

KEYNOTE PAPER

Household Travel Surveys: Cutting-Edge Concepts for the Next Century

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This paper focuses on how U.S. household travel surveys are executed and how they will be executed in the future. Many cultural and contextual factors result in marked differences between household travel surveys in the United States and those conducted in other countries. It is not the intent of this paper to deal with these differences nor to provide an overview of household travel surveys in other countries. However, the problems currently experienced in the United States may be a decade or two away for other countries; therefore, the information in this paper may be useful to survey developers abroad.

This paper examines where we are in the development of household travel surveys, what forces have shaped travel surveys being conducted today, and what changes will affect the evolution of household travel surveys. The paper is intended to raise challenges about the concepts that will transport household travel surveys into the next century.

HISTORY OF HOUSEHOLD TRAVEL SURVEYS

Household travel surveys began in the early 1950s, a mere 40 years ago. Before this, transportation planning, which was rapidly evolving into the regional type of planning performed today, relied principally on roadside surveys that collected origin and destination information from travelers on specific roads. Data about trip-making patterns have always been a mainstay of transportation planning. Surveys of trip making traditionally have provided the basis for formulating transportation policy, developing transportation plans, and making improvements to transportation operations.

Household travel surveys play two primary roles. First, they describe travel trends to facilitate understanding of demands on the transportation system and identify areas in which problems can be expected. Second, surveys provide information for input into travel-forecasting models, which are used to identify potential long-term problems and to provide a means to test the efficacy of proposed solutions.

Household travel surveys are conducted primarily by federal, state, and local governments. The primary impetus for conducting these surveys is for compliance with rules and regulations affecting transportation planning and the need to replace aging data, data that no longer represent the travel patterns and characteristics of an urban area. Household travel surveys usually are conducted in three different cycles. The first is to collect data once a decade

However, relatively few metropolitan areas in the United States collect household travel data this frequently. The second is to collect data approximately every 20 years, perhaps because 20 years is the typical long-range planning horizon. In addition, data collection every 20 years is consistent with the view that we should check to see how well our forecasts turn out (although if this is done, it is rarely reported). The third is to collect data as often as funds are available, which may range from every 15 to 30 or more years.

Many metropolitan areas collect their data as close as possible to a decennial census to ensure the availability of current information on the entire population from which their samples are drawn. Because the Bureau of the Census requests that jurisdictions avoid collecting data too close to a decennial census, conducted April 1 in each year ending in a zero, household travel surveys usually are undertaken in the 2 years preceding or following the census.

EVOLUTION OF HOUSEHOLD TRAVEL SURVEYS

Since their inception, household travel surveys have undergone substantial growth and change. Originally, household travel surveys were conducted almost exclusively by means of face-to-face interviews in respondents' homes, having household members recall the previous day's travel and often involving extensive proxy reporting for most of the household by one family member. Interviews usually were conducted through "cold" contacts because no previous contact had been made with the household to request its cooperation or to arrange interviews. Recent household travel surveys involve recruiting a household by means of the telephone and sending the household a 1- or 2-day activity diary with instructions on which day activities should be recorded. This frequently is followed by retrieving data from the diary by a telephone interview conducted using computer-assisted telephone interviewing (CATI) and involving real-time error checking and data entry.

Another aspect of the evolution of household travel surveys is sampling. Early household travel surveys used either simple random sampling or cluster sampling to reduce interviewer travel. Current household travel surveys usually use a form of random stratified sampling with variable sampling fractions. Strata are typically based on household characteristics determined in the initial recruitment call.

Because the mission of this conference is to consider new concepts and research needs in household travel surveys, it is appropriate to establish what has been driving the evolution of these surveys during the past 40 years. One element of this drive is the desire to improve survey accuracy. Early on, it was recognized that the conventional home-interview survey, which is based on recall, results in a significant level of undercounting of certain trips, particularly trips associated with minor errands and short non-home-based trips. The shift from recall reporting to use of a diary designed to be completed at a subsequent date was one step taken to address the problem of trip underreporting. The hope was that, by reducing proxy reporting (each family member would have a diary in which to record the trips he or she made) and by shifting from recall to real-time recording of a person's travel, the number of short trips reported would increase. Some anecdotal information suggests this may have happened, but it has not been established whether a significant improvement in reporting non-home-based travel actually occurred through this mechanism.

