

- Institute of Management Sciences, New York, May 1978.
4. E. Hauer, E. Pagitsas, and T.B. Shin. Estimation of Turning Flows from Automatic Counts. TRB, Transportation Research Record 795, 1981, pp. 1-7.
  5. E. Hauer and T.B. Shin. Origin-Destination Matrices from Traffic Counts: Application and Validation on Simple Systems. Traffic Engineering and Control, Vol. 22, No. 3, March 1981, pp. 118-121.
  6. L.G. Willumsen and D. Van Vliet. Validation of the ME2 Model for Estimating Trip Matrices from Traffic Counts. Presented at Eighth International Symposium on Transportation and Traffic Theory, Toronto, Canada, June 1981.
  7. P. Robillard. Estimating an O-D Matrix from Observed Link Volumes. Transportation Research, Vol. 9, 1975, pp. 123-128.
  8. H.J. Van Zuylen. Some Improvements in the Estimation of an O-D Matrix from Traffic Counts. Presented at Eighth International Symposium on Transportation and Traffic Theory, Toronto, Canada, June 1981.
  9. H.J. Van Zuylen and L.G. Willumsen. The Most Likely Trip Matrix Estimated from Traffic Counts. Transportation Research, Vol. 14B, 1980, pp. 281-293.
  10. H.J. Van Zuylen. The Estimation of Turning Flows on a Junction. Traffic Engineering and Control, Vol. 20, No. 11, Nov. 1979.
  11. L.G. Willumsen. Estimation of an O-D Matrix from Traffic Counts--A Review. Institute for Transport Studies, Univ. of Leeds, England, Working Paper 99, 1978.
  12. L.G. Willumsen. O-D Matrices from Network Data: A Comparison of Alternative Methods for Their Estimation. Proc., Summer Annual Meeting, Planning and Transport Research and Computation Co., London, England, July 1978.
  13. H.R. Kirby and J.D. Murchland. Gravity Model Fitting with Both Origin-Destination Data and Modelled Trip Engineering Estimates. Proc., Eighth International Symposium on Transportation and Traffic Theory, Toronto, Canada, June 1981.

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## Toward Improved Collection of 24-H Travel Records

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A major concern of many transportation-planning surveys is to collect data on a 24-h weekday period of travel for all members of a household who are five years of age and older. Traditionally, this has been done by asking household members to recollect their travel for the immediately preceding 24-h weekday period. A travel diary that has been developed to be used by each household member to record travel as it is undertaken is described. Although the concept of a travel diary is not new, several aspects of this diary are new and appear to be very effective in obtaining a response. The diary has been used in some recent surveys and the results of these applications are described briefly. In general, response to the instrument was found to be good when it was administered in an effective supporting survey context. It is concluded that this travel diary represents a good procedure for measuring travel and should be tested in comparable studies with conventional procedures.

Travel-behavior surveys are designed to obtain information about where, when, how, and with how many others the respondent and members of his or her household over the age of five have traveled during a 24-h period. Strictly speaking, when asked as a historical record, the information obtained is the respondent's perceptions of his or her behavior. In a travel-behavior survey, such perceptions are likely to be flawed significantly because a respondent is being asked to remember a sequence of events (and details about these events) that, to the average person, may have seemed unimportant when they occurred. The probability of the omission of trips or of the reporting of inaccurate trip details is heightened even more when (as is often necessary) one household member is asked about the travel of another. Another problem is created when lengthy travel records are collected following a lengthy home interview survey and both respondent and interviewer are tired. The possibility also exists that trips made on another day will be remembered incorrectly as having been made on the subject day. From the early metropolitan area transportation studies,

such as the Detroit Metropolitan Area Transportation Study (1), to the present, most travel-behavior surveys have employed this method as part of the urban transportation planning process (2,3). A typical example of such a survey instrument may be found in books by Stopher and Meyburg (4) and by Domencich and McFadden (5).

A second method of collecting travel-behavior information is to intercept people in the process of making a trip. The roadside interview and the on-board transit survey (6) are the most common. The significant advantage of such a technique is that respondents are surveyed at the time when they are least likely to forget trip details. On the other hand, such surveys, for logistical reasons, must be kept relatively short and it is impossible to construct a 24-h trip record for the respondent and his or her household by using this method.

The third method is to use a travel diary in which respondents are asked to report their own future behavior. Such a technique is a cross between observing behavior (such as counting riders on a bus) and a participatory survey (7). The major problem such a technique is designed to circumvent is that of memory. Evidence that memory can be a significant problem in recalling behavior has been provided by Cantril (8). In his survey, only 87 percent of persons interviewed twice at a three-week interval gave the same answer both times about the person for whom they voted in the 1940 presidential election. By presenting a respondent with a document that needs to be filled out about travel for the next day, which can be filled out partly or fully while traveling or partly while traveling and partly at the end of the day, less information should be lost to memory problems. One problem not solved, of course, is that certain trips (such as

trips a person may not want his or her spouse to know about) still will not be reported. Another problem is that the respondent may modify behavior by postponing trips to avoid having to spend time making entries in the diary (9). Yet another problem is that respondents, in order to impress the interviewer, may report making some trips (such as a trip to church) that actually were not made.

