 2000 to provide a baseline rate from which to measure safety belt use trends following the implementation of standard enforcement in Michigan. In this study, 8,943 occupants traveling in four vehicle types (passenger cars, sport-utility vehicles, vans/minivans, and pickup trucks) were surveyed from January 13 to January 27, 2000. 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 by age, sex, road type, day of week, time of day, and seating position were calculated. Statewide belt use was 64.7 percent. When compared with the safety belt use rate determined in September 1999, this survey's estimated use rate shows that safety belt use in Michigan has decreased over the past four months. Belt use was 68.7 percent for passenger cars, 65.9 percent for sport-utility vehicles, 69.2 percent for vans/minivans, and 49.8 percent for pickup trucks. For all vehicle types, belt use was higher for females than for males, and higher for drivers than for passengers. In general, belt use was higher during the morning and evening rush hours and while it was snowing. Belt use did not vary systematically by time of day or day of week. Implementation of standard enforcement of mandatory safety belt use combined with maintenance of effective public information and education programs and targeting programs at low use populations, could be effective in increasing safety belt use in Michigan and in helping Michigan reach the national and state belt use standards set for the year 2005.

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INTRODUCTION

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). As a result, the overall medical costs from motor vehicle crashes decrease. It has been estimated that as much as 85 percent of these costs are absorbed by society. These costs can increase by as much as 50 percent when the individual is not wearing a safety belt (NHTSA, 1999a). Safety belt use must be further increased to continue to minimize automobile related injury and cost to society.

It is an established fact that the most effective way to increase the frequency of safety belt use is to mandate its use. The introduction of mandatory safety belt use laws has been accompanied by a significant decrease in automobile fatalities and injuries. 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, 49 states and the District of Columbia have passed similar laws (New Hampshire only requires safety belt use until occupants are 18 years of age). In general, these laws have produced a dramatic increase in belt use immediately following implementation, followed by a subsequent decline in belt use that generally remains above prelaw levels. This was the case in Michigan following implementation of a secondary safety belt law in July 1985 (see Eby, Molnar, & Olk, in press).

For a variety of reasons, nearly all of the first mandatory safety belt use laws were enacted with secondary enforcement. With secondary enforcement a police officer can only issue a safety belt citation if he or she stops the vehicle for some other reason, such as speeding. Thus, if a vehicle is otherwise being operated in a legal manner, unbelted occupants in the vehicle cannot be cited for disobeying the mandatory safety belt use law. This is in contrast to standard (or primary) enforcement where an officer can stop a vehicle and cite an occupant for lack of safety belt use.

Prior to 1993 only nine states had laws allowing standard enforcement: Connecticut, Hawaii, Iowa, Mississippi, New Mexico, New York, North Carolina, Oregon, and Texas (Motor Vehicle Manufacturers Association, 1991). Mississippi later amended their law to allow standard enforcement only for child occupants (Winnicki, 1995). Findings from a study by Campbell (1987) showed that states with standard enforcement have significantly higher safety belt use rates than states with secondary enforcement. Additionally, these states report lower automobile crash fatality rates for front-seat occupants. Specifically, an analysis of some of the first states to enact safety belt legislation found that secondary enforcement resulted in a reduction in fatality rates of about 7 percent, while states with primary enforcement saw a reduction of almost 10 percent (Wagenaar, Maybee, & Sullivan, 1987).

As a result, several states began to reexamine the enforcement provision of their laws and, starting in 1993, a handful of states passed legislation to change their mandatory safety belt use law from secondary to standard enforcement. Since 1993, eight jurisdictions have both passed and enacted such legislation: Alabama, California, District of Columbia, Georgia, Indiana, Louisiana, Maryland, and Oklahoma. New Jersey has also passed standard enforcement legislation, effective May 1, 2000 (Insurance Institute for Highway Safety, IIHS, 2000). Dramatic increases in safety belt use rates are seen when a state changes from secondary to standard enforcement. When California changed to standard enforcement, the safety belt use rate rose from 70 percent to 90 percent, an increase of 20 percentage points. The rate in Louisiana changed from 50 to 68 percent. Georgia saw similar results following implementation of standard enforcement, with an overall increase of 17 percentage points (NHTSA, 2000).