A second driving force has been concern about the confusion that travel surveys often engender in the minds of respondents. Although early diary surveys relied on face-to-face contact with interviewers, the diary required that the respondent complete it. This requirement initially was not recognized as a difficulty, and early surveys used a form that was similar to the type of form previously used by trained interviewers only. Not surprisingly, these survey forms did not perform well. First, response rates dropped because many people were unable to complete the survey form or were intimidated by the amount of information packed into it. Second, responses obtained often showed considerable confusion about how to answer questions correctly; therefore, surveys had to be discarded or major inferential work had to be done to correct them.

A third driving force has been changes in the models and other procedures developed from collected data. Much early work in household travel surveys ignored the survey purist's notion that a survey should be designed carefully with eventual data uses in mind. Data were collected because they were always collected or because someone thought the data would be interesting, even though he or she had only a vague idea of how the data might be used. Recently, significant attention has been given to the concept of measuring only what will be used in descriptive or modeling work with the data. In addition, some data items are included for political reasons, relating to the need to show the types of households included in a sample.

Changes to survey instruments have been made to reflect the fact that more attention is being given to justifying each data item to be included and because parts of the travel-forecasting model system are evolving slowly. General acceptance of disaggregate multinomial logit models for mode-choice modeling made a significant impact on the design of data collection instruments during the 1980s and is reflected in renewed attention given to (a) the sequence of use of different travel modes on a single trip, (b) auto occupancy, (c) parking costs, (d) vehicle availability, and (e) collection of data on modes of access to and egress from public transportation. Widespread acceptance of disaggregate models also resulted in an interest in collecting data about subjective evaluations of travel options in addition to the standard reporting of objective data. In the 1970s and 1980s, significant interest was sparked in collecting data on attitudes, preferences, and opinions about transportation alternatives. However, little of this information was helpful in travel forecasting, and sufficient doubts were raised about its usefulness even for descriptive purposes; therefore, the late 1980s experienced a significant decline in the collection of such data.

The 1990s have brought a resurgence of interest in collecting conjoint data, now commonly referred to as stated-preference data, or perhaps, more correctly, as interactive stated-response data. This evolutionary change resulted from two coincident issues. First, in the late 1980s, the United States became interested in high-speed rail systems. Because the nation had no intercity service similar to high-speed rail at the time, determining stated preferences for such a service seemed to be the best method for determining potential patronage. The success of this approach resulted in the credibility of using stated-preference measurement to deal with an alternative for which the marketplace had no current equivalent. With current urban policies focusing on new options for handling transportation problems, such as transportation demand management (TDM) strategies and pricing strategies, interest in using stated preference to estimate how the traveling public will respond to such transportation alternatives is increasing rapidly.

Another significant issue in the past 10 to 20 years has been the decrease in survey response rates. There are no hard facts available to explain this decline, but several surveys indicate that it is substantial and continuing. There are a number of contributors to this decline, including the following:

- Increased use of telephone surveys by marketing agencies, which tend to contribute to burnout of the U.S. public with respect to surveys;
- Increased use of marketing surveys as a "foot in the door" to sell a product, as evidenced by the frequent response "I'm not buying anything" when a transportation survey interviewer calls a household;
- The increasing pace of life in the United States, which makes people reluctant to spend time on activities not directly connected to their own busy schedules;
- Increased concern about personal privacy and the potential for outside agencies to know personal details, which represents an invasion of privacy and results in a decreasing willingness to answer questions relating to demographics, activities, and the like;
- The perception of vulnerability to crime through the types of information typically requested in a household transportation survey; and
- The increasing number of immigrant households in which English is not spoken well or not spoken at all.

These and other factors make it difficult to obtain adequate responses to household travel surveys.