This paper looks briefly at some past uses of travel diaries in survey research and then reports on the development, design, costs, administration, and results from the travel diaries designed by us for several recent travel surveys.

#### PREVIOUS USE OF DIARY TECHNIQUE

Diary techniques have seen considerable use in television-viewing surveys and in market research (in which persons list in a diary the products they buy) (7). Some use has also been seen in sociological studies. Willcox (10) compared the morbidity data collected via a diary technique, in which respondents filled in illnesses as they occurred over a period of weeks, with such data collected in a retrospective interview and, based on medical records, found the former to be more reliable.

One of the most comprehensive uses of the diary technique is a sociological study by Young and Willmott (11) of the manner in which people spend their time. A study of a respondent's time budget is similar to a study of travel behavior in that respondents are asked to record some details about a sequence of events. In addition, such studies have the same problems with defining an event as transportation planners have in defining a trip to respondents. In Young and Willmott's study, after respondents had completed the main questionnaire, those who were married and between the ages of 30 and 49 were left a time-budget diary, which they were asked to complete and mail back. They rejected holding a second interview after the diary was completed as too costly for the additional information it might generate. Because they were collecting data for Saturday, Sunday, one weekday, and five weekday evenings, it was questionable how useful probing might be after one week had elapsed. Instead, interviewers spent considerable time explaining the form when it was distributed. About 40 percent of respondents refused even to keep the diary; 48 percent returned the diaries as intended; an additional 11 percent returned theirs after either a mail or a personal follow-up. Thus, only about 60 percent of those eligible accepted and completed diaries. In addition, of those who returned diaries, about 3 percent did not complete the diary for the weekend and 31 percent omitted the four weekday evenings. The conclusion to be drawn is that the personal second interview rather than the mail-back might have been worthwhile. In fact, the response rate for the weekday evenings was considered to be so poor as to obviate any analysis. As is discussed below, a second interview can be very effective in assuring a high response rate with quality information.

The use of the diary technique in transportation research is somewhat limited and includes studies that have asked respondents to record their travel for a 24-h period as well as studies that query travel behavior for extended periods.

McGrath and Guinn (12) report a technique that is a variation of the historical-record method for collecting information for a 24-h period. Questionnaires were mailed to 100 000 households in the New Haven area in 1962. An advertising campaign was designed to encourage potential respondents to watch a television show about how to fill out the survey.

Only a 10 percent response rate was achieved. It was also impossible to discern the percentage of respondents who had watched the television program. Significant income bias was found in the results. In addition, the survey was biased against those without televisions. It is not clear from the instructions provided whether the travel cards were to be completed for a day in the past or for a future date. In either case, the low response rate tends to suggest why this technique has not seen further use.

Memcott (3) suggests that evidence exists to indicate that home interview surveys result in a 10 percent underreporting of trips. He suggests three possible modifications to the traditional methodology. The first is to have the interviewer question all persons in the household directly and not rely on one person to describe the travel of all in the household. This obviously increases costs due to the need to make one or more additional calls back if given household members are not at home. A second modification is to leave the respondent a telephone number to call in case he or she realizes after the interviewer has departed that he or she forgot to report a given trip.

The third modification is simply a travel diary technique similar in administration to that described below in which diaries are left with the household and are picked up and checked in a second interview. Memcott cites three studies that experimented with the travel diary technique in the 1950s. The basic question posed back in 1962 by Memcott (and still unanswered today) is, Would the improvement in trip reporting more than compensate for the additional interviewer time and cost involved in using this procedure? Data from a New Orleans travel diary show no conclusive results. Results from experiments with diaries in Pittsburgh were promising, which indicates superiority of the diary. Evidence from an experimental use of diaries in the Penn-Jersey Transportation Study indicated that the diary yields no basic improvement over the historical-record method.

For the Niagara Frontier Transportation Study reported by Memcott, interviews were conducted by using three methods. The first involved the traditional historical-record method. The second developed trip records historically, but interviewers were required to interview everyone individually (called "intensive interviewing"). Travel diaries were used with a third group. The conclusion is drawn that the intensive-interviewing method is effective at improving response, but that the travel diary technique is not.

Some studies have used travel diaries that were kept by selected households for extended time periods. Marble, Hanson, and Hanson (13) administered a travel diary to 1179 households in Uppsala, Sweden. Diaries were kept for a five-week period by all household members older than 16 (14). A copy of the diary form may be found in a paper by Burnett (15). The diary collected information on trip time, whether the respondent planned to make the stop before leaving the house, mode, vehicle occupancy, address at destination, and activities performed at each destination.

A monetary incentive was offered to encourage cooperation. The drop-out rate was only 15 percent, probably because much attention was given to assuring understanding during an initial interview. Also, interviewers called respondents on a regular basis to see whether they had questions and respondents were given a telephone number to call if questions arose. A 17-page set of instructions with examples was given to each household.

Kuzmyak and Prensky (16) discuss the problems of

measuring changes in travel mobility for the elderly population. Memory problems in a historical-record type of survey may be more significant for this group. Also, because travel may vary a great deal for the elderly from one week to the next, long-term data are needed (17). Thus, they suggest the use of a travel diary and report the planning and implementation of a before-and-after survey that incorporated diary techniques as part of the evaluation of a user-side-subsidy demonstration project in Lawrence, Massachusetts. In recognition of the need for a significant incentive, each respondent was given a \$5 beginning payment and a \$15 completion bonus. Once-a-week visits were made to each household. Information collected was kept to a minimum: origin, destination, mode, purpose, and start time. The final cost was \$77 per usable diary; 285 completed one-month diaries were returned.