One additional state, Michigan, has passed standard enforcement legislation, but the change in enforcement will not be implemented until March 10, 2000. After a multiyear struggle by state safety officials and community members, Michigan's standard enforcement law (Senate Bill 335) was signed on May 26, 1999, seven years after it was first introduced (Winnicki, 1995). Besides allowing for standard enforcement, there are several additional points to Michigan's new law:

- All front seat occupants must use a safety belt;
- All children 0-to-3 years of age must be in a federally approved child restraint device, such as a child safety seat;
- Violators are responsible for a civil infraction with no license points assessed;
- Law enforcement agencies must investigate all reports of police harassment resulting from enforcement of the law;
- An independent agency will assess the effect of the law on the number of incidents of driver harassment during the first year of implementation;
- If after December 13, 2005, the Michigan Office of Highway Safety Planning certifies that there has been less than 80 percent compliance with the safety belt requirements during the preceding year, the law will revert back to secondary enforcement.

This final point sets an important goal for Michigan in the coming years. Besides this internally set goal for safety belt use, national goals have also been set. In an effort to increase safety belt use nationally, the president of the United States (US) ordered the development of a plan for increasing safety belt use in the US, called the *Presidential Initiative for Increasing Seat Belt Use Nationwide.* The first goal of the plan is to increase safety belt use nationally to 85 percent by the year 2000 and 90 percent in 2005. NHTSA (1997) estimates that this increase in safety belt use by 2000 would prevent about 4,200 fatalities and 102,500 injuries, and result in economic savings of about 6.7 billion dollars annually. The second goal is to reduce child occupant fatalities (0-to-3 years of age) 15 percent by 2000 and 25 percent by 2005.

The strategy outlined in the presidential initiative for reaching these goals details a four-point plan. The first point is *to build strong public-private partnerships* at local, state, and national levels. With strong partnerships at various levels, it is believed that a positive attitude toward safety belt use can become a "national attitude." Such partnerships would also serve as a conduit for the distribution of Public Information and Education (PI&E) programs. The second point is for states *to enact strong legislation* for mandatory safety belt and child restraint use. The strategy recommends that states work hard to pass standard safety belt use laws and that child passenger safety laws mandate restraint use by every child up to 16 years of age. The third point is *to conduct active and highly visible enforcement* of restraint use laws. It is well known that enforcement efforts combined with publicity about those enforcement efforts lead to increased compliance with a law. The presidential initiative recommends that enforcement programs be designed to fit community needs and give examples of programs such as ticketing, conducting checkpoints, using safety checks and clinics, and using officers as role models by assuring that they use their own safety belts. The fourth point is *to increase the presence of effective public education* regarding the benefits of restraint use. The critical element of this point is to provide the public with a single, simple message from a variety of sources and media.

Although Michigan did not meet the national goals for safety belt use set for 2000, the change to standard enforcement will help meet the goals set for 2005. Following implementation of this legislation, we expect to see a marked increase in safety belt use followed by a slight decline, that will remain at a rate higher than the prelaw safety belt use, rate. We also expect to see a reduction in child occupant fatalities as the safety belt use rate increases. Studies have shown that adult belt use has a significant effect on child safety. Specifically, children are much more likely to be belted in vehicles in which the adult driver of the vehicle is also belted (e.g., see Eby & Kostyniuk, 1999; Eby, Kostyniuk, & Vivoda, 1999; NHTSA, 2000). The purpose of the current study is to determine Michigan's baseline safety belt use rate, prior to the implementation of standard enforcement, from which to measure safety belt use trends in Michigan over the next year and beyond. Two additional surveys will be conducted to evaluate the effect of the standard enforcement law in Michigan. Annual surveys will continue to measure safety belt use rates to ensure that state and national goals are met.

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 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 which 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 to correlate positively with belt use (e.g., Wagenaar, Molnar, & Businski, 1987a). Wayne County was chosen as a separate stratum because of the disproportionately high VMT for Wayne County 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.

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

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 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 (*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 selected randomly. 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 randomly chosen. This happened for only two of the sites.

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,

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[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.

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 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 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.

