Problems of Nonreported Trips in Surveys of Nonhome Activity Patterns

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The problem of nonreported trips has become the subject of substantive basic research activities. This has occurred in line with increasing concern about potential artifacts in the development of travel-behavior data attributable to the specific survey method used. In that context, three types of trips have to be distinguished, namely, (a) trips that were not reported by the respondents due to increasing lack of care in case of survey periods of several days' length, (b) trips that were not reported by the respondents because they forgot or considered them redundant, and (c) trips that the respondents did not want to report on the basis of their own deliberate decisions. It is relatively simple to check the loss of accuracy caused by type-a trips. A methodological experiment was conducted to disclose errors of type b and to gain at least a certain idea about errors of type c. The results confirm previous findings from the analysis of reporting losses for multiple-day surveys. Accordingly, in the analysis of trip volumes, a distinction has to be made first between the "nonhome share" and the "number of trips for mobile persons." Use of the (artificial) measure "trips per person" would cover up important relationships. In addition, the level of underreporting of trips measured by this means can be set between 5 and 15 percent. This underreporting is not equally distributed across all transportation modes and trip purposes, but it occurs to a disproportionately large degree for discretionary and recreation travel, especially by nonmotorized modes.

Transportation planning practice has always been dependent on reliable empirical data sets of substantial size. The expectations about the level of detail for such data have increased continuously. Whereas initially information describing the volume and direction of vehicle flows was sufficient, today information is also desired about the participants in the traffic stream. The intent is to be able to classify the travelers (e.g., according to sociodemographic criteria) as well as their type of travel participation (e.g., according to activities).

The associated switch from measuring by means of simple counting to measurement by means of surveys has quantitative as well as qualitative implications. The reason for this is that the survey techniques to be employed, regardless of their specific methodological orientation, usually prohibit their development on a massive scale due to time and budget constraints. Generally they can only be implemented in conjunction with a specific survey sampling technique.

This circumstance leads to great concern about the quality of the survey data. Consequently, extensive consideration was given to methods that could determine the magnitude of the random-sampling error. This effort usually overlooked the fact that survey techniques typically are dependent on cooperation with the prospective respondent (1). Respondents obviously are individuals subject to a variety of human weaknesses. This means that the respondent as well as the manner in which he or she is questioned will influence the survey results to a considerable degree; i.e., systematic errors, or bias, play an important role in survey responses. Since it has been demonstrated repeatedly in the literature that the importance of such systematic errors substantially exceeds that of random errors (2), the systematic investigation of these error sources is one of the most important areas of fundamental research into survey methods.

In comparison with the importance of such research, the results published to date are rather modest (3). Therefore, it will not come as a surprise that little information is available even about comparatively obvious sources of error in surveys of human subjects. It is of even greater concern that many planners, who are the users of such empirical data, often lack the awareness of these problems, and these obvious areas for investigation hardly undergo close scrutiny.

One such source of errors can be found in the fact that even in the most carefully selected survey designs, e.g., in the case of travel-behavior surveys, it cannot be avoided that the respondents do not indicate all trips they took. This phenomenon of nonreported trips is investigated more closely in this paper.

STUDY DESIGN

The acquisition of data about the accuracy of the information provided by the respondents is particularly delicate, especially due to the fact that it can only be performed with the respondents themselves, i.e., not by means of a control group. Therefore it requires a particularly carefully composed survey design.

The basis for such a design has to be a survey instrument that is as free as possible of typical error sources for such surveys and that also has been used in other, preferably large-scale travel surveys. Such a survey instrument was available for the experiment described here, namely, that used in the Continuous Travel Survey (KONTIV) of the Ministry of Transport, a survey form that has become known internationally (4).

The basic plan of this experiment was to hand to a randomly selected set of individuals a KONTIV survey form (consisting of a household survey form and a diarylike personal survey form per household member for two prespecified successive survey days, in this case work days) and to specify a time for pickup of the forms on the day following the second survey day. During the delivery of the survey instrument, a brief interview was performed during which the respondents were presented with a number of items by which their respective attitudes were measured. By this means, it was intended to determine a potential relationship between subjective attitudes and care in filling out the survey forms.

Under the pretext that the travel-mode alternatives had been grouped incompletely and improperly due to a mistake by the survey personnel, the interviewer asked the respondent at the time of pick-up for permission to once again review with him or her the relevant entries in great detail. The interviewers had been trained to explore thoroughly all ambiguous and incomplete entries. They designated all corrections in such a fashion that they could be identified later. Also, they filled out a survey form about the interview and the interviewee, which reflected the interviewer's assessment of the reliability of the follow-up exploration.

