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Impact of Interviewing by Proxy in Travel Survey Conducted by Telephone

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Telephone-interview surveys are a very efficient way of conducting large-scale travel surveys. Recent advancements in computer technology have made it possible to improve upon the quality of data collected by telephone surveys through computerization of the entire sample-control process, and through the direct recording of the collected data into a computer. Notwithstanding these technological advancements, potential sources of bias still exist, including the reliance on an adult member of the household to report the travel information of other household members.

Travel data collected in a recent telephone interview survey in the Toronto region is used to examine this issue. The statistical tool used in the research was the Analysis of Variance (ANOVA) technique as implemented within the general linear model framework in SAS. The study-results indicate that reliance on informants to provide travel information for non-informant members of their respective households led to the underreporting of some categories of trips. These underreported trip categories were primarily segments of home-based discretionary trips, and non home-based trips. Since these latter two categories of trips are made primarily outside the morning peak period, estimated factors to adjust for their underreporting were time-period sensitive. Further, the number of vehicles available to the household, gender, and driver license status respectively were also found to be strongly associated with the underreporting of trips and thus were important considerations in the determination of adjustment factors.

Work and school trips were found not to be underreported, a not surprising result giving the almost daily repetitiveness of trips made for these purposes and hence the ability of the informant to provide relatively more precise information on them.

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Introduction

The recognition of the importance of data quality to the conduct of transport planning has over the last decade spurred improvements insurvey-methods that capitalize on the advancements in computer technology. Ng and Sarjeant [1993], for example, report the use of the direct entry of data into the computer in a major travel survey conducted in the Greater Toronto Area (GTA) in 1991. In Fall 1996, another large-scale travel survey was conducted in the GTA and selected surrounding municipalities, referred to as the 1996 Transportation Tomorrow Survey (TTS). The survey was conducted by telephone, and made use of computer technology to improve upon the data collection process, through use of software that controlled the sample in all phases of the process [Steuart, 1997].

The objective of the survey was to record household, person and travel information from 5 percent of the households in the survey area. The resident-population of the survey area was 6.3 million, clustered into 2.3 million households. The sample of households was randomly selected from the local phone-company's listing of households with residential telephone numbers. An advance letter was sent to each household one to two weeks in advance of the expected day of the interview. This letter explained the purpose of the survey, and informed the respective households to expect a phone call.

Interviewers contacting a household requested to speak to an adult, who normally lived in the household and was familiar with the travel patterns of all its members. This adult, henceforth referred to as an informant, provided information on the household, each household-member, and information on the trips made by each member 11 years of age or older in the 24-hour period between 4:00 a.m. the previous day and 4:00 a.m. on the day of the interview. The other members of the household the informant provided information on are referred to as non-informants. In all, informants represented 43.5 percent of all persons in the database, while non-informants represented 56.5 percent of all persons.

The information collected in the interview was directly entered into a computer [Ng and Sarjeant, 1993]. In households where an answering device responded to the interviewer's call, a message, requesting an adult from the household to contact the survey-team for the interview to be conducted, was left. If this did not happen within two days after contact,

the sample control software brought up that particular household phone number three days after first contact for an interviewer to re-contact it. Provision was made for each household to be contacted up to seven times after first contact if no member of the household responded to each of the previous call-attempts. The total number of households interviewed successfully, all told, topped 115,000, representing 69 percent of all the households contacted.

Logic checks were built into the sample control software to detect any discrepancies in the information collected from each interviewed household. In addition, a hardcopy of the questions and responses to these questions by the informant-member in each interviewed household underwent a thorough visual check.

Expansion factors were computed for each household based on an aggregate zone system that was consistent with census boundary definitions. The expansion factor is defined as the ratio of the number of household units in a given aggregate zone obtained from the 1996 Canada Census to the number of household units in the same zone as surveyed in the 1996 TTS. This expansion factor is applicable to all household, person, and trip data. Comparisons of the expanded 1996 demographic data with corresponding 1996 census information indicated very good agreement, and hence of the 1996 TTS sample being representative of the GTA population in terms of demographics.

Notwithstanding all of the technological improvements and checks made in the data collection process, there is still the potential for bias in the trip-data obtained stemming from a number of sources.