Kuzmyak and Prensky (16) also report the results of a disaggregate data set pilot test by the State University of New York at Buffalo. Presumably because of the lack of incentive and the absence of surveillance, the survey suffered from a low level of success. A survey performed in London, the London Transport Survey (LTS) (18), used travel diaries to collect information on transit trips. Perhaps because of the public spirit of transit riders in England and the brevity of the instrument, 98 percent accepted the diaries and 81.5 percent completed the survey. A 1966 Skokie survey (19) tested various travel diary procedures, including the effects of different instrument formats, incentive plans, and levels of surveillance. Incentives varied from \$3.50 to \$11.50. Surveillance levels varied from one to three visits per week. About 56 percent of those contacted agreed to participate; about half eventually completed the survey.

Two travel surveys by Schimpeler-Corradino Associates also have used a travel diary. One done in Washtenaw County, Michigan (1980), was part of a mail-out/mail-back survey that followed a telephone survey (20,21), but little analysis of the results has occurred to date. The second was a similar effort, in Broward County, Florida, by using a forerunner of the travel diary reported below (22). The poor response rate to the travel diary section of this survey (about 20 percent) suggests the difficulty of convincing an entire household to undertake such an arduous task in a mail survey. Finally, a travel diary on which the one described below is based has been used successfully in Germany, according to W. Brög, Socialdata GmbH, Munich.

A number of conclusions may be drawn. First, convincing respondents to participate in a travel diary survey implies the need for a reasonably significant incentive. Second, surveillance, either in the form of an appointment to pick up the travel diary (for a 24-h diary) or repeated visits (for a long-term diary), seems essential. Third, the diary must be kept as simple as possible and explicit instructions must be provided. Finally, although all agree that the historical-record method leads to underreporting of trips, the evidence that travel diaries are superior is mixed.

#### TRAVEL DIARY IN THIS SURVEY

##### Survey

The subject survey was designed to collect data from a stratified random sample of the population in seven southeast Michigan counties (23). The principal purposes of the survey were to provide the following:

1. The means to update trip-generation rates and modal-split models,

2. Attitudes of the population toward transportation and energy,
3. Attitudes toward possible changes in the transit system, and
4. Preferred methods of obtaining information on carpooling.

The trip-generation and modal-split models to be updated use certain demographic characteristics and income as input variables, so these characteristics must be measured to permit updating to be accomplished. Also, the survey coincided with a period of high unemployment in the southeast Michigan region (mainly connected to a low cycle in the automotive industry). Because of the potential effects of this on tripmaking, detailed information was required on employment status.

##### Survey Mechanism Pretest

The selected survey mechanism was the home-interview survey. Two instruments were used. The first was an attitudinal, demographic survey asked of a randomly selected adult household member. The second was a travel diary distributed to each household member 5 years old and older and designed to obtain trip information for a 24-h weekday period.

Since it had been recognized that convincing respondents to participate in the travel diary section of the survey might be difficult, two possibilities were pretested as part of the pilot survey:

Procedure 1: Distribute the travel diaries, make an appointment to pick up the travel diaries, and then do the attitude survey when picking up the diaries (travel diary first, interview later).

Procedure 2: Do the attitude survey, distribute the travel diaries, and then make an appointment to pick up the travel diaries (interview first, travel diaries later).

Procedure 1 had the following advantages. Because the attitude survey was of limited utility unless the travel diaries had been completed, and a high percentage of refusals to complete the travel diaries was expected, time would not be spent on the attitude survey unless the travel diaries were complete. Also, it would permit the interviewer to probe more easily for completion and correct interpretation of the travel diaries. A disadvantage of procedure 2 is that a respondent might feel as if he or she had done his or her duty by being interviewed and might use this as an excuse not to accept the travel diaries. Procedure 2, on the other hand, would permit some rapport between the interviewer and the interviewee to develop during the course of the interview. It might then be expected to be easier to convince the household to take and complete the travel diaries.

Both procedures were pretested in the pilot study in which 138 households were contacted. There were 41 nonresponses, including 17 outright refusals, 1 termination, and 23 "no answers." Of the remaining 97 households, half were given travel diaries first (procedure 1); half, interviews first (procedure 2). Procedure 2 was clearly superior. When presented with the travel diaries first, 53 percent of respondents refused to take them compared with a 4 percent refusal rate when the interview was held first. Evidently, it is necessary to build up rapport prior to asking respondents to participate in something that, on the surface, appears to be a difficult task. Also, in both procedures, once respondents had complied with whatever form was presented first, very low refusal rates (4 and 5 percent) were experienced for the other form.