This approach was very successful and the intended sample size of 201 respondents who undertook 1527 trips was reached with ease. The repondents rarely objected to the procedure. Their final assessment of the complete survey was mainly positive (Table 1). As was expected, they had hardly any difficulties in filling out the survey instrument, which had been tested repeatedly. This characteristic is a necessary prerequisite for an investigation of this kind. Eighty percent of the respondents had no difficulties at all in filling out the household and the personal forms. Approximately 5 percent had substantial yet surmountable difficulties. This agrees basically with the documented experience in the use of the KONTIV survey instruments.

During the data-tabulation and coding process, each data item was marked as to whether it had been provided by the respondent from the beginning (reported information) or whether it was altered due to the follow-up exploration (explored information). For the second case a distinction was made between a correction of a recognizably incorrect entry and a complementation of information that was not entered initially. An additional effort identified which of these complementary items also could have been obtained by means of a very careful coding process, e.g., nonreported return trips to the home (coded information).

Of course, even this procedure will not uncover activities that the respondent is absolutely unwilling to disclose. However, this phenomenon is not uncommon in the realm of empirical measurement techniques. No measurement technique can measure "true" reality; it can only come close to this reality (5). Therefore, for subsequent analyses three error sources could be distinguished:

1. Errors that could be eliminated in the coding process,
2. Errors that could only be detected by means of a follow-up exploration, and
3. Errors that could not be detected through coding or follow-up exploration.

The next sections will concentrate on errors of the second category.

TRAVEL FREQUENCY (TRIP QUANTITY)

The most commonly used mobility indicator in transportation planning is the number of trips per person. Several research studies, for example, one by Brög and Meyburg (6), show, however, that it is usually more meaningful in methodological investigations to consider the two components of mobility separately, namely, the share of nonhome activities and the mobility per mobile person (tripmaker). Such a separation shows that the reported information on mobility increases significantly in all three mobility categories (share of nonhome activities, trips per mobile person, trips per person) by means of the follow-up exploration (Table 2).

It should be pointed out that due to the sample design, which excluded so-called immobiles (persons who did not undertake activities outside their homes), the nonhome share of activities is relatively high, whereas the mobility per mobile is well within the range of comparable values. At the same time it can be recognized that approximately one-half of the additional information obtained through the follow-up exploration could have been gathered by means of a careful coding process. But since usually only the quantity and to a lesser degree the quality of such trips can be captured in the coding process and since such methods also depend strongly on the respective data-preparation process and the training and supervision of the coding personnel, this paper will not present a separate evaluation of the coded information in the course of the following discussion. This information allows the quantification of an error source, however, that is hard to avoid, especially in strongly automated data-preparation processes (7), which are used preferably in transportation planning.

A first indication of the quality of the nonreported trips (no follow-up exploration conducted) is provided through the evaluation of the quantitative measures of trip length (in kilometers) and duration (in minutes) (Table 3). There exists a clear negative correlation between trip length and the probability that a trip will not be reported. This also leads to the conclusion that a substantial number of nonreported trips are more likely attributable to carelessness rather than to conscious nondisclosure. Nevertheless, the trips detected by means of the follow-up exploration add up to a total travel distance of a magnitude that can play a role in considerations of transportation system performance: The respondents in this experiment did not report 8.8 percent of their total travel distance. In relation to the distance of all reported trips, which is the usual basis for model computations, the deficit amounts to 9.6 percent.

TRAVEL CHARACTERISTICS (TRIP QUALITY)

As is to be expected, the statistically significant correlation between the additional trips (from the follow-up exploration) and the trip length is reflected in the relevant travel-mode choice. The highest nonreported trip rate is evident for walking and bicycle trips. But underreporting for motorized travel, which is distinguished by its far higher service volume, should not be overlooked either

Table 1. Statements by respondents about filling out survey forms.

Statement by Respondent	Yes (%)	No (%)	NA (%)
Filling out form was fun	51	42	7
Expected greater difficulty	30	67	3
Can imagine that investigation will facilitate transport planning	68	28	4
Found the recording procedure for trips quite simple	84	12	4
Found it interesting to participate in a survey	63	34	3
Find filling out such survey forms an imposition	10	87	3
Can visualize the necessity for this investigation	74	22	4
May have made more accurate entries than other people	24	64	12
Recording of trips took too much time	10	89	1
Would like to participate in such a transportation study again	46	48	6
Basically it was unnecessary to review the recorded trips again in the interview	42	53	5
Anybody can fill in such survey forms	75	21	4
Found forms hard to read due to small type	3	96	1

Note: Sample size was 201 respondents.