In the United States there has been a marked decline in the effectiveness of face-to-face interviewing. First, the crime problem makes it difficult to send interviewers into certain parts of many cities and to guarantee their safety. Second, the perception of vulnerability to crime makes it less likely that a respondent will allow a stranger to enter his or her home. Third, the rapid growth of two-worker households and the increased amount of time spent by household members in out-of-home activities can make it difficult to find a responsible adult at home who can be interviewed. As a result, the costs of performing face-to-face interviews have skyrocketed, while the effectiveness of such interviews and their ability to cover a random sample of households has declined dramatically.

CONTEXTUAL CHANGES IN HOUSEHOLD TRAVEL SURVEYS

Changes in Transportation Policies

The limitations of previous transportation policies that consider only vehicular travel must be reconsidered. There is an emerging need to consider trips taken by walking and bicycling. Traditionally, data on such trips have not been collected by conventional household travel surveys. Obtaining these data could be a challenge because it is not apparent how households that use these modes with some frequency can be located within the sampling process. Based on recent experiences with adding such travel modes to household travel surveys, problems also arise in reporting and coding such travel. In Southern California, many walk and bicycle trips in the data base report travel distances that are too long to be credible. This suggests that considerable care is needed in the design of survey instruments, to ensure that walk and bicycle are not reported as the only modes for trips in which one of the two modes is used primarily to gain access to or egress from another mode. In addition, it probably will be necessary to introduce other measurements related to walking and bicycling that will allow appropriate values to be developed for the travel times involved.

TDM is another area in which emerging policy changes will dictate significant changes in household travel surveys. Many TDM strategies involve options different from those traditionally featured in household travel surveys, such as use of carpools, vanpools, and high-occupancy vehicle (HOV) lanes and various parking management and parking pricing options. One change in recent surveys is a focus on collecting data about parking locations and prices. However, the level of detail obtained is inadequate for the types of analyses required.

New Paradigms for Travel Forecasting

The Travel Model Improvement Program (1,2) and frustration with the inadequacies of current travel forecasting models are likely to result in new paradigms of travel behavior and changes in data collection. To improve the accuracy and completeness of data collected and to respond to likely paradigm shifts, we have already shifted toward collecting data on activity patterns and how they affect travel, as opposed to collecting data on trip patterns. Whether the activity focus or another new paradigm will emerge as the principal new direction of travel forecasting is unclear at the moment. However, these shifts probably will be the most significant contextual changes to occur in the history of household travel surveys.

Another contextual factor that is changing the collection of data on travel patterns is the issue of trip tours or trip chains, which have increased as a proportion of total travel in recent years and which pose serious problems for modeling and measurement. The shift to an activity focus in collecting data on travel patterns stems from the fact that using this approach produces more complete information on trip tours than using the trip focus approach. The trip focus leads to respondents omitting intermediate, less-consequential stops in the trip chain, and thus produces incomplete data.

One reason for the increased focus on trip chains is the existence of households in which all adults are in the work force, making it impossible for them to make trips from home dur-

ing the day. Recognition of this trend has resulted in more interest in microsimulating household life-cycle and life-style changes. This, in turn, is driving a need to collect more complete and more detailed data on household life-styles and lifecycles.

Declining Response Rates

A number of factors of life in the late 20th century are causing response rates to decrease. This decrease is likely to continue, which will put pressure on survey designers to develop new designs. Telemarketing and the ability of households to screen calls through such mechanisms as answering machines and caller identification systems are likely to increase. This will result in greater difficulty in reaching households that do not want to participate and will present a major challenge to any form of telephone-based survey. In the United States, response rates have fallen far below acceptable levels. Typical response rates (depending on how calculated) often run below 40 percent of all eligible households, leaving more than 60 percent of households about which nothing is known. The potential for nonresponse biases in such surveys is enormous.

Literacy and Language

Another contributor to the high nonresponse level in the United States is the drop in literacy and the increasing number of people who are not fluent in English. It appears that as rapidly as demand for information from travel surveys increases, the level of literacy of the population decreases, resulting in an increased disparity between requests for information and the ability of the population to respond. There is no question that an increasing element of the U.S. population is illiterate or has a sufficiently low level of literacy that complex questionnaires traditionally found in transportation surveys are becoming too challenging for people to handle. The design of survey instruments must be simplified, and the level of language used must be adjusted so that it is more readily understood. Use of multisyllabic words, complex ideas, and extensive instructions must be avoided. Perhaps more than ever, it is incumbent on the survey designer to simplify every demand made in a survey.