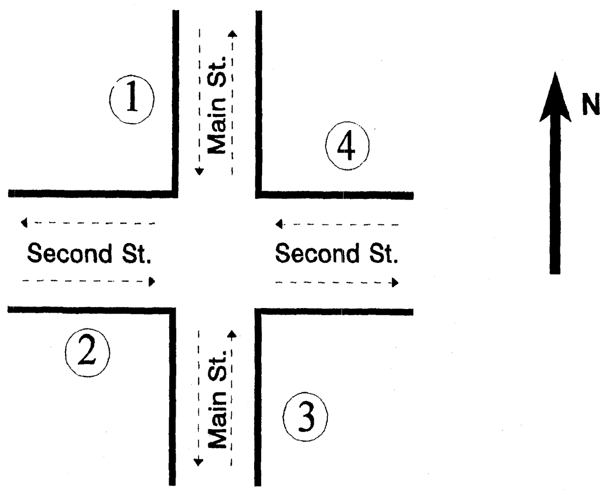

Figure 1. An Example "+" Intersection Showing Four Possible Observer Locations.

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 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 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 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 traffic control.

The day of week and time of day for site observation were quasirandomly assigned to sites in such a way that all days of the week and all daylight hours (8:00 am - 5:00 pm) had essentially equal probability of selection. The sites were observed using a clustering

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[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 & Streff, 1994) by contacting UMTRI -SBA, 2901 Baxter Rd., Ann Arbor, MI 48109-2150 or by visiting the Internet World Wide Web site at: *http://www-personal.umich.edu/~eby* and looking at the occupant *protection section.*

[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.

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 counterclockwise 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 pseudorandom 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/minivans, sport-utility vehicles, and pickup trucks) on the traffic leg under observation was conducted for a set duration (5 minutes) immediately prior to and immediately following the observation period (10 minutes total).

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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.

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 every site observed was the primary site and observations were well distributed over weather conditions, with the exception of rain.

Table 2. Descriptive Statistics for the 168 Observation Sites							
Day of Week		Observation Period		Site Choice		Weather	
Monday	12.5%	7-9 a.m.	7.1%	Primary	100.0%	Sunny	36.3%
Tuesday	15.5%	9-11 a.m.	20.9%	Alternate	0.0%	Cloudy	32.7%
Wednesday	11.9%	11-1 p.m.	19.0%			Rain	0.0%
Thursday	17.2%	1-3 p.m.	24.4%			Snow	31.0%
Friday	15.5%	3-5 p.m.	23.8%				
Saturday	14.9%	5-7 p.m.	4.8%				
Sunday	12.5%						
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 January 13 through January 27, 2000. Safety belt use, sex, and age 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 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, sex, 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-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 new NHTSA (1999b) guidelines, the observer also recorded whether the vehicle was commercial or noncommercial. 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 1 hour, with the exception of sites in the city of Detroit. To address potential security concerns, these sites were visited by two-person teams of observers 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 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 5-minute vehicle count was conducted at single-observer sites.

Observer Training

Prior to data collection, field observers participated in 5 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 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. 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, 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 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 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 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 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

[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.

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:

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

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. 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 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 new NHTSA (1999b) guidelines, this survey wave included commercial vehicles. In the sample, only 7.6 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, 64.7 percent ± 2.4 percent of all front-outboard occupants traveling in either passenger vehicles, sport-utility vehicles, vans/minivans, or pickup trucks in Michigan during January 2000 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 62.3 percent and 67.1 percent.

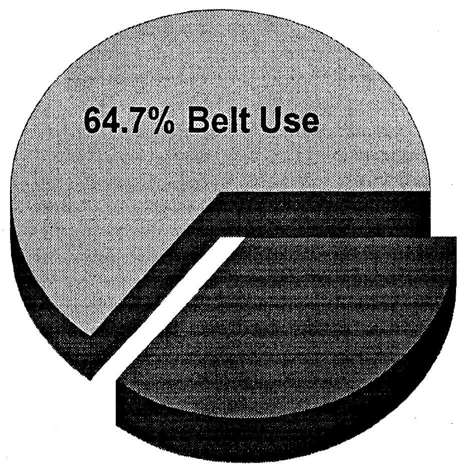

Figure 2. Front-Outboard Shoulder Belt Use in Michigan (All Vehicle Types and Commercial/Noncommercial Combined).

Estimated belt use rates and unweighted numbers of occupants (N) by strata are shown in Table 3. As is typically found in Michigan, the safety belt use rate for Stratum 1 was the highest in the state, followed by Stratums 2 and 3, respectively. The use rate for Stratum 4 (which contains the city of Detroit) was the lowest, following established trends.