### Administering the Survey

The procedure used in the main survey was as follows. The interviewer made an initial contact with a randomly selected household and used respondent selection grids similar to those described by Backstrom and Hursh (24) to select a household member to interview for the attitude survey. The interview then proceeded and lasted about 45 min. At the conclusion of the interview, the interviewer informed the respondent that the first part of the survey was now complete and the second part involved all in the household 5 years old or older. As many members of the household that were at home then were gathered to listen to the instructions. These oral instructions were designed to emphasize the written instructions and to make certain that all understood the task. (The design features to encourage understanding and response are described below.) The following materials were then given to the household:

1. One travel diary for each household member 5 years old or older [three exceptions were made: (a) if a person was incapable of travel, perhaps due to illness or injury, no travel diary was left; (b) if respondents indicated that they were likely to make more than 10 trips, two travel diaries were left; and (c) out-of-town guests, although not strictly members of the household, were given travel diaries];
2. A travel diary envelope, which contained some instructions on the outside and was designed to be used by the respondents to put their diaries in when complete so that they were all together when the interviewer arrived to pick them up; and
3. Two "Travel-Logging Day" signs.

The travel-logging day was assigned as the weekday after the interview; those interviewed on Friday were assigned Monday as the travel-logging day. Also, if the interview was on Saturday and the interviewee was male, diaries were to be used on Monday; if female, on Tuesday. If the interview was on Sunday and the interviewee was male, Thursday became the travel-logging day; if female, Wednesday. This procedure was designed so that, as far as possible, a uniform number of travel diaries would be completed for each weekday. The signs indicated the proper weekday and had a peel-off label that permitted them to be hung on the front door and refrigerator to remind respondents to take their travel diaries with them on the correct day. In addition, if the travel-logging day was not the next day, interviewers were instructed to call the respondent the night before as a reminder.

Because respondents were being asked to perform what might at first seem to be an arduous task, an incentive was offered consisting of free tickets for round trips on the bus. One free ticket was provided for each returned travel diary, given that all travel diaries were returned. In addition, each household was provided informational brochures and bus-route and road maps of the area. These incentives improved the interviewer's morale by providing an additional tool to encourage response on the travel diaries. Interviewers were paid for an interview only if all travel diaries were obtained. The incentive was effective also in building good public relations for the survey.

Once all materials had been distributed and explained, an appointment was established for the interviewer to return and collect the completed travel diaries. At first, the same interviewer returned to collect the diaries, because this person had already established a rapport with the household. Although this is certainly the preferred procedure, to accelerate the process, specially trained personnel were

developed to pick up the diaries. In either case, the appointment was set to be within four days of the travel-logging day. When picking up the travel diaries, the interviewer checked them for completeness, particularly for trips back home during the day and at the end of the day, because pilot testing had shown such journeys to be omitted most often. Also, the need to enter each leg of a round trip often was omitted. If a respondent only showed trips to and from work, he or she was quizzed about where lunch was eaten and what was done in the evening.

If a household forgot to complete one or more travel diaries, the interviewer was instructed to attempt to reconstruct the information. If the household completed the diaries for the wrong day, this was judged as acceptable and not worth the cost or bad feelings from asking the household to repeat the procedure.

### DESIGN FEATURES TO ENCOURAGE RESPONSE

Of the 2706 attitude surveys that were completed (which represents an 85 percent response rate), 2502 complete sets of travel diaries (6453 diaries) were received (93 percent of those handed out). Because the travel diary was not introduced until after the interview had been completed, the 15 percent initial refusal had nothing to do with the travel diary. The effective refusal of the travel diary was 7 percent of the interviewed households. We believe that this relatively high rate of response to this seemingly difficult task was due to a combination of small devices employed to give the impression that the information was important, that the task was not difficult, and that it might even be fun.

Some of these devices have been referred to above: The use of the travel diary envelope gave the respondent a place to put completed diaries. The obvious expense of this tricolored envelope acted to emphasize the importance of the survey. The travel-logging signs acted as an important reminder to fill out the forms. The incentive was of sufficient value (as much as \$5.00 for some respondents) to act to encourage response significantly. It is also probably true that merely the idea that there is some payoff to the respondent encourages response (26).

### Travel Diaries

The travel diary was the subject of an extensive design process aimed at encouraging understanding and response. The effect of each individual design element is not known; however, the overall combination of these elements was effective in producing quality responses from 93 percent of the households asked to complete travel diaries.

The diary was designed as a booklet measuring 7 in by 5 in, so that it would be relatively easy to put in a pocket or purse and be carried around by the respondent on the designated travel-logging day. The outside front cover provided various pieces of identification: of the study, the household, the person (by number and name), and the travel-logging day. Two brief instructions were also included in a color-highlighted box. The entire travel diary was set up in three basic colors--white, orange, and yellow. In addition to being pleasing and effective in guiding responses, the colors are also those used in the logo on the vehicles of the sponsoring agency, thereby providing an additional subtle tie to that agency and implicitly reemphasizing the seriousness of the survey activity.

The inside front cover of the booklet is marked out for 10 trips, each one of which has space pro-

Table 1. Trips per person from travel diary.