This trend also raises questions about the long-term validity of surveys that are based on written instruments and that require respondents to write their responses. There is little doubt that the telephone retrieval of data from a written survey provides some increased comfort to those who are "literacy challenged," particularly when they are able to provide verbal responses to questions without having to complete a written survey instrument. However, when a person of low literacy responds by telephone, using recall, questions arise about the validity or completeness of data obtained, compared with data provided by literate respondents who recorded responses at the time the travel or activities took place.

Another aspect of this problem is the increasing number of U.S. households in which languages other than English are spoken or whose members' mastery of English is limited or nonexistent. Although frequent efforts are made to translate survey instruments into other languages, many urban areas in the United States need translations into multiple languages, which results in several problems. First, there is the problem of translating English-language questions and directions into another language so that the meaning is retained. Because many languages exhibit regional differences in dialects and word usage, retaining the precise meaning often can be beyond the capabilities of survey organizations. In addition, the requirements for English-language versions of surveys apply to survey translations, such as the use of simple words and ideas. Second, translations add significantly to the cost of a survey. Third, using multiple languages will, with CATI retrieval of data, require multilingual interviewers and a procedure to identify the language spoken and to assign a respondent to an interviewer who speaks his or her language.

Failure to include the marginally literate, the illiterate, or those who speak only a foreign language will lead to serious biases in survey data, because these population subgroups usu-

ally have different travel patterns and personal characteristics than the literate, English-speaking segment of the population. Literacy and language problems are on the increase and must be taken into account in household travel surveys.

ISSUES IN HOUSEHOLD TRAVEL SURVEYS

Many issues arise in the area of designing household travel surveys. Some of these issues are generated by the contextual factors discussed in the preceding section, whereas others relate to specific design issues that arise in our attempt to make survey instruments more effective and less costly.

Incentives

One way of dealing with declining response rates is to offer people incentives to complete a survey. There are at least three variations in the offering of incentives. First, the incentive could be money, a gift, a combination of a gift and money, or entry into a lottery or drawing. Second, the incentive could be offered before a respondent completes a survey (i.e., as a "bribe" to complete the survey) or after a survey is completed (i.e., as a "thank you" gesture). Third, the incentive could be offered to the individual respondent or to the household as an entity.

Several incentives have been used to encourage people to complete household travel surveys: money (ranging from \$1 per person to \$10 per household); gifts (such as state highway maps, pens, and refrigerator magnets); combinations of money and gifts (e.g., a pen and money); and entry into a game of chance in which a limited number of major prizes may be won. Little has been done to experiment with different forms of incentives. However, in an experiment in the Seattle area, a limited number of incentives were compared (3), and recent pretests in North Central Texas have provided evidence on how alternative incentives affect response rates (4).

Little is known in the transportation community about the potential biasing effects of incentives. It is reasonable to conjecture that households that respond to incentives and households that are offended by them may be a biased subset of the population. In both cases, offering incentives may result in a significant bias in the respondent sample.

Beyond the simple issue of whether incentives are useful in raising response rates and whether incentives bias responses, issues relating to the fact that most household travel surveys are conducted by or for public agencies frequently arise. As a result, respondents may question the use of public money for gifts or monetary incentives, and significant questions may be raised about the appropriateness of any type of game of chance (lottery or drawing) in which a public agency is the sponsor and public monies are used to pay for prizes. For example, offering a drawing in which respondents may win free air travel to vacation destinations of varying distances and desirability might come under considerable criticism from the general public as well as the media. Adverse publicity about incentives probably harm survey response more than not offering any incentives at all.

Issues of whether to provide an incentive before or after survey completion are partly tied to the issue of what a public agency is doing with taxpayer dollars and partly tied to costs of administration. There is little debate over the fact that it is much cheaper to send an incentive in every mailed-out survey than to keep track of who responds and then send out, in a second mailing, the incentive to those who complete the survey. In addition, the postcompletion incentive is effective only when it is promised before survey completion. This leads to problems about what type of response qualifies for an incentive and opens the door to controversy over whether a specific person's or household's response is complete enough to merit receipt of the incentive.