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

	Percent Use	Unweighted N
Stratum 1	70.5	2,632
Stratum 2	64.7	1,742
Stratum 3	64.2	1,472
Stratum 4	58.8	3,097
STATE OF MICHIGAN	**64.7 ± 2.4 %**	8,943

Estimated belt use rates and unweighted numbers of occupants by stratum and vehicle type are shown in Tables 4a to 4d. Within each vehicle type we find that belt use was highest within Strata 1 and 2, except for vans/minivans, where belt use was highest for Stratum 3, followed closely by Stratum 1. The belt use rate was the highest for occupants of vans/minivans, with the rate for passenger cars a close second. As expected from previous surveys (e.g., Eby & Christoff, 1996; Eby & Hopp, 1997; Eby & Olk, 1998; Eby, Streff, & Christoff, 1995; Eby, Vivoda, & Fordyce, 1999), the overall belt use rate of 49.8 ± 4.8 percent for pickup trucks was significantly lower than for any other vehicle type (Table 4d).

Table 4a. Percent Shoulder Belt Use by Stratum (Passenger Cars)		
	Percent Use	Unweighted N
Stratum 1	75.5	1,351
Stratum 2	67.3	840
Stratum 3	66.3	696
Stratum 4	65.4	1,768
STATE OF MICHIGAN	**68.7 ± 2.9 %**	4,655

Table 4b. Percent Shoulder Belt Use by Stratum (Sport-Utility Vehicles)		
	Percent Use	Unweighted N
Stratum 1	70.6	347
Stratum 2	68.3	214
Stratum 3	66.5	170
Stratum 4	57.3	393
STATE OF MICHIGAN	**65.9 ± 4.4 %**	1,124

Table 4c. Percent Shoulder Belt Use by Stratum (Vans/Minivans)		
	Percent Use	Unweighted N
Stratum 1	73.9	388
Stratum 2	66.8	308
Stratum 3	75.5	226
Stratum 4	59.6	469
STATE OF MICHIGAN	**69.2 ± 3.6 %**	1,391

Table 4d. Percent Shoulder Belt Use by Stratum (Pickup Trucks)		
	Percent Use	Unweighted N
Stratum 1	53.7	546
Stratum 2	53.7	380
Stratum 3	51.5	380
Stratum 4	39.1	467
STATE OF MICHIGAN	**49.8 ± 4.8 %**	1,773

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. Typically, safety belt use surveys in Michigan (Eby, Molnar, & Olk, in press) have shown that safety belt use was higher for occupants in vehicles leaving limited access roadways (exit ramps) than for occupants in vehicles on surface streets. In the current study, this effect was observed across all vehicle types except for passenger cars. Although the belt use rate for all vehicle types combined was higher for vehicle occupants on surface streets than for occupants in vehicles observed on exit ramps, the difference is not great. The difference in overall rates can be explained by the high proportion of passenger cars observed in the study.

Time of Day. Estimated safety belt use by time of day, for each vehicle type, and for all vehicles combined is shown in Table 5. Note that these data were collected only during daylight hours. For all vehicles combined, belt use was highest before 1:00 p.m. Safety belt use rates for each vehicle type were generally higher during morning and evening rush hours.

Day of Week. Estimated safety belt use by day of week, for each vehicle type, and for 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 trends were evident.

Weather. Estimated belt use by prevailing weather conditions, for each vehicle type, and for all vehicles combined is shown in Table 5. There was no difference in safety belt use rates for observations conducted during sunny or cloudy weather. Safety belt use was higher for each vehicle type and for all vehicle types combined when it was snowing.

Sex. Estimated safety belt use by occupant sex, type of vehicle, and all vehicles combined is shown in Table 5. Estimated safety belt use was 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 (see, e.g., Eby, Molnar, & Olk, in press).

Age. Estimated safety belt use by age, for each vehicle type, and for all vehicles combined is shown in Table 5. According to revised National Highway Traffic Safety Administration guidelines (NHTSA, 1998), children traveling in CSSs are not to be included in the survey of statewide safety belt use. Children under 4 years of age account for an insignificant portion of the survey because about 75 percent of children in this age group tend to ride in CSSs rather than being restrained in a safety belt (see Eby, Kostyniuk, & Christoff, 1997). The other age groups were not affected by the revised guidelines.