No. of Trips	No. of Respondents	Percent	Cumulative Percent
0	1289	19.98	19.98
1	30	0.46	20.44
2	2360	36.57	57.01
3	476	7.38	64.39
4	972	15.06	79.45
5	361	5.59	85.04
6	403	6.25	91.29
7	172	2.67	93.96
8	162	2.51	96.47
9	93	1.44	97.91
10	101	1.57	99.48
11	18	0.28	99.76
12	8	0.12	99.88
13	4	0.06	99.94
14	1	0.01	99.95
15	1	0.01	99.96
16	1	0.01	99.97
25	1	0.01	99.98
	6453		

vided across one line. An eleventh trip is included as an example before trip 1. The lines for the trips are colored alternatively white and orange. The remainder of the travel diary is stapled on the top edge to the back cover. The topmost page is an instruction page on yellow stock (to distinguish it from all other pages) that uses both boldface type and two screen boxes to emphasize and highlight the most important instructions. Beneath this are 11 pages, one for each line on the inside front cover. These pages are colored to match their corresponding line on the cover, and have indent cuts on the left side, so that each is cut in from the bottom to its line level. The line (trip) number is printed on the tab and corresponds to a number printed at the left end of the line on the inside front cover. Arrows are used to direct the respondents' attention to the corresponding page for each line. The yellow page was cut to a narrower width than the underlying pages, so that this matching was immediately apparent when the booklet was opened.

The diary is designed to be used in the following manner. The front cover (the Travel Record page) can be folded over and the diary carried displaying the inside front cover throughout the travel-logging day. The remainder of the log provides a thick-enough base to permit easy use of the front cover. The respondent is asked to fill in each line as he or she makes each trip during the day. The information requested (in order) is the start time, the destination, and arrival time for each trip. This is designed basically as a memory prompt to identify each trip made and to provide enough information to the respondent to allow him or her to provide more detailed information later. This more detailed information is requested on the individual pages on the right of the diary (the Trip Detail pages) and consists of trip purpose, main mode of travel, access mode (if any), destination address, and automobile occupancy and parking cost, if automobile was used. Color highlighting, screening, and arrows are used to help the respondent through conditional-question sequences. Each successive page, as noted previously, is colored either orange or white and uses the other color for color highlighting. The first line of the inside front cover and the page immediately below the instruction sheet are used for an example; possible information is filled out in blue and appears as a handwritten record. Finally, the back of the back cover was laid out as a space for comments.

The extent to which respondents actually did fill

in the Travel Record page during the day and the Trip Detail pages at night is unknown. Chances are that a significant number of persons completed the entire form at night. Nevertheless, it is contended that superior information is obtained, even from those not following instructions, than would be obtained from a historical record. Just knowing that it would be necessary to record information about one's travel for the day should cause the respondent to pay attention to, and thus remember, trip details.

Various other items were used to assist the respondent. A box was provided to be checked on the inside front cover if the respondent did not leave home on the travel-logging day. Different type faces were used to distinguish between questions and instructions, and whenever possible, multiple answers were provided by means of boxes to check. Considerable care was taken in choosing wording to try to ensure nonambiguity, clarity, and simplicity and also to be nonthreatening, e.g., the use of "What to Do" in place of "Instructions." Although it was not overdone, "please" and "thank you" were used whenever appropriate.

Respondents were asked to continue on a blank page if more than 10 journeys were made. (If a respondent indicated that he or she would make more than 10 journeys at the time the diaries were distributed, two diaries were provided.) It was felt that most respondents would make less than 10 journeys [in fact, only 0.5 percent, or 34 respondents, reported making more than 10 (Table 1)] and that producing extra pages would not be worth the additional cost and bulk. On the other hand, the sudden drop in the number of respondents between 10 and 11 trips shown in Table 1 suggests that had more pages been provided, some respondents might have reported more trips.

The design described is the result of a developmental application in one locality (including pretests) and subsequent pretests in a second locality.

#### Travel Diary Envelopes

The need for the travel diary envelope was seen as a result of the in-field pilot survey. Interviewers would arrive to pick up the travel diaries and some member of the household would need to walk around the house to find the diaries. Even worse, diaries for given household members could not be found and interviewers had to return for one or more diaries. In addition, interviewers were having trouble keeping the interview forms and travel diaries together for the household. This same problem was experienced by supervisors and other personnel checking to make certain that travel diary sets were complete. These problems were solved by the envelope, which was a standard legal size so that both the travel diary sets and the 8.5-by-11-in interview form could be placed inside. This filing system also proved invaluable through the geocoding, keypunching, data-cleaning, and data-analysis stages of the project.

As with the travel diaries, the envelopes were designed to be eye-catching. Bands of orange and yellow were printed as background to certain instructions whose importance was emphasized by their placement on the envelope. An important feature of the envelope was the presentation of a "toll-free hotline" number. Respondents could call this number to ask any questions about completing the diaries. It was manned by a supervisor in the office of one of the firms conducting the survey. A telephone-answering machine was used during off hours to provide round-the-clock service. In fact, use of the hotline by respondents (as expected) was minimal. Nevertheless, the hotlines served an important function in emphasizing that completing the travel dia-

ries accurately was a very important task.

One change that should be made to the travel diary envelope deriving from its use in the main survey is that a box needs to be added (marked "For Office Use Only") to be used to keep track of the contents of the envelope and the varying clerical tasks that must be performed to computerize the results.

Thus, much care was given to the design of both the diary and the envelope. The overall positive effect is demonstrated by the overwhelmingly positive response by the public to this rather difficult task.