The survey administrator has little control over how an incentive is handled, once it has been sent to a household. However, the intent to reward each member of a household can be

made clear when the incentive is attached to each individual's instrument, compared with sending a single incentive to the household. Whether there is any difference in the effectiveness of offering the incentive to each person in the household or to the household as an entity has not been researched in the travel survey context

Finally, in the event a precompletion incentive is offered, the question should be addressed about whether the incentive should be included in the survey package, which is how it is usually done, or whether the offer of the incentive should be indicated during the recruitment call. Announcing the incentive in the recruitment call may lead to more households indicating a willingness to complete the survey in order to receive the incentive, even though the household has no intention of completing the survey. However, some interesting information could be obtained by ascertaining how much of an incentive must be offered to gain compliance by every household called

Length and Complexity of Surveys

Survey length refers to the length of the survey instrument and the length of time required to complete it. Complexity refers to the structure of the survey, including such items as conditional skip patterns, multipart questions, and the use of complex ideas and concepts. There is a widespread perception that both length and complexity are negatively correlated with response rates. Yet there is anecdotal information suggesting that length alone may not result in decreased response. Experiences in the 1970s with psychometric questioning on topics of comfort, convenience, and reliability indicate that survey length is not necessarily detrimental to response rate if the survey is interesting and simple to complete (5)

More information is needed on a number of issues related to survey length and complexity for the purpose of designing effective household travel surveys

Form of Survey Document

There are at least two schools of thought with respect to the form of survey instrument. One school believes that a booklet form of diary is appropriate and that surveys whose layouts contain a reasonable amount of white space and whose questions are in a more conversational style are better. The other school believes that the survey instrument should be on as little paper as possible and should be provided on two sides of a single sheet or on as few additional sheets as possible. Whether respondents perceive any difference between these is open to question. Two tests are under way, one as part of the North Central Texas survey (4) and one as part of the pretest of the 1995 Nationwide Personal Transportation Study (NPTS) (6). At the time of this conference, the results of the Texas survey were unknown, although NPTS results (undocumented as of this writing) indicate that a more complete diary form produces better results than a one-page "memory-jogger" instrument. NPTS did not test a full diary instrument with multiple pages stapled into a booklet form. This form was tested in Texas.

Surprise Questions

Another issue related to survey length and complexity is the completeness of questions asked in a written survey compared with the completeness of questions asked during telephone retrieval. Again, there are two schools of thought, and comparative tests of the alternatives have not been made

The first school holds that there should be no surprises for respondents; all questions to be asked during retrieval should be asked on the survey form. The exception would be asking probing questions during retrieval to correct incorrect information or to uncover information a respondent forgot to provide, such as information on an unreported activity. Reasons for this school of thought revolve primarily around the notion that respondents (a) may forget

key information they were not asked to record on the paper instrument and (b) may be unable to recall information or may be annoyed or upset at being asked for details about which they were not asked before the retrieval phase

The second school holds that it is sufficient for respondents to record only major aspects of travel or activities on which information is being collected so that respondent burden is minimized, while additional data can be collected during the retrieval interview. This position assumes that (a) the memory-jogger format is sufficient to allow people to recall other details about their activities and (b) respondents are less likely to be negatively affected when asked additional questions during retrieval.

These two positions result in significantly different survey costs, complexity, and length. A controlled comparative study needs to be conducted to ascertain whether there are significant differences in quality and quantity of responses from either approach.

Multiday Surveys

Conventional household travel surveys collect data for a single weekday, usually in the spring or fall. Because of changes that have taken place in the past 2 or 3 decades in the structure and behavior of households and because of an emerging realization that certain dynamics of travel behavior have not been captured by 1-day surveys, there is an emerging trend to collect data for more than 1 day. In addition, planning for air quality improvements has shifted the focus toward winter and summer travel, because winter is when most carbon monoxide violations occur and summer is when most ozone violations occur. One wave of the Puget Sound (Wash.) Panel Survey used a 2-day diary, whereas the Portland, Ore., 1994–1995 Survey is using a 2-day diary. North Central Texas will use a 2-day diary for its household travel survey, to be conducted during the balance of 1995.