Safety belt use over all vehicle types combined is generally highest for the 4-to-15 and the 60-and-over age groups. Belt use for the 16-to-29 year old age group generally shows the lowest belt use rate, with rates for the 30-to-59 year old age group below that of occupants older than 59 years of age. These results are similar to findings in previous UMTRI studies (Eby, Molnar, & Olk, in press) and show that new drivers and young drivers (16-to-29 years of age) should be one focus of safety belt use messages and programs.

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

Vehicle Type. Tables 4a - 4d show front-outboard safety belt use by vehicle type. As can be seen in this figure, pickup truck occupants, with a belt use rate of 49.8, were much less likely to use a safety belt than occupants of other types of vehicles. Occupants of vans/minivans were most likely to wear safety belts, with a use rate of 69.2, followed closely by passenger car occupants with a rate of 68.7, and sport-utility vehicles with a rate of 65.9 percent. Thus, enforcement and PI&E programs should continue to target pickup truck occupants.

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	64.6	6,211	69.9	3,158	64.0	797	67.9	986	49.5	1,270
Exit Ramp	64.2	2,732	65.1	1,497	69.9	327	70.4	405	52.4	503
Time of Day										
7 - 9 a.m.	73.4	746	75.8	399	71.1	112	73.2	132	65.3	103
9 - 11 a.m.	66.5	1,372	73.0	674	70.1	158	72.9	227	46.6	313
11 - 1 p.m.	66.3	1,525	72.0	788	74.6	167	67.4	256	46.3	314
1 - 3 p.m.	64.0	2,389	68.3	1,262	62.9	308	71.1	351	47.3	468
3 - 5 p.m.	63.3	2,599	66.3	1,354	64.0	343	66.8	384	53.9	518
5 - 7 p.m.	57.5	312	65.2	178	88.8	36	90.3	41	30.4	57
Day of Week										
Monday	60.6	1,474	61.3	851	66.8	200	66.1	221	52.7	202
Tuesday	62.5	1,412	66.1	745	70.5	165	61.5	195	50.5	307
Wednesday	68.0	752	72.5	377	61.2	104	69.2	136	55.6	135
Thursday	68.1	1,266	75.6	623	73.6	128	65.8	211	53.4	304
Friday	62.2	1,849	75.7	935	65.6	240	71.4	278	26.4	396
Saturday	68.5	1,055	73.9	535	74.9	137	70.6	143	55.5	240
Sunday	70.6	1135	71.0	589	71.4	150	82.5	207	50.6	189
Weather										
Sunny	63.7	3,266	67.4	1,697	65.0	387	67.5	531	49.9	651
Cloudy	63.7	3,175	67.9	1,715	65.5	395	67.5	475	49.7	590
Snow	68.3	2,502	71.7	1,243	71.1	342	75.3	385	50.8	532
Sex										
Male	57.6	5,009	63.5	2,260	57.8	585	59.3	730	47.4	1,434
Female	74.0	3,934	74.0	2,395	74.7	539	79.2	661	60.2	339
Age										
0 - 3	53.9	12	53.2	3	0.0	1	65.3	3	58.2	5
4 - 15	64.3	335	72.3	157	54.0	40	62.8	91	61.2	47
16 - 29	53.6	2,420	57.6	1,509	57.8	274	57.2	188	40.1	449
30 - 59	67.9	5,221	73.0	2,360	67.8	745	72.4	974	53.1	1,142
60 - Up	77.4	952	79.7	624	85.4	64	69.0	135	70.6	129
Position										
Driver	65.8	7,082	70.2	3,685	66.2	893	69.7	1,061	51.1	1,443
Passenger	60.4	1,861	62.6	970	64.2	231	67.4	330	45.1	330

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. For better estimates of safety belt use for these age groups in Michigan see Eby, Kostyniuk, and Vivoda (1999). Excluding the youngest age group, belt use for females was higher than use for males in all age groups. However, the absolute difference in belt use rates between sexes varied greatly depending upon the age group. The most notable differences are found in the 16-to-29 year old and 30-to-59 year old age groups, where the estimated belt use rates are 16.2 and 18.7 percentage points higher, respectively, for females than for males. These results argue strongly for statewide efforts to be directed at persuading young males, and males in general, to use their safety belts.