#### COSTS OF TRAVEL DIARY PROCEDURE

One input to any decision about the value of an effort is cost. Unfortunately, as with many multifaceted expensive projects, it is often difficult to assign costs to individual elements. The final estimated cost for the entire survey described here was \$310 000, including data collection, verification of 15 percent of interviews, coding, keypunching, editing, and preliminary analysis. The survey effort resulted in 2706 complete home-interview attitude surveys and 2502 complete surveys with travel diaries. This implies a per-interview cost of \$115/completed attitude survey and \$124/attitude survey with complete travel diaries. The travel diaries added costs to three aspects of the survey: printing, administration, and data analysis.

The printing costs added a reasonably significant amount. Because of the enormous economies of scale in printing, it is obviously superior to make one large print run than several small ones. It was estimated that obtaining the original goal of 2605 surveys might mean contacting 3000 households, because some households would take diaries and then fail to complete them. Also, figuring an average household size of four who were more than 5 years old (it turned out to be 2.638) implies the need for 12 000 travel diaries. The average cost of these was about \$1 each in 1980 dollars (subsequently it was found to be possible to produce the travel diaries for as little as \$0.65-0.69 each). The total cost, then, was about \$12 000 or about 4 percent of the cost of the completed interview. Because of this expense, some cost-cutting procedures were examined but rejected: the color (orange) added only 6 percent to the cost of each diary; the blue for the answers on the sample page, only 2.5 percent of the diary cost; and the screening to produce the grey areas, less than 0.1 percent of the cost. Most of the cost derived from the need to collate non-standard paper sizes. From the average cost per household must be subtracted some small cost for the additional printing that would have been necessary if a historical travel record section had been included on the interview survey. The 4000 travel diary envelopes ordered cost \$665 or \$0.166 each.

The chief administrative cost introduced was the need to conduct a second interview when the travel diaries were to be picked up and checked over. Although returning to the household was not very far out of the way for the interviewer in some cases (because of the multistage sampling process in which traffic-analysis zones were sampled randomly, then blocks, and then households), interviewers often found themselves needing to make special trips to pick up travel diaries. On the other hand, the time spent in the home to check that the information was complete was considerably less than would have been needed to ask all the questions as a historical record. There is no question that this procedure complicated the interviewer's task considerably and that the survey was slowed down because new inter-

views could not be conducted while the interviewers were busy picking up travel diaries. As mentioned above, special personnel were developed to collect travel diaries in order to speed up the survey.

Some additional costs were incurred during the data-preparation stages as well. The existence of separate forms for each person and the need to turn each page to keypunch each trip led to increased keypunching charges. The geocoding process also was hampered slightly by the need to turn pages. Costs were added by the need to sort the interview surveys into the travel diary envelopes after they had been keypunched. Computer analysis was complicated by the need to match identification numbers between the travel diaries and the attitude surveys in order to add demographic information to the trip-record file and trip information to the home-interview file.

Thus, some significant costs are added to the survey. It is impossible to calculate an exact amount over what the cost would have been had the information been collected historically. Obviously, the additional costs must be weighed against the results obtained. Certainly, obtaining seemingly logical and complete diaries from 93 percent of those interviewed speaks positively for the procedure. The next section reports the results (trip rates) from the travel diaries.

#### RESULTS FROM TRAVEL DIARIES

The question that one would want to answer is whether the results obtained are more accurate than would have been obtained from recording trips via the historical-record method. As revealed by the literature review, no definitive answer to this question exists and, unfortunately, this case study does not provide one either. Had, for example, half of the respondents been asked about their travel historically and half by using the diaries, a comparison of trip rates could be made. Even this would not reveal anything about the quality of information obtained by either procedure. Obviously, a major regional travel survey is not the place for each experimentation.

The comparisons in trip rates that can be made include both temporal and spatial dimensions. That is, the trip rates for this survey can be compared with earlier rates found in this region as well as with rates found in other cities. The question, then, is: Were more trips reported by respondents via the diary method than is usual for surveys that use the historical-record method? Unfortunately, the results reported below can be viewed only as instructive rather than definitive, because factors that affect trip rates (such as energy prices, unemployment rates, and the number of households in various income and automobile-ownership groups) are not static either spatially or temporally.

The discussion that follows reports trip rates for 1980 and for 1965 for the region of the case study. Both sets of trip rates are based on a sample of households. Optimally, the procedure that should be used is to test for significant differences between average trip rates in 1965 and 1980. Unfortunately, the appropriate statistical test (the difference-of-means t-test) requires knowledge of the standard deviations of the trip rates for both years. These statistics are unavailable for 1965, which precludes the use of statistical tests.

In this instance, however, this problem is not critical. The 1965 survey was a 4 percent sample of households; the resulting sampling error is very small. The 1980 survey, although only a 0.15 percent sample ( $N = 2502$ ), was designed for and obtained a sampling error of no more than  $\pm 5$  percent at the 90 percent confidence level. With such large sample

sizes and such small sampling errors, it is highly unlikely that any of the differences in trip rates between 1965 and 1980 are not significantly different (with the probable exception of person trips for personal business in Table 4, discussed below).

Trip rates by purpose for both households and individuals are shown in Table 2. The motorized person trip rate of 2.797 consists chiefly of work (0.672), school (0.380), shop (0.302), and non-home-based trips (0.691). This rate compares favorably both temporally and spatially with trip rates measured in other cities with study area populations more than 1 million [Table 3 (25,26)]. Detroit's 1980 rate is considerably higher than the rates shown for all but two of the other cities in Table 3. Also, this rate represents a 14 percent increase over the 1965 data from the Detroit Regional Transportation and Land Use Study (TALUS).