Although some decrease in response rates is associated with additional days of diary completion, no controlled comparative studies have been conducted to determine the extent of this drop. (There are anecdotal reports of increases in response on the second day or at least increases in the number of activities reported.) In addition, no studies have been done to determine the gain in total information that might be offered by a 48-hour instrument instead of a 24-hour instrument. The question of repetitiveness of activities over 2 consecutive weekdays has not been addressed adequately; therefore, there is no information available on whether “real” additional data are obtained from a second day or how much additional data are obtained.

In the Portland and Texas cases, households were asked to complete their diaries for 2 consecutive days, and a fraction of the households completed diaries for a combination of a weekday and a weekend day. The importance of collecting data on weekend days has not been established. From a behavioral viewpoint, it can be argued that households trade off activities and travel between weekdays and weekend days and that weekday travel patterns cannot be completely understood unless the relationships between weekday and weekend activities are understood. It also can be argued that peak congestion is moving to the weekend and that a majority of air pollution excesses are occurring then. Both of these phenomena point to an increasing importance for measuring weekend travel.

In-Home Activities

It can be debated that travel occurs as a result of whether a person undertakes activities or satisfies needs at home or at locations outside the home. For this reason, information is needed about in-home activities that may be substituted by or for out-of-home activities. This means that respondents must report all daily activities, whether in or out of the home, with the possible exclusion of in-home activities of a short duration and in-home activities that are too personal or unlikely to be satisfied by an alternative out-of-home activity.

Asking respondents to report in-home activities, however, even with certain restrictions on duration and nature, raises two thorny issues. The first concerns invasions of personal privacy with concomitant impacts on both response rate and the credibility of the public

agency conducting the survey. The second concerns the explosion of information that may result from such questioning, which affects the length of the survey instrument, respondent burden in completing the instrument, and time required to retrieve data from respondents. The Portland survey requested information on in-home activities that took more than 30 min, whereas the North Central Texas survey will not collect data on any in-home activities other than working at home. Comparison of response rates and information content of the two surveys may be a first step in understanding whether significant gains result from collecting in-home activity data and whether there are identifiable costs on response rates and data quality.

Time-Use Surveys

Another issue to resolve in the area of survey length and complexity is determining the amount of detail needed about activities. This can be seen first by considering the additional length incurred in the instrument if each change of travel mode is defined as an activity to be recorded in an activity diary. A change of travel mode theoretically could be defined as occurring any time a person enters or leaves a vehicle. The information provided from such an activity definition is "rich" and valuable. However, respondent burden rapidly increases with the requirement to fill in details about many activities within a 24-hour or 48-hour period.

A further extension of this concept is the time-use diary, in which respondents are asked to fill out information on everything they do throughout the recording period, providing certain characteristics of each activity and treating everything, travel and nontravel, as an activity (7). The primary difference between a time-use and an activity diary is that the former does not define travel as an activity and instead collects information about travel involved in getting to an activity, whereas the latter defines travel as simply another activity and collects certain information about travel and nontravel activities. A time-use diary also leads to collecting detailed data on each change of travel mode.

It appears that the time-use diary may involve fewer questions about an activity than an activity diary; however, the time-use diary will lead to reporting more events during the survey period, even if the same restrictions, described in the previous section, are applied about recording in-home activities. In addition, respondent burden of such an instrument, whether its length is acceptable, and whether the time-use diary represents a simplification of the activity diary still need to be determined.

Data Repair

Should data be repaired? To what extent and at what point in the data collection effort should data be repaired? How should we define a complete response so that we know when data repair is necessary? Data repair can take place on at least two levels. First, data can be repaired by recontacting the respondent to correct or complete data. Such repair depends on rapid identification of data damage so that the respondent can be called shortly after the original data collection. Failure to identify damage early will compromise the ability of the respondent to recall correct information, particularly if the damage has to do with reported activities instead of a characteristic of the person or household.

