SAMPLE DESIGN

FOR THE

CALIFORNIA SEATBELT SURVEYS

by

Thomas Piazza
and
Raul Betancourt

Survey Research Center
University of California, Berkeley

November 2005
Contents

Abstract .................................................................................................................... 1

Introduction .............................................................................................................. 1

Overview of the Sample Design .......................................................................... 2

1. Highway Sample .................................................................................................. 4

2. Non-Highway Sample .......................................................................................... 10

3. Estimation of Seatbelt Usage ............................................................................. 17

4. Results for 1998-1999 and Possible Refinements ........................................ 22

References .............................................................................................................. 25
Sample Design for the California Seatbelt Surveys

Abstract

The sample design used in California since 1992 to measure seatbelt usage in passenger vehicles is described. A stratified cluster sample of 160 observation sites was selected, and fieldworkers observed approximately 100 vehicles annually at each site. Results for drivers in 1998 and 1999 are presented, and possible modifications to the sample design are discussed.

Introduction

The Department of Transportation of the State of California has been collecting data on the rate of seatbelt usage since about 1985. Beginning in 1992, the data collection has been based on a probability sample of passenger vehicles, and the sample design for the seatbelt surveys has remained the same. The purpose of this report is to summarize and explain the sampling methods currently used in California.

Since California is a large state with many thousands of miles of highways and roads, it was important to design a sampling strategy that could be implemented in as simple a manner as possible. Resources, of course, were limited, but good estimates of seatbelt usage were required.

The sample design adopted conforms to the “Belt Use Survey Guidelines” distributed by the National Highway Traffic Safety Administration in 1992. In particular,
the sample was designed around measures of the “average daily traffic” (ADT) on the
various highways and roads of the state.

The California sample design is similar in many respects to designs reported for
North Carolina (Reinfurt et al., 1988), New York (Brick and Edmonds, 1984), and
several other states (Brick and Lago, 1988). These samples are all observational studies,
in which the observation sites are selected by the methods of stratified cluster sampling
(see Kish, 1965 and Cochran, 1977). The California sample, however, made special use
of the ADT data for selecting highways and of maps for selecting other roads.

Overview of the sample design

For purposes of sampling, all the highways and roads in California were divided
into two major parts (strata). Separate probability samples were taken in each of those
parts, and the results were then combined, to provide estimates of seatbelt usage for the
state as a whole.

The first part of the sample included all major highways for which ADT figures
were published by the California Department of Transportation. A sample of 80
observation sites was drawn with probability proportional to ADT from the published
sources. Then approximately 100 vehicle observations were made at each selected
observation site. The second part of the sample covered non-highway roads in California
(those for which ADT figures were not published). Eighty small areas, 1/4 mile square,
were selected from maps of the state (excluding very sparsely populated areas such as
deserts and forests). In each selected small area, any highways that were covered in the
first part of the sample were excluded. If other roadways were present in the small area, approximately 100 vehicle observations were made, the same as for the highway sample.

At each observation site, two field workers were always assigned. One worker identified each selected vehicle. Both workers observed whether or not the driver in the selected vehicle had his or her shoulder strap buckled. Then the second worker recorded the result on a form. Days of the week and times of the day were assigned at random.

Observation was attempted only during daylight hours. Before 1998, only automobiles were observed. From 1998 onward, observations included vans, sport utility vehicles, and pickup trucks without commercial identification.

The statistic being estimated is the rate of seatbelt usage per mile traveled in California. For each estimate, standard errors and confidence intervals were calculated. We will now describe each step of the sampling process in more detail. For a description of the actual field work procedures, see the “Project Management Manual” (Betancourt 2001).
1. Highway Sample

Sampling frame for highways

The State of California periodically issues a report entitled, “Traffic Volumes on the California State Highway System.” It includes the results of a mechanical count of vehicle traffic, in both directions, conducted periodically approximately every mile on all the major highways in California. For each mile-post, the report gives the peak hour traffic volume, the average traffic per day in a peak month, and the average traffic per day in a year (combining the traffic in both directions). This last statistic is the ADT – the average daily traffic – that we used for sampling.