Table 4 compares the 1965 and 1980 person trip rates for Detroit by purpose. Although both household and person trip rates are shown, the household trip rates are difficult to compare over time because average household size has decreased by 24 percent from 3.48 to 2.64 in the 15-year period. It is thus not surprising that with the exception of school trips, all trip purposes show decreasing household rates, with an overall drop of 14 percent in household tripmaking.

An examination of the person trip rates reveals some interesting, but not unexpected, trends. Work trips have increased by 27 percent, which probably reflects increased labor-force participation, par-

ticularly among women. School trips have increased by an astounding 88 percent, perhaps due to an increase in persons attending evening classes. The 17 percent decrease in home-based shopping trips may be due to increased trip chaining, which results in an increase in non-home-based trips; note the 28 percent increase in the "non-home-based all" category. The three discretionary trip categories--shop, personal business, and social or recreation--all show decreases, although the decrease in personal business trips is not significant. The 28 percent increase in non-home-based trips is clearly due to an increase in trip chaining as a result of energy costs. Overall, a 14 percent increase in person trips is shown.

The question not answered is whether the changes in trip rates are due to the methodology change from the historical-method record or to actual changes in behavior. Is the increase in school trips due to greater participation in educational activities or to a higher level of reporting of, say, the child's trip home for lunch during the school day? Is the increase in non-home-based trips due to increased trip chaining as a response to the energy crisis or to the fact that the diary is a better method to

Table 2. Travel diary trip rates by purpose.

Trip Type <sup>a</sup>	Household Trip Rate		Person Trip Rate	
	All Trips	Motorized Trips <sup>b</sup>	All Trips	Motorized Trips <sup>b</sup>
Home-based				
Work	1.775	1.775	0.672	0.672
Shop	0.962	0.796	0.364	0.302
School	1.459	1.002	0.553	0.380
Restaurant	0.253	0.237	0.096	0.090
Serve passenger	0.388	0.375	0.147	0.142
Personal business	0.522	0.470	0.198	0.178
Visit friend or relative	0.508	0.394	0.192	0.149
Health care	0.155	0.145	0.059	0.055
Recreation	0.341	0.277	0.129	0.031
Other	0.117	0.088	0.044	0.033
All	6.566	5.559	2.483	2.106
Non-home-based all	2.043	1.825	0.774	0.691
All trips	8.609	7.384	3.261	2.797

<sup>a</sup> Average number of trips for a 24-h period.  
<sup>b</sup> Excludes walk only and bicycle trips, except work trips.

Table 3. Comparison of motorized person trip rates with rates from earlier studies.

City	Study Year	Person Trip Rate
Dallas	1964	2.89
Denver	1971	2.83
Detroit	1953 <sup>a</sup>	2.15
Detroit	1965 <sup>b</sup>	2.46 <sup>c</sup>
Detroit	1980	2.80 <sup>c</sup>
Minneapolis-St. Paul	1970	2.72
San Diego	1966	2.67
Chicago	1970	2.45
Cleveland	1963	2.34
Los Angeles	1967	2.28
San Francisco	1965	2.25
Boston	1963	2.23
Washington, D.C.	1968	2.17
Cincinnati	1965	2.17
Miami	1964	2.16
Houston	1960	2.12
Milwaukee	1963	2.07
Buffalo	1962	2.04
Philadelphia	1960	2.03
St. Louis	1957	1.94
New York (Tri-State)	1963	1.81
Seattle	1961	1.76
Pittsburgh	1967	1.72
Baltimore	1962	1.66

<sup>a</sup> Detroit Metropolitan Area Transportation Study.  
<sup>b</sup> Detroit Regional Transportation and Land Use Study (TALUS).  
<sup>c</sup> 14 percent increase.

Table 4. Comparison of motorized trip rates by purpose with 1965 TALUS survey in Detroit.

Trip Type	Trip Rate, 1980		Trip Rate, 1965		Increase or Decrease			
	Household	Person	Household	Person	Household		Person	
					Trip Rate	Percent	Trip Rate	Percent
Home-based								
Work	1.775	0.672	1.852	0.531	-0.077	-4	0.141	27
Shop	0.796	0.302	1.284	0.364	-0.488	-38	-0.062	-17
School	1.002	0.380	0.711	0.204	0.291	41	0.176	88
Personal business <sup>a</sup>	1.078	0.408	1.435	0.411	-0.357	-25	-0.003	-1
Social or recreation <sup>b</sup>	0.908	0.270	1.393	0.408	-0.485	-35	-0.138	-34
Non-home-based all	1.825	0.691	1.885	0.538	-0.060	-3	0.153	28
Total	7.384	2.797	8.558	2.460	-1.174	-14	0.337	14
Avg household size	2.64		3.48					

Note: Data for 1965 are from TALUS report (25); for 1980, from Stopher and Sheakin.  
<sup>a</sup> For 1980, this category includes personal business, health care, serve passenger, and other.  
<sup>b</sup> For 1980, this category includes recreation, eat meal, and visit friend or relative.

emphasize remembering and reporting such journeys?