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	59.8	8	34.7	4
4 - 15	63.2	191	66.3	144
16 - 29	46.7	1,316	62.9	1,104
30 - 59	59.8	2,935	78.5	2,286
60 - Up	72.3	556	83.8	396

DISCUSSION

The estimated statewide belt use rate for front-outboard occupants of passenger cars, sport-utility vehicles, vans/minivans, and pickup trucks combined was 64.7 ± 2.4 percent. When compared with the statewide use rate from September 1999 of 70.1 ± 2.2 percent (Eby, Vivoda, & Fordyce, 1999), the current rate shows that front outboard shoulder belt use in Michigan has declined over the last 4 months. An examination of safety belt use patterns between the two studies showed that the patterns in safety belt use were nearly the same, except that belt use was lower in the present study.

We examined four hypotheses to explain the difference in safety belt use rates between the surveys. The first was that the present survey had a larger proportion of pickup truck occupants than in the previous survey leading to lower overall use because of the lower safety belt use rate in pickup trucks. Analysis of the proportions of different vehicle types in both surveys showed that the proportion of each vehicle type was nearly identical. In addition, the safety belt use rates for each vehicle type was lower than the previous survey by about the same amount. A second possibility was that occupants in the 16-to-29 year old age group were observed in greater proportion than in the previous survey. Again, analysis showed that the proportions of observed occupants by age group were the same as in the previous survey. A third possibility was that people simply use safety belts less frequently in winter than in fall, possibly because heavy coats impede use of a safety belt. An exhaustive review of previous studies found no consistent evidence of a seasonal effect on safety belt use (see, e.g., Richardson, 1972; Fhaner & Hane, 1973; Oranen, 1973; Wilde, 1977; Sigwart & Harvey, 1992). A recent analysis of safety belt use in Michigan from 1984 to 1998 showed that in the early 1980s, safety belt use in winter may have been slightly lower (one or two percentage points) in winter than in summer (see Eby, Molnar, & Olk, in press). Thus, the lower safety belt use rate in Michigan found in the present study, may be partially due to a seasonal effect. The fourth hypothesis was that belt use was higher in September 1999 than in the present study because the threat of getting cited for lack of safety belt use by law enforcement was higher in the earlier study than in the present one. The September study occurs over Labor Day weekend, a holiday that is associated with high motor vehicle travel. Because of this, many local police agencies conduct visible traffic safety enforcement programs during the same time as the

September study. In addition, the Michigan State Police, have on occasion conducted statewide safety belt enforcement programs during Labor Day and the week following. No similar programs tend to occur in January. Thus, it is highly likely that one reason why statewide safety belt use was higher in September 1999 than January 2000 is that the threat of enforcement is higher in September in Michigan.

Belt use by the various subcategories showed typical trends in sex, seating position, age and vehicle type (Eby, Molnar, & Olk, in press). Belt use was higher for females than males by about 16 percentage points. This finding suggests that statewide efforts to increase belt use for males should be intensified. Despite the fact that female belt use is significantly higher than male belt use, females should not be ignored in PI&E efforts; their current belt use rate of 74 percent is still far below the national goal of 90 percent by 2005.

The study also showed that belt use for drivers is higher than for passengers. Our analysis indicates that new efforts should be made to encourage passengers to use safety belts. Further research is essential to better understand the dynamics of passenger belt use in order to develop appropriate and effective PI&E programs.

As is typically found, belt use for the 16-to-29 year old age group was the lowest of any age group. NHTSA has recognized that current traffic safety messages for this age group may not be cognitively appropriate and has begun an effort to better understand cognitive development and the factors which influence thinking in young drivers (see, e.g., Eby & Molnar, 1999). Such information may allow for the development of more appropriate traffic safety messages for this age group.

The analysis of safety belt use by vehicle type showed that occupants in passenger cars, sport-utility vehicles, and vans/minivans used safety belts at a rate above 65 percent (see Tables 4a - 4d). Unfortunately, the use rate for pickup truck occupants continues to be much lower than the use rate for occupants in other vehicle types, as found in previous surveys. Thus, continued efforts to encourage belt use by occupants of pickup trucks are warranted.

These findings collectively suggest that the new national goal of 90 percent safety belt use by 2005 (NHTSA, 1997), and Michigan's goal of maintaining at least 80 percent overall belt use by December 2005, are still many percentage points away. Thus, new efforts must be implemented to boost the rate of safety belt use in Michigan.