The most recent “Traffic Volumes” report available in 1992 was the report for 1990. To prepare that report for use as a sampling frame, we added up the ADT on each page, and then cumulated the page totals. In 1990 the total ADT was approximately 349 million – which means approximately 349 million vehicle-miles per day on California highways.

Stratified selection of highway observation sites

We selected 80 observation sites, paired into 40 strata, from the 1990 “Traffic Volumes” report. Selection was done using systematic random selection with probability proportional to size, where the measure of size is ADT.

The “Traffic Volumes” report lists the highway mile-posts in numerical order by highway number and then by county within each highway number. Therefore, a systematic random selection of sites from this list (by skipping through the list with a
fixed interval after a random start) provides a selection of sites implicitly stratified by highway number (and therefore geographical area as well). We could have divided the “Traffic Volumes” report from front to back (in highway order) into 40 separate parts, each with approximately an equal total of ADT, thus forming 40 explicit strata.

However, the use of systematic random selection from an ordered list produces implicit strata that are the same as explicit strata, for most practical purposes. (See Kish, pp. 113-115, on this use of systematic sampling as a stratification technique.)

Within each (implicit) stratum or zone, two mile-posts were selected at random with probability proportional to each mile-post’s ADT. Each stratum represented about \( \frac{349}{40} = 8.725 \) million daily vehicle miles. By selecting two random numbers between \( I \) and that total number, and applying those numbers to the cumulative sum of site ADT, each mile–post had a probability of selection that was proportional to the size of its ADT measurement. The same two random numbers were used to select sites in each of the 40 strata – by adding the size of the interval (about 8.725 million) to each random number successively.

Formally, therefore, we had two separate systematic random samples from the ordered list, and the two selections within the same zone (implicit stratum) constitute a pair, for purposes of calculating sampling errors. (See Kish, pp. 193-195, for a discussion of this type of paired selection of stratified unequal clusters; see also pp. 308-313 for further discussion and examples.) These 80 selected mile-posts were retained in the sample through the year 2001, unless road closures or construction required that some other mile-post within the same stratum be selected.
If the seatbelt surveys continue, a new selection of observation mile-posts should be carried out, in order to include new highways contained in more recent “Traffic Volumes” reports. Note, however, that new highways not currently covered in the highway sampling frame could in principle be selected in the non-highway part of the sample (to be described below), but that has not been done in the surveys conducted through 2001.

Selection of vehicles on highways

Field workers were sent to each selected highway mile-post, to find an appropriate observation point. Procedures were developed with the California Highway Patrol that would allow safe observation of vehicles traveling on major highways. This often entailed choosing an observation point on an overpass or an off-ramp. In every case, however, an observation point was chosen that would allow the field workers to observe the vehicles passing the selected mile-post in both directions.

The actual days of the week and hours of the day assigned to observation sites were rotated randomly among the selected sites in a geographic area used as a base by the field workers. Observation was done seven days a week, but only during daytime hours.

At each selected observation site, a selection ratio was established that would allow the observation of 100 vehicles in approximately one hour. This ratio was established based on the ADT for the site, which reflected the expected traffic volume. For example, if the ADT for a site was 4,800 vehicles per day, the expected hourly traffic flow (assuming a constant flow for all 24 hours) would be 4800 / 24 = 200 vehicles per hour. This means that a selection ratio of 1/2 of the vehicles passing that mile-post would
yield 100 observed vehicles in an hour. Selection ratios were always simplified – they could be 1/2, 1/3, 1/4, and so on. In the case of major multi-lane highways, the selection ratio also incorporated a factor for selection of one of the lanes at random. After 15 minutes of observation the ratio was adjusted, if necessary, to reflect the actual volume of traffic.