Table 2. Nonreporting and mobility information.

Mobility Category	Reported Information	Coded Information	Reported and Explored Information	Nonreported Trip Rate[a] (%)
Nonhome share (%)	90.5	90.5	94.5	4.8
Avg no. of trips per tripmaker (mobiles)	3.60	3.90	4.02	10.4
Avg no. of trips per person	3.26	3.53	3.80	14.2

Note: Sample size was 201 respondents.

[a]Nonreported trip rate = $[T_E/(T_R + T_E)] \cdot 100$, where T_E is explored trips and T_R is reported trips.

Table 3. Nonreporting by trip length and duration.

Trip Length[a] (km)	Reported Information (%)	Explored Information (%)	Nonreported Trip Rate[b] (%)
0.0-0.4	11.0	3.9	26.3
0.5-0.9	9.4	2.9	23.4
1.0-2.9	23.9	3.8	13.9
3.0-4.9	10.7	1.2	9.9
5.0-9.9	16.6	1.4	7.8
10.0-19.9	7.1	0.6	7.7
>20.0	7.1	0.4	5.3
Total	85.8	14.2	14.2

[a]Avg trip distances: reported information, 5.7 km; explored information, 3.3 km. Avg trip duration: reported information, 20.4 min; explored information, 15.9 min. Nonreported trip rates, 8.8 and 11.4 percent, obtained as follows: [(no. of explored trips) x (avg length for explored trips)] /[(total no. of trips reported and explored) x (avg trip length)].
[b]For definition, see Table 2.

Table 4. Nonreporting by travel mode use.

Item	Reported Information (%)	Explored Information (%)	Nonreported Trip Rate[a] (%)
Predominantly used travel mode			
Walk	26.4	7.9	22.9
Bicycle	7.8	1.3	14.4
Moped, motorbicycle, motorcycle	1.2	0.4	25.0
Automobile driver	30.3	2.9	8.9
Automobile passenger	6.1	0.8	12.3
Public transit	12.6	0.9	6.7
Train	1.4	-	0.0
Total	85.8	14.2	14.2
Mode aggregation			
Nonmotorized	35.2	9.2	21.1
Motorized	37.6	4.1	9.9
Public transport	14.0	0.9	6.1

[a]For definition, see Table 2.

Table 5. Nonreporting by trip purpose and activities.

Item	Reported Information (%)	Explored Information (%)	Nonreported Trip Rate[a] (%)
Trip purpose			
Work	19.0	1.2	5.9
School (training)	6.7	0.6	8.2
Shopping	22.7	5.1	18.4
Other discretionary activities	11.8	2.0	14.5
Recreation	25.6	5.3	17.2
Total	85.8	14.2	14.2
Purpose aggregation			
Regular activities	25.7	1.8	6.4
Discretionary activities	34.5	7.1	17.1
Recreational activities	25.6	5.3	17.2

[a]For definition, see Table 2.

(Table 4). Corresponding to this fact is the particularly high level of information completeness for the trip-purpose categories that reflect regular repetitive travel (Table 5). It decreases substantially with the degree of flexibility that exists for planning the activities associated with the trips such that every sixth trip associated with recreational activities is no longer reported (for the reported information, even every fifth trip). Again, the relationship between travel modes (and associated activities) and reporting accuracy is statistically significant.

An even more accurate picture can be obtained about the relationship between the information completeness and the type of travel when the travel modes are combined with the activities for whose pursuit they were used. For this illustration the combinations already presented in Tables 4 and 5 (nonmotorized, motorized, public transit traffic, and regular occasional recreational activities) are employed to determine the matrix elements reflecting the frequency as well as the duration and length of reported and explored trips (Table 6). It becomes evident immediately that the nonreported trips for trip frequency, duration, and length are of fairly similar magnitude, but the trip frequency is somewhat more often underreported.