The second level of data repair consists of repairing missing and erroneous information after a significant amount of time has passed since the original data collection. This can be done either by imputation of values from a mathematical procedure, assignment of average values from other data, or another analytical procedure for imputation of missing or erroneous data. The question arises about whether either or both forms of repair—imputation and assignment of average values—should be undertaken routinely. Because of the nature of consultant contracts for data collection, the imputation type of data repair is almost always conducted, because it is cheaper to repair minor problems in data than to collect data from additional households for replacement. Beyond the purely financial aspects, the following issues must be considered: (a) potential biases that occur when partially complete households are dropped

from a data set, (b) the quality of information that can be obtained from recontacting household members, and (c) the rate at which such information degrades over time.

Another data repair issue that must be addressed is determining what constitutes a "complete" household. A survey's purpose will have a significant influence on this question. However, standards would be helpful to the transportation profession so that comparability between data sets is maintained and a certain level of quality is ensured. Trade-offs between adding new households versus completing existing households in the sample need to be explored so that better information is available about the comparative costs and benefits of performing rapid data repair through recall. When data are repaired much later by imputation procedures, the issue to be explored is the extent to which such imputation adds new information and the extent to which modeling efforts and other activities are improved. Because statistical tests of models usually are based on the number of observations contributing to a model, imputed data corrections may be necessary in cases in which the imputed values do not represent new information and should not be counted as observations used in the modeling.

Other Issues

Many other concerns need to be tackled. It is hoped that the conference will raise at least as many issues as have been raised here. Probably the biggest omission in household travel surveys has been the commissioning of thorough comparative studies that allow controlled comparisons among different methods and approaches. Even if the conference does no more than provide pressure to commence such comparative studies, it will advance the state of the practice in household travel surveys more extensively than it has advanced in the past.

CUTTING-EDGE CONCEPTS

It may seem premature to include a section on cutting-edge concepts in the keynote paper for a conference intended to develop these concepts. However, in this final section of the keynote paper, an attempt is made to speculate on areas in which cutting-edge concepts may be developed and on areas that might represent some of the recommendations of this conference.

Panels

Probably the most underutilized survey device in household travel surveys is the longitudinal panel. Only one panel of significant duration has been undertaken in the United States (3), and few such surveys have been undertaken elsewhere in the world. The benefits offered by panels have been discussed in numerous other places—including the First U.S. Conference on Panels for Transportation Planning, held in Lake Arrowhead, Calif., in 1993—and are not elaborated further in this paper. Because of response problems and the size and complexity of the measurement task transportation planners must undertake, such panels probably should be paid and should represent a cross section of the population to eliminate some of the biases perceived to exist in current cross-sectional, telephone-based surveys.

Panels offer advantages by measuring the dynamics of change, measuring seasonal variations in travel behavior, and providing opportunities for more extensive measurement over time, by combining different subsets of stated-preference questions at different waves. Reliance on ongoing, small paid panels is a concept whose time has come. A panel can be benchmarked from time to time by conducting a modest cross-sectional survey to determine the extent to which the panel represents the target population and how panel attrition should be managed. The potential to gain more data from ongoing panels than from large cross-sectional surveys conducted at lengthy time intervals must be explored.

Remote Sensing

A technology that is advancing rapidly is remote sensing. At least two remote sensing advances have potential applications for household travel surveys. First, there is a remote sensing device that can be fitted to an automobile to record various attributes of automobile operation such as starts, stops, acceleration, deceleration, time, and distance (8). Coupled with a time-use or activity diary, this device offers great potential for improving collection of data about vehicle use. In the United States, no coupling of remote sensing vehicle devices with multiday diaries has been done, although some work has been done in Canada (9).

Another technological advance is the Global Positioning System (GPS), which could be combined in a variety of ways with data collection through diaries. At one extreme, GPS could be connected with the type of automobile sensing device just discussed to provide continuous position information for vehicle routing and to collect data on vehicle function, time, and distance. At the other extreme, if GPS equipment is sufficiently miniaturized and if issues of privacy are resolved, such equipment could be attached to individuals who are completing diaries. This would provide fully geocodable data on where people go during a reporting period.

Nonresponse and Non-Telephone Surveys

Returning to face-to-face interviewing must be given serious consideration, although perhaps this survey method is not a cutting-edge concept. Because of nonresponse to telephone-based surveys discussed earlier in this paper and given the biases that might result from excluding households without telephones, face-to-face interviewing may be the only way to improve response and reduce biases.