Once the day, time, and initial selection ratio had been set, the field workers were sent to the selected mile-post to observe the vehicles. They were always sent in pairs. One field worker selected a vehicle travelling on the road and also observed seatbelt usage. The second worker observed and validated the first worker’s observation and then recorded on a form whether or not the driver (and passenger, if any) had seatbelts fastened – that is, whether or not fastened shoulder straps were visible to the observer. Observation was carried out in one direction of the highway for a period of time and then was carried out in the other direction for an equal period of time. This continued until 100 passenger vehicles were observed. See the “Project Management Manual” (Betancourt 2001) for more details. (Some deviations from 100 observations per site occasionally occurred in the final data file, but they were not substantial.)

These procedures were designed to generate 100 vehicle observations that could reasonably be treated as a random sample of all the passenger vehicles passing the selected mile-post. Although all of the observations at a site were clustered into a single randomly chosen day and hour, there was no reason to expect that the rate of seatbelt usage varied substantially at that mile-post, at least during the daytime hours used for observation. The usage rate was expected to vary more by location (urban/rural and size
of road or highway). But this latter variation is precisely what was accounted for in our stratified cluster design.

Assuming, therefore, that our procedures yielded a random sample of 100 passenger vehicles at each selected highway site, the probability of selection for the vehicles in the highway portion of our sample, can be summarized in the following equation:

$$P_{hi} = \frac{(80 \cdot ADT_{hi})}{(\sum ADT_{hi}) \cdot (100 / ADT_{hi})} = k$$  \hspace{1cm} (1)

The first term in the equation is the probability of selecting site $i$ in stratum $h$. Eighty highway sites were selected with probability proportional to $ADT_{hi}$ which is the estimated ADT for each site. The second term in the equation is the probability of selecting a vehicle at a selected site. The selection of 100 vehicles is done with probability inversely proportional to the estimated daily traffic flow, $ADT_{hi}$. Since the $ADT_{hi}$ in the two terms of the equation cancel out (or at least reduce to a constant, assuming a constant ratio between passenger vehicles and total vehicles at all highway sites), and since the sum of the ADT (in the first term) is a constant, the equation reduces to a constant term, $k$, and we see that all vehicles in the highway portion of our sample have the same probability of selection. This means that the rate of seatbelt usage on California highways can be estimated by simply pooling the results of all the highway observations. No weighting is necessary for this part of the sample.

We should note, however, that the assumption of a constant ratio between passenger vehicles and total vehicles at all highway sites is probably not very realistic. A more correct procedure would have been to select 100 vehicles (or some other fixed number) at each observation site and then simply to ignore the non-passenger vehicles,
resulting in slightly unequal sample sizes of passenger vehicles at each site. Since the probability of selecting each highway mile-post depended on the total vehicle ADT, and not on the (unknown) passenger ADT, the selection of vehicles for observation at each site should also have been based on total vehicle ADT. We therefore recommend that future users of this design adopt the more correct selection procedure. An alternative would be to keep track of the ratio between passenger vehicles and total vehicles at each site and to create a weight variable that would be the inverse of that ratio for all observations at that highway site.

Nevertheless, the departures from the average ratio between passenger vehicles and total vehicles are unlikely to have had much impact on the results, given the similarity of seatbelt usage observed at the various highway observation sites. Observed seatbelt usage at almost all highway sites fell into a narrow range of about ten percentage points. Therefore, small departures from a constant sample size of passenger vehicles at each highway site could not have had much effect on the overall highway estimate.
2. Non-Highway Sample

The second part of the California sample is the non-highway portion. This part represents the roads in the state that were not included in the “Traffic Volumes” report, which covers principal highways. As a result we could not use that report as a (very convenient) sampling frame. Instead, we had to construct a geographic sampling frame for this project, to be described next.

Sampling frame for the non-highway sample

The sampling frame for the non-highway portion of the California sample was constructed from maps. The starting point was *The California Road Atlas* published by Thomas Brothers. That atlas divides the state into 110 maps of equal area, each measuring 37.5 miles by 50 miles. A reorganized version of those maps made up our frame.

Many of the 110 maps were deleted in whole or in part because they covered National or State forests, deserts, areas covered by water, or areas outside California borders. Some remote and sparsely populated areas were also excluded, as allowed by the Guidelines. The remaining map areas were combined into 40 composite maps of equal size, each covering an area of 37.5 by 50 miles.