Throughout the matrix the particular susceptibility of nonmotorized travel to underreporting is confirmed; this effect, in line with the overall trend, increases from regular via discretionary to recreational activities. In contrast, the nonreported trip rates are particularly low for motorized travel to regular activities. They are particularly high for discretionary activities, i.e., in that area where the use of public transport reaches encouraging values. This can probably be explained on the basis that shopping trips that constitute the dominant share of discretionary trips are performed usually by persons who mainly use public transport, whereas they constitute the exception among the users of private motorized modes. It is not clear how social desirability plays a role in this connection. (At least in the German context, where these data were collected, automobile drivers might not want to admit that they also perform shopping trips for the family.) It has to be observed here that, again, nearly 10 percent of the total travel distances were not reported for motorized travel to regular and recreational activities. And it can be taken for granted that the sum of the reported and explored values still underestimates the true degree of actual travel participation.

FEASIBLE REMEDIES

The results of this methodological investigation were evaluated in greater detail than can be presented within the constraints of this paper. In-

Table 6. Nonreporting by combinations of travel modes and activities.

Activity	Nonmotorized Travel			Motorized Travel			Public Transit		
	RI	EI	NRTR	RI	EI	NRTR	RI	EI	NRTR
Regular									
Trip frequency	7.6	1.0	11.5	11.0	0.4	3.4	7.1	0.4	5.3
Trip length (km)	1.4	0.7	6.1	10.7	7.4	2.4	9.0	9.2	5.4
Trip duration (min)	13.3	8.1	7.4	22.5	15.0	2.3	37.6	40.0	5.7
Discretionary									
Trip frequency	17.2	4.8	21.8	14.2	2.2	13.6	3.2	0.1	3.9
Trip length (km)	0.9	0.6	16.2	6.8	4.6	9.6	9.2	10.0	4.2
Trip duration (min)	11.6	8.3	11.7	15.6	14.5	12.6	44.6	60.0	4.0
Recreational									
Trip frequency	9.4	3.4	26.5	12.4	1.5	10.8	3.7	0.4	9.5
Trip length (km)	1.1	0.9	17.4	8.4	7.8	9.3	9.8	8.0	5.1
Trip duration (min)	15.0	20.9	32.6	24.1	25.5	11.3	41.9	33.8	8.0

Note: RI = reported information, EI = explored information, NRTR = nonreported trip rate (for definition, see Table 2).

Table 7. Differences in mobility measurements.

Mobility Category	Coded Information	Reported and Explored Information	Nonreported Trip Rate[a] (%)	KONTIV[b] Relationship of First to Second Survey Day[c]
Nonhome share of activities (%)	90.5	94.5	4.8	5.6
Avg no. of trips per tripmaker (mobiles)	3.90	4.02	3.0	2.0
Avg no. of trips per person	3.53	3.80	7.1	7.2

[a]For definition, see Table 2. However, in this case "coded information" replaces "reported information."
[b]Workdays only.
[c]Comparable with the computation of NRTR.

stead a few speculations and suggestions are put forth about the consequences that arise out of the findings that are presented here.

First, it would be interesting to determine whether a correlation exists between nonreporting of trips and respondents' personal characteristics that would make it possible to identify those respondents who have a high probability of inaccurate reporting. Two types of personal data can be considered: sociodemographic and/or attitudinal data. For both cases there exist appropriate basic hypotheses. For example, with respect to sociodemographic variables it could be determined that age, education, and employment type especially have a statistically significant influence on the reporting accuracy for well-established and tested survey instruments. This observation is based on past experience on the basis of reported information only, i.e., without follow-up explored information (8). With respect to attitudes, it could be observed that positive interest in the subject matter of the mail-back survey constitutes a substantial determining factor for the response rate and therefore is a decisive element for evaluating nonresponse effects, which also have an influence on the survey results (9).

Both relationships were analyzed in the research presented here, but no clear answer was obtained for either case. Stratification of nonreported trips by means of respondents' sociodemographic characteristics showed that the level of nonreporting was particularly high for women, 10- to 15-year-olds, persons with poor education levels, and retired persons. These observations are plausible on the basis of theoretical considerations. These relationships were not statistically significant, however.

Similar results were obtained for the statistical evaluation of the scales that were handed to the respondent at the beginning of the follow-up interview. One of the scales dealt with interest in the survey subject matter, which contained 13 items; another scale was for reporting accuracy and care and had a total of 54 items. The evaluation of both scales resulted in weak correlations that were plausible but did not suffice for formulating statistical significance.

Neither case disproves the existence of such relationships, however. Their lack of significance could be due to special sociodemographics, to the small sample size, or to the scales, in which the items might not have been formulated so that clear separation between them was guaranteed.