New technology, however, does play a role in the return to face-to-face interviewing. Notebook computers offer the opportunity to conduct face-to-face interviews using the computer-assisted personal interviewing (CAPI) process. In addition, the potential exists for allowing respondents to enter data directly into a computer, even through the use of touch screens. As notebook computers increase in power and decrease in weight and cost, the possibilities for this type of face-to-face interviewing are considerable. For example, if paid panels are used, panel members could be given notebook computers, with modem hookup to survey administration, so that they can enter their data directly and have these data transferred to those conducting the survey, without the need for telephone or face-to-face interviewing.

Other Technological Advances

The technological advances that are moving us into an era of two-way television, shopping by television, and other innovative means of communication have enormous potential to change the way in which household travel surveys are conducted. One possibility is using videotapes to conduct surveys or to provide instructions to respondents on how to complete a written survey. Future developments could allow respondents to enter data in real time in response to a videotaped interview.

Similarly, it is possible that computer networks will assist in the conduct of household travel surveys. It is more difficult to determine how this technology could be used, both as a result of issues relating to appropriate uses of networks and because of the undesirability of self-selection. Nevertheless, it is an area worth considering.

Development of a National Sample of Households

It may be time to undertake a national sampling for household travel surveys, which would allow regions to use the data to develop models and plans. Such a sample probably would be

best treated as a panel, but drawn from the entire geographic area of the United States and stratified into a range of household and personal characteristics. Distribution of data on such media as CD-ROM would make these data accessible to most metropolitan planning organizations and state agencies.

This concept goes well beyond that of NPTS by creating a national longitudinal panel designed to provide data for regional modeling and based on differential expansion factors for different regions of the country. Occasional benchmarking surveys at the local level still would be needed to determine how the panel relates to each region of the country. Targeted sampling also may be needed in order to provide data on rare behaviors, such as transit use in areas that have small transit systems, or on low levels of transit use. For such a concept to be embraced, considerable effort would need to be expended to show how the data collected would be transferrable from the national sample to local jurisdictions.

Expanded Sample Coverage

The final area addressed in this paper is expansion of sample coverage in household travel surveys. The time has come to abandon older concepts, such as collecting data only on weekdays in the spring or fall, from households with telephones, and for a 24-hour period. Instead, future data collection must (a) include weekend days; (b) cover different seasons of the year, including summer (particularly in ozone nonattainment areas) and winter (particularly in carbon monoxide nonattainment areas); and (c) be conducted over multiple days for each household included in the sample. Finally, expanded coverage should include non-telephone-owning households, unless it can be established that such households are similar to their telephone-owning counterparts. However, initial anecdotal information from the North Central Texas pilot tests indicates that there may be a disproportionate number of transit riders from non-telephone-owning households, making it likely that this group will need to be part of expanded coverage in future surveys.

CONCLUSIONS

It may not be appropriate to draw conclusions in a keynote paper, because such a paper is intended to set the thought processes in motion for the conference and to generate new ideas and concepts. However, the following comments may provide a further impetus for conference deliberations.

First, we should not lose sight of the purposes of data collection. Data are collected primarily to allow us to understand where we are at present and how the system is functioning. Of equal importance, data are usually collected to update models or construct new ones. The principal consideration that should guide which data we collect and the quality we demand of these data are their eventual uses. We also must recognize that data uses change over time. Data that are collected infrequently, such as every decade or two, may not be useful by the time we use it. This demands that more thought be given to which data to collect than to satisfying current policy issues. We must anticipate future issues and problems and future developments in the modeling area.

Second, we need to carefully consider data quality. It is easy to collect data of poor quality and to collect data that contain large biases and errors without realizing it. Many data collection practices in household travel surveys have generated such problems. Reaching total sample requirements by adding more households from the total population to make up for nonresponding households and households that provide only partial data is one way in which data quality and accuracy can be compromised.

Data collection is susceptible to the phenomenon of "garbage in, garbage out." Therefore, we must pay more attention to improving the quality of the data we collect.

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