These 40 maps contained more than 90 percent of the California population, since all cities and virtually all populated areas were included. This was verified using Census figures for counties and cities. The actual estimate of population coverage was 91.36 percent. Furthermore, since highways passing through the excluded rural areas were still
included in the highway portion of the sample, the combined highway and non-highway sampling frames included much more than 90 percent of the vehicle traffic in California.

**Stratified selection of non-highway observation sites**

The 40 composite maps of the state were treated as strata. Two observation sites were selected from each of those strata. To achieve this, each map covering 37.5 by 50 miles was overlaid with a grid of lines 1/4 mile apart. This resulted in each map being divided into 30,000 areas, each area being 1/4 mile square. (Note that the product of 4 * 4 * 37.5 * 50 equals 30,000.) These small areas served as the primary sampling units for this part of the sample.

Within each of the 40 large areas (strata) our problem was to select two observation sites that contained roads not already included in the sampling frame for the highway portion of the sample. Frequently we had to make more than two primary selections in order to achieve that goal.

Each primary selection of a small area (1/4 mile square) was carried out by selecting random numbers for the vertical and horizontal coordinates of the grid containing 30,000 small areas per map. If the selected small area contained no roads at all or only contained a segment of a highway already included in the highway frame, an additional primary selection was made. This procedure continued until two small areas with non-highway roads were selected.

Note that in rural areas more selections were usually required to find small areas containing eligible roads, and the probability of selecting a small area was generally higher than in a city with many non-highway streets. The probability of selecting a given
area was $A_h / 30,000$, where $A_h$ is the total number of selections actually made in stratum $h$. Usually $A_h$ equaled 2, but frequently $A_h$ was larger in rural areas. This difference in the probabilities of selection was compensated for by weighting, as will be described below.

Some selected small areas had only one road passing through the area, and therefore an observation site could be set up at any convenient point in that area. If there was more than one non-highway street or road in the area, one was selected at random, and an observation site was established along the selected street or road at a point as close as possible to the northwest corner of the quarter-mile-square small area. The probability of selecting a particular street or road in PSU $i$ of stratum $h$ was $1/R_{hi}$ where $R_{hi}$ is the number of eligible roads in the small area. Frequently $R_{hi}$ was equal to one, but often it was higher. This difference in probabilities of selection was also compensated for by weighting.

These 80 selected non-highway observation sites were retained in the sample through 2001, unless road closures or construction required that other sites within the same stratum be selected. When those changes were occasionally made, the weights based on selection probabilities were adjusted to reflect the new sites.

**Selection of vehicles at non-highway observation sites**

Field workers were sent to each selected observation site. The observation procedures were basically the same as for highway observations. One field worker identified the selected vehicle; both workers observed seatbelt usage in the selected
vehicle; and the second worker recorded the observation. This usually continued until 100 passenger vehicles were observed, including both directions.

As for highways, observation days and times were randomized. Unlike highways, however, it was usually necessary to continue observation for more than an hour to reach 100 observations, even when seatbelt usage was recorded for every passing vehicle. Sometimes it was necessary to return for some hours on additional days. Nevertheless, the observations generally continued until 100 vehicles were recorded, in order to improve the sample estimates. However, in some rural areas 100 vehicles could not be observed in a reasonable period of time. In such cases the difference was compensated for by weighting.

These procedures were designed to generate approximately 100 vehicle observations that could reasonably be treated as a random sample of all the passenger vehicles passing the selected observation site. Even though the observations at a site were clustered into a single randomly chosen time on one day (or occasionally more days), there was no reason to expect that the rate of seatbelt usage would vary substantially at that site, at least during the daytime hours used for observation.