Aside from the problems of explaining and therefore controlling the effect of nonreported trips due to personal characteristics, it is, of course, of special importance to find reference points by means of which the influence of this effect on the measurement results can be determined. For this objective there also exist two basic hypotheses that were tested in this research effort. Both hypotheses relate to the measured and to the unreported mobility. The third section of this paper has already referred to the first hypothesis. It states that the share of trips that can be added to the reported ones purely by means of careful coding provides an indication of how large the share of the remaining nonreported trips might be. The second hypothesis refers to the observation that reported trip frequency decreases over time for surveys that include several survey days (10); the greatest reduction often takes place after the first survey day. Furthermore, this hypothesis states that the mobility difference between the first and the second survey day can be used as a measure of the share of nonreported trips that have occurred on the first survey day (11).

The test of the first hypothesis generates several problems, irrespective of the indicated uncertainty about varying coding methods and rules. Table 2 has shown already that such a relationship is likely to exist only for the artificial measure "trips per person" (which does not make it useless, however, as an aggregate correction measure from the outset). Furthermore, opportunities for influencing such corrections are only present in certain cases, particularly for (unreported) return trips home. The relatively large share of nonreported trips that is correctible by means of the coding process is only due to the fact that the nonreported trip rates are particularly high for return trips to home (27.2 percent compared with 5.6 percent for the first trip on the first survey day). This means that the correction factors thus derived permit only a rough quantitative improvement of the data and by no means a structural one.

An examination of the second hypothesis leads to similar but slightly better results. For this test, appropriate information is required from suitable comparable surveys about the effect of the first and second survey days. The most appropriate survey for this purpose is KONTIV (12) because it is fully compatible methodologically and it is statistically sound. However, for the KONTIV survey the coding corrections have been performed already. Therefore, the comparison of the reporting differences between survey days has to be based on the difference between the coded and the explored information. As shown in Table 7, rather substantial agreement exists for the mobility measurements. Unfortunately, given the present level of knowledge, it is impossible to go beyond the formulation of a rough estimate for a mobility correction factor, because an in-depth analysis on the basis of a table structured analogous to Table 6 results in partial agreement only for the mobility measurements. Therefore, further research has to be performed in this instance also in order to gain more solid footing for formulating firm conclusions. Nevertheless, the rule of thumb holds that a decrease in mobility between the first and second survey day constitutes an acceptable indicator for the quantity of nonreported trips.

SUMMARY AND CONCLUSIONS

The methodological investigation reported in this paper discloses some disturbing facts about underreporting that typically go undetected. The effect of such information reduction can be substantial when the survey data are used uncritically for assessing mobility levels and for determining modal shares and overall travel activity levels in terms of duration and length. The paper identifies a number of methods, indicators, and relationships that permit the analyst or planner to upgrade the results of surveys by means of careful adjustments.

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Estimation of Cross-Cordon Origin-Destination Flows from Cordon Studies

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When traffic counts obtained in a cordon study are supplemented by information about the origin and destination of a small sample of trips crossing the cordon, it is possible to obtain estimates of the prevailing origin-destination (O-D) flows. The purpose of this paper is to describe a coherent method for the identification of the maximum-likelihood estimates of vehicular O-D flows. The solution procedure proves to be relatively simple. The estimates obtained are of flows between the cordon stations, flows between the stations and the area inside the cordon, flows between traffic zones, etc. The method is illustrated by a detailed numerical example. A real-life application of the estimation method to the downtown Toronto cordon is described. It appears that it is possible to obtain much-needed O-D information at relatively little extra cost.

The pattern of tripmaking in an urban area is precisely and succinctly described by an origin-destination (O-D) flow matrix. This is why O-D matrix estimates should serve as basic information for traffic management and transport planning tasks. Unfortunately, methods for obtaining such estimates are time consuming and costly. This is why, even in major metropolitan areas, information about the prevailing pattern of tripmaking is often sketchy.

Many cities conduct cordon studies periodically. Traffic into and out of the cordon area is counted and some inferences about traffic flow patterns and trends are possible. However, a cordon study does not yield information about O-D flows. The idea explored in this paper is the possibility of attaching a small-sample O-D survey to the routine cordon counts and of using the combined information for the estimation of the prevailing O-matrix of vehicle flows crossing the boundary of the cordon at least once.

This idea is in line with other recent developments, which all rely on better utilization of the ubiquitous traffic-count information for O-D estimation. A detailed review of such models is available (1-3).

For some simple transport systems one can obtain good estimates about the O-D flows by using traffic counts only (4). In more complex systems, regulari-