#### CONCLUSIONS

This paper has suggested that the traditional method for obtaining travel-behavior information may be flawed. That is, logic, and some evidence, seems to suggest that when people are asked about their behavior in a retrospective manner, as a historical record, they tend to forget trips, particularly trips made irregularly.

One possible alternative is to use a travel diary in which respondents are asked to record various details about their travel for some future date. Previous use of such a technique to collect information has seen only limited use in transportation research. The travel diary developed by us is the first use of this technique for a major metropolitan areawide travel study.

This paper has discussed the development, design, administration, and costs of the diary technique. A number of conclusions may be drawn. First, the household must be presented with the diaries after a home interview rather than before. This allows the development of rapport and commitment prior to asking respondents to participate in a seemingly difficult task. Second, every detail of the diary and supporting materials must be examined carefully for their possible impact on the response rate and the quality of response. Third, a second interview is needed during which the travel diaries are checked for logic and completeness. Fourth, a significant cost is added to the survey both in terms of dollars and time. Finally, although logic would seem to suggest that at least some of the increase in trip rates shown between Detroit and other cities and within Detroit over time is due to the use of the diary technique, the results presented above cannot prove this contention. Further research is needed in which the diary method and the historical-record method are used in the same survey.

#### REFERENCES

1. Detroit Metropolitan Area Transportation Study: Final Report. Schimpeler-Corradino Associates, Coral Gables, FL, July 1955.
2. Manual of Procedures for Home-Interview Traffic Study. U.S. Bureau of Public Roads, 1954.
3. F.W. Memmott. Home-Interview Survey and Data-Collection Procedures. HRB, Highway Research Record 41, 1963, pp. 7-12.
4. P.R. Stopher and A.H. Meyburg. Urban Transportation Modeling and Planning. Lexington Books, Lexington, MA, 1975.
5. T.A. Domencich and D. McFadden. Urban Travel Demand: A Behavioral Analysis. North-Holland Publishing, Amsterdam, 1975.
6. I.M. Sheskin, G.S. Spivack, and P.R. Stopher. The Dade County On-Board Survey. Transit Journal, Spring 1981, pp. 15-28.
7. J.L. Simon. Basic Research Methods in Social Science. Random House, New York, 1978.
8. H. Cantril. Gauging Public Opinion. Kennikat Press, Port Washington, NY, 1971.
9. C.J. Dixon and B. Leach. Questionnaires and Interviews in Geographic Research. Univ. of East Anglia, Norwich, England, Geo Abstracts, 1979.
10. K. Willcox. A Trial of Methods for Collecting Household Morbidity Data. U.S. Public Health Service, Publ. 1163, 1973.
11. M. Young and P. Willmott. The Symmetrical Family. Routledge and Kegan Paul, London, 1973.
12. W.R. McGrath and C. Guinn. Simulated Home Interview by Television. HRB, Highway Research Record 41, 1963, pp. 1-6.
13. D.F. Marble, P.O. Hanson, and S.E. Hanson. Household Travel Behavior Study: Report No. 1--Field Operations and Questionnaires. Transportation Center, Northwestern Univ., Evanston, IL, May 1972.
14. S. Hanson. The Importance of the Multi-Purpose Journey to Work in Urban Travel Behavior. Transportation, Vol. 9, 1980, pp. 229-248.
15. P. Burnett. Spatial Constraints-Oriented Modeling: Empirical Analysis. Urban Geography, Vol. 1, No. 2, 1980, pp. 153-166.
16. J.R. Kuzmyak and S. Prensky. Use of Travel Diaries in Collection of Travel Data on the Elderly and Handicapped. TRB, Transportation Research Record 701, 1979, pp. 36-38.
17. G. Gilbert and others. Taxicab User Characteristics in Small and Medium-Sized Cities. U.S. Department of Transportation, Jan. 1976.
18. Research Services Limited. London Transport Fare Increases: An Investigation of Research Methodology. London Transport Board, Feb. 1969.
19. Monitoring Urban Travel. NCHRP, Project 2-8: Final Report, Aug. 1966.
20. Washtenaw County Transportation Needs Study: Final Report. Schimpeler-Corradino Associates, Coral Gables, FL, 1980.
21. I.M. Sheskin, P.R. Stopher, and S.S. Lin. Spatial Variations in Beliefs and Judgments About Transit-Service Provision. Presented at Annual Meeting, Southern Regional Science Association, Arlington, VA, April 1981.
22. Broward County Travel Survey: Final Report. Schimpeler-Corradino Associates, Coral Gables, FL, 1980.
23. Southeast Michigan Regional Travel Survey: Final Report 6. Schimpeler-Corradino Associates, Coral Gables, FL, 1981.
24. C.H. Backstrom and G.D. Hursh. Survey Research. Northwestern Univ. Press, Chicago, 1963.
25. R.L. Smith. Base Year Travel Survey. Detroit Regional Transportation and Land Use Study (TALUS), Detroit, MI, Oct. 1969.
26. Wilbur Smith and Associates. Characteristics of Urban Transportation Demand: A Handbook for Transportation Planners. Urban Mass Transportation Administration, U.S. Department of Transportation, Rept. UMTA-IT-06-0049-79-1, April 1978.

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