At each site, therefore, the 100 (sometimes less) observed vehicles were treated as a random sample of the average number of passenger vehicles passing that site daily. And the average number of passenger vehicles was estimated from ADT figures. Although the ADT for non-highway sites is not published in the “Traffic Volumes” report, it was possible to obtain an estimated ADT from one of various sources. The California Department of Transportation sometimes had ADT estimates for the selected roads; otherwise, city or county estimates were used.
The probability of selection for all the vehicles in the non-highway portion of our sample can be summarized with the following equation:

\[ P_{hi} = \left( \frac{A_h}{30,000} \right) \cdot \left( \frac{1}{R_{hi}} \right) \cdot \left( \frac{b_{hi}}{\text{ADT}_{hi}} \right) = k \cdot A_h \cdot b_{hi} / (R_{hi} \cdot \text{ADT}_{hi}) \]  

(2)

The first term in the equation is the probability of selecting site \( i \) in stratum \( h \). In each of the 40 strata represented by a map of a 37.5 by 50 mile area, \( A_h \) small areas were selected, where \( A_h \) was at least 2 but was often more. The second term in the equation is the probability of selecting a specific road within the selected small quarter-mile-square area. If there was only one road, this term equals 1. The third term is the probability of selecting a vehicle at a selected observation site. The selection of \( b_{hi} \) passenger vehicles (usually 100) is done with probability inversely proportional to the estimated ADT at that site.

Unlike the case in equation (1) for the highway portion of the sample, the subscripted terms in equation (2) do not cancel out to a single constant term for all sites. In the non-highway portion of the sample, the probabilities of vehicle selection differ from one site to another, and a weight is required to compensate for those differences when seatbelt usage is estimated.

As we noted above in regard to the highway sample, the ADT figures available are for total vehicle traffic, whereas our sampling procedure assumes that we are selecting approximately 100 passenger vehicles out of the total number of passenger vehicles daily passing the observation site. Since we do not know how different the ratio of passenger vehicles to total vehicles is at each site, a more correct procedure would be to select 100 vehicles (or some other fixed number) of all types and then simply to ignore the non-passenger vehicles. An alternative procedure would be to keep track of the ratio
between passenger vehicles and total vehicles at each site and then adjust the ADT accordingly when creating weights. We recommend that future users of this design adopt one of those procedures.

For the non-highway estimates, however, a more substantive issue concerns the accuracy of the ADT figures. Since the ADT for each site does not cancel out in equation (2), it will remain as part of the weight and will affect the estimates. And since the ADT figures available for non-highway sites were often based on average traffic flow in an area larger than the selected quarter-mile-square area, this is a potential source of bias. Nevertheless, we should note that although we would use the exact ADT figures for every site for which they are available, there is some advantage in using ADT figures based on larger areas in rural parts of the state. It is the small rural areas that are less likely to have ADT figures for a particular road, and the real ADT could vary substantially from one road to another. The effect of using an ADT figure for a larger area (possibly even for a whole small town) is to smooth out what could otherwise be very large differences in the ADT component of equation (2) and, consequently, in weights based on the inverse of that equation. And it is usually a good idea to reduce large variations in weights, whenever possible.

In any case, the use of ADT figures, even for larger areas, is important to the non-highway sample design. That design allows field workers to be sent to a rural site with relatively clear and simple instructions about what they are expected to do. Without the ADT (third) term in equation (2), it would be necessary to devise a separate sampling scheme for each of the 80 non-highway observation sites based on information obtained at each site, and to keep track carefully of all the sampling stages at each site, so that the
appropriate weight factors could be calculated. Since the cost of sending skilled
sampling personnel to all those sites would be prohibitive, most of that sampling work
would have to be done by relatively untrained field workers. The errors involved in such
an operation would very likely produce less reliable estimates than we obtain by using the
ADT figures available. Therefore, we believe that the current non-highway sample
design is a realistic and effective one.
3. Estimation of Seatbelt Usage

The overall seatbelt usage for drivers of passenger vehicles in California can be estimated by calculating usage separately in the highway portion of the sample and in the non-highway portion, and then combining the results. We will describe each of those steps.

Mean seatbelt usage

Under our sample design for the highway portion of California roads, all vehicles had the same probability of selection, as shown in equation (1). Estimation of seatbelt usage for this portion of the sample was very straightforward, since no weights were required. There were about 100 observations at each of 80 sites, and those 8,000 observations were simply pooled.