The four-point plan outlined earlier for increasing nationwide belt use provides a good framework for increasing belt use in Michigan. As stated in this plan, enactment of strong policy for mandatory safety belt use is crucial. Thus, one activity that will very likely be effective in increasing safety belt use is the change from secondary to standard enforcement, effective March 10, 2000. Findings from a number of studies (e.g., Campbell, 1987; NHTSA, 1997) indicate that statewide belt use rates are higher in states with primary enforcement than in states with secondary enforcement. States with standard enforcement have safety belt use rates which are, on average, 17 percentage points higher than states with secondary enforcement (NHTSA, 1999a). If Michigan experiences this large an increase in safety belt use following the new legislation, we will be within reach of our state and national goals.

The presidential safety belt initiative also highlights the importance of active and visible enforcement programs. Strict and visible enforcement of Michigan's new standard enforcement law, combined with major publicity campaigns, could be effective in further increasing belt use. According to NHTSA (1999a), there is no way to achieve a safety belt use rate higher than 85 percent without widely publicized and strongly enforced laws. NHTSA (1997) also suggests several enforcement approaches, including ticketing, conducting checkpoints, conducting safety checks, holding child safety seat clinics, and having officers serve as role models for the public through their own safety belt use, that could be tailored to a particular community's needs.

The other two points outlined in the plan--building public-private partnerships and increasing effective public education--can also be used to increase safety belt use in Michigan. While Michigan already devotes extensive efforts in both areas, continued and expanded support of the efforts is critical for reaching both the state and national goals.

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APPENDIX A

Data Collection Forms

SITE DESCRIPTION 2000

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

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): __ __/__ __/2000 (7 8 9 10)

OBSERVER
1☐ Steve
2☐ John
3☐ Ken
4☐ Jennifer
5☐ Tiffani
6☐ Jonathon
7☐ Dave
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) (14 15 16 17)   END TIME: __ __:__ __ (24 hour clock) (18 19 20 21)

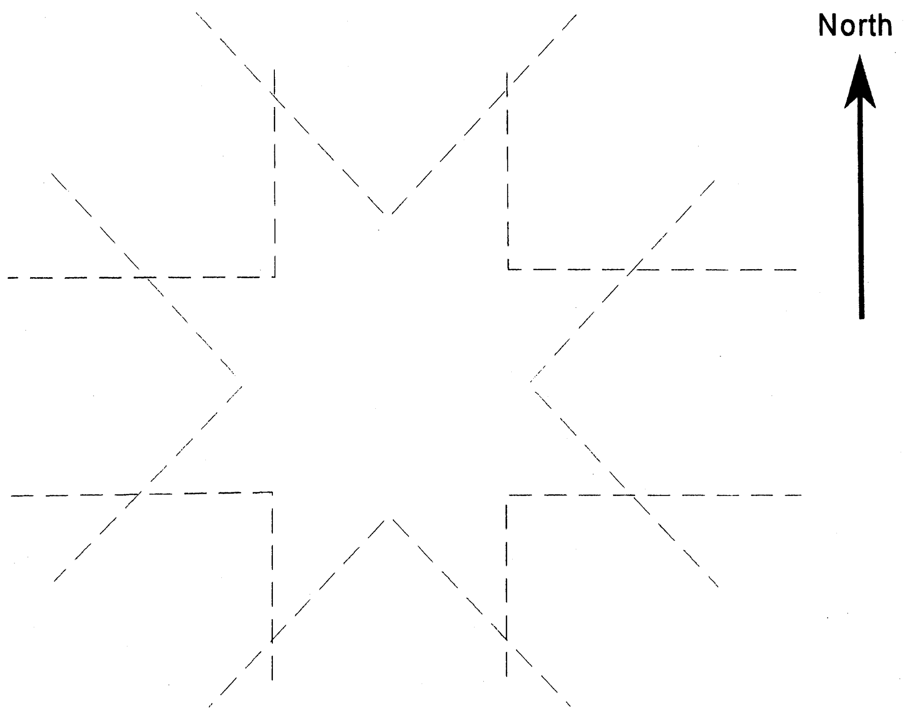
INTERRUPTION (total number of minutes during observation period): __ __ (22 23)

MEDIAN: 1☐ Yes
2☐ No
24

TRAFFIC COUNT 1: __ __ __ (25 26 27)

TRAFFIC COUNT 2: __ __ __ (28 29 30)

COMMENTS::



SITE # ___ ___ ___
1 2 3

PAGE #________

ATTENTION CODING: DUPLICATE COL 1 - 3 FOR ALL VEHICLES

2000

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

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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. & Kinneyville 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:

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

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:

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

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.