The non-highway portion of the sample was more complex. The probabilities of selection varied from one site to another. Therefore, weights inversely proportional to those probabilities were used when estimating seatbelt usage for this part of the sample. The probabilities are shown above in equation (2). The weight used (ignoring the constant term, $k$) was the inverse of the expression to the right of the equal sign:

$$\frac{A_h \cdot b_{hi}}{(R_{hi} \cdot ADT_{hi})}.$$

The combined estimate of seatbelt usage was the weighted average of the highway and the non-highway estimates. The appropriate weights for the highway and the non-highway estimates were calculated from statistics contained in the “Assembly of
Based on the 1998 report, we estimated that in 1998 the proportion of total California passenger vehicle miles that was traveled on the highways included in the “Traffic Volumes” report was .537, and that the remaining proportion (.463) of total miles was on the non-highway portion. The corresponding proportions for 1999 were .5361 (highway) and .4639 (non-highway). The overall estimate of seatbelt usage in a given year, $Y_{overall}$, is consequently calculated as follows:

$$Y_{overall} = W_{hwy} \cdot Y_{hwy} + W_{non-hwy} \cdot Y_{non-hwy}$$

(3)

where each $W$ is the proportion of traffic on highways or non-highways for that year, and each $Y$ is the seatbelt usage estimated from the highway or non-highway part of the sample.

Although these estimated proportions of total passenger vehicle traffic on highway and non-highway roads vary slightly from year to year and should be updated when possible, we should point out that it is not a problem to use a somewhat older proportion when calculating overall seatbelt usage. As we shall see, the observed seatbelt usage in the highway and the non-highway portions of the sample were not observed to differ very much, and therefore the overall combined estimate of usage will not be sensitive to small, or even moderate, changes in the estimated proportions of total passenger vehicle traffic on highways versus non-highway roads.

Note that instead of estimating overall seatbelt usage by calculating a weighted average of highway and non-highway usage, it would have been possible to pool all of the highway and the non-highway vehicle observations into a single sample, by keeping track of all of the selection factors affecting the differences in probabilities of selection.
between the two major strata and then constructing the appropriate weights. Without State estimates of the proportion of total traffic in each of the two categories, we would have had no choice but to do so. However, the availability of those estimates allowed for the sample design to be simplified. We were able to treat each of the two major strata (highways and non-highways) as separate samples, without the need for figuring out the relative probabilities (and weights) for observations generated by the highway list-based method versus the non-highway geographic-based method. The sample design for California, as a result, has been relatively simple both to understand and to implement on a regular basis.

**Standard errors and confidence intervals**

Both the highway and the non-highway portions of the sample were stratified cluster samples. A mean estimated from such a sample is technically a “ratio mean,” since both the numerator and the denominator can be expected to vary from one sample to another. Accordingly, special procedures were necessary to calculate the standard errors and confidence intervals for our estimates of mean seatbelt usage. The Taylor series method is probably the most commonly used method for this purpose, and that is the method that we used as well. Several software packages were available to carry out the calculations. Of those available, we used PC CARP, from Iowa State University, and SDA, from the University of California, Berkeley (both packages gave the same results.)

Using the Taylor series method, the formula for the variance of a ratio mean, \( r \), is:

\[
\text{Var}(r) = \sum D^2 z_{b} / x^2
\]  

(4)
In this equation the summation is over the $h$ strata, and $Dz_h$ is calculated within each stratum as follows:

$$Dz_h = (y_{h1} - r x_{h1}) - (y_{h2} - r x_{h2})$$

where $x_{hi}$ is the total number of observations (usually 100) in stratum $h$ at site $i$ (where $i$ is either 1 or 2, within a stratum), and $y_{hi}$ is the corresponding number with seatbelts fastened. The value of $r$ is simply $y/x$, where $y$ and $x$ are summed over each major part of the sample (highway and non-highway). The values of $y$ and $x$ are weighted if necessary, as was the case for the non-highway portion of the sample. In this formula the finite population correction is ignored, since our sampling fraction is very small. (For this formula, see Kish, p. 195.)

The formula in equation (4) was used to calculate the variance separately for the highway and the non-highway portion of the sample. The variance for the combined overall estimate of seatbelt usage was then calculated from the formula for a stratified variance (cf. Kish, p. 78):

$$Var_{overall} = W^2_{hwy} \cdot Var_{hwy} + W^2_{non-hwy} \cdot Var_{non-hwy} \quad (5)$$

The $W$ to be used here are the same year-specific proportions of total traffic on highway and non-highway roads as were used in equation (3), except that here they are squared, in order to calculate the combined variance (instead of the mean). And the $Var$ are the variances for the highway and the non-highway estimates of seatbelt usage, as calculated from equation (4).

The standard error of the overall seatbelt estimate is the square root of the variance as calculated in equation (5). The confidence intervals for the desired level of precision can then be created. For the 95 percent confidence intervals, for example, the
standard error is multiplied by 1.96, which gives the figure to be added to, or subtracted from, the overall estimate of seatbelt usage.
4. Results for 1998-1999 and Possible Refinements

The results for passenger vehicle drivers for the 1998 and 1999 surveys are summarized in Table 1. We show the results separately for the highway and non-highway portions of the sample and then for the combined estimate. Standard errors, design effects, and clustering coefficients are shown also.

The overall estimate of seatbelt usage increased by 0.3% from 1998 to 1999. This change, compared to the standard error for each of the two years (0.52% and 0.28%, respectively) is well within the expected bounds of sampling error. Consequently the change would not be considered statistically significant, especially if we treat the yearly surveys as independent samples. However, since all of the observation sites (primary sampling units) were the same in both years, except for the occasional replacement due to construction, it would be possible to calculate a (smaller) standard error for the change in seatbelt usage that incorporates the correlation between the 1998 and the 1999 estimates for each site, but that is beyond the scope of our present purposes. The main focus of the seatbelt surveys has been to generate estimates of seatbelt usage for a particular year.

Note also in Table 1 the design effects for these estimates. The design effect (deft) is the ratio of the standard error we obtained from this complex sample, divided by the standard error expected from a simple random sample of the same size. Since our observations were clustered in only 160 sites each year, each cluster was relatively large (about 100 observations), and the design effect was substantial. The standard error
obtained from each year’s sample of about 16,000 observations was about twice as large (2.12 times as large) in 1998 as would be obtained from a simple random sample of that magnitude, and 24 percent larger in 1999. Of course, a simple random sample of 16,000 vehicle observations scattered throughout California would be prohibitively expensive and is not a realistic option.

A more relevant consideration might be to investigate the impact of modifying the overall and relative sample sizes in the two parts (highway and non-highway) of each sample, and changing the size of the clusters. The clustering coefficients (rho) presented in the table are helpful for these types of analyses. (See Kish, pp. 161-164, for a
discussion of the clustering coefficient and its calculation.) However, costs would also need to be considered. Since the cost of each observation is very small compared to the cost of sending two field workers to an observation site, it is efficient to make many observations once the team arrives on site. The design problem is to find the optimal cluster size and number of clusters for a given budget and for a desired level of precision. (See Kish, pp. 268-272, for a discussion of the use of clustering coefficients and relative costs in optimizing sample designs.) This problem is made more complex because of the large variation in the design effects and clustering coefficients for the non-highway samples in different years, as shown in Table 1. This would make it difficult to arrive at a design that would be optimal over a number of years.

Nevertheless, most sample designs can be improved based on results obtained in implementing the design. We hope that this description of sampling procedures (including implementation errors and problems), and the presentation of results obtained in 1998 and 1999, will provide adequate information for evaluating the design and possibly improving on it in the future.
References


Note on the Authors of this Report

Thomas Piazza is the Senior Survey Statistician at the Survey Research Center, University of California, Berkeley.

Raul Betancourt is Professor Emeritus of Psychology at the California State University, Fresno, and the Project Director for the California Seatbelts Surveys.