One such source is the reporting of travel information for the non-informant members of the household by the informant-members of their respective households. Unlike diary-surveys in which each household member completes a personal diary, telephone surveys rely on informants to report trip-information of non-informant household-members. This presents the possibility for the underreporting of trips [Stopher, 1997; Stopher and Sheskin, 1982; Hassounah *et al*, 1993]. In response to the above source of error amongst others, use of the travel-diary technique, in which travel is recorded as it is undertaken, and is completed personally by each household member was advocated [Stopher and Sheskin, 1982; Brog and Ampt, 1983]. Use of the travel-diary technique or some variant of it, has since gained in popularity in US surveys [Jou and Mahmassani, 1997]. Notwithstanding this, however, survey instruments based on telephone interviews are still used [Walker *et al*, 1997; Stopher and Stecher, 1993], and because of their relatively

lower costs, tend to be used in large-scale transportation data collection efforts [JPT, 1987; Meyer and Miller, 1984]. Steuart [1997], in tracing the history of travel surveys, writes:

> "*Since that time, data collection related to urban travel has taken a different direction in Canada from that in the United States. Although it is dangerous to generalize, and both continue to use predominantly a sample frame defined on households, Canadian data collection efforts have developed survey instruments based on telephone interviews and use relatively large sample sizes. American cities, although very diverse in technique and implementation, are more inclined to use a small sample, interview each household more intensively, use the telephone for increasing the rate of response, and supplement the data with extensive use of simulation models.*"

Thus research on issues associated with the conduct of travel surveys by telephone interviewing is still relevant in many other countries.

Hassounah *et al* [1991 and 1993] investigated the underreporting of trips in a telephone interview travel-survey conducted in the Toronto region in 1986. Their study results showed that discretionary-trips of short trip-length made during off-peak periods were underreported very significantly. Though this latter study yielded useful insights into the underreporting of trips in telephone surveys, there are two motivating reasons for this additional study. The first is that survey procedures used in the 1996 TTS were different and considerably improved upon from what was used in the 1986 TTS, the data-source for the work by Hassounah *et al* [1991 and 1993]. The issue here is whether the improvements in data collection techniques did result in measurable improvement in the quality of the data collected. Second, this work presents some refinements to the analysis in Hassounah *et al* [1991 and 1993] in two ways.

First, the study by Hassounah et a/1991 and 1993 eliminated several potentially important variables from the statistical analysis based on the results of preliminary one-way cross-tabulations. The problem on hand, however, is a multivariate one. Hence the effect of each variable in explaining differences in trip-making behavior should be assessed in the presence of the other potential explanatory variables and not independently. In other words, all the potential explanatory variables should be considered simultaneously in the statistical analysis

framework, and those without any impact on the underreporting of trips identified accordingly. Second, their variable elimination-analysis was based on "total trips" rather than on trips stratified by purpose. Working with an aggregate of trips in this fashion had the potential to have "buried" some of the variation in the trip-data. Thus a major objective of this paper is to examine the issue of under-reporting of trips in telephone interview surveys resulting from interviewing by proxy using the 1996 TTS data.

Analysis of Trips

Comparison of Trip Rates Computed from Total Trips

As stated in the introduction, the reliance on informants to report trip information of non-informant members of their respective households presented the possibility for the incorrect reporting of trips. To investigate this, estimates of person trip-rates for these two categories of respondents were computed. The obtained estimates for informants and non-informants were 2.818 and 2.235 trips/person respectively, indicating a significant difference between reported trips made per person by members of the two respondent categories. This difference in trip-rates, however, could be due to:

1. differences in the personal characteristics of members of the two groups; and/or
2. Informants giving incorrect information on the trips made by the non-informant members of their households.

Where the trip-rates are different primarily because of the differences in personal characteristics of members of the two groups, then under-reporting of trips by informants is not an issue. However, where informants forget to report some of the trips made by non-informants and/or do not report trips for some purposes, either for lack of complete knowledge of the trips made by non-informants, or deliberately so, then this leads to trips being under-reported. A bias could exist in the data if the under-reporting is different for different trip-purposes and/or different groups of people.

The remainder of the paper details the investigation into this one source of possible bias, and develops factors for adjusting the subgroups of underreported trip-data.

Analysis of Trip Rates

One-way cross-tabulations were performed to give insight into the data, and to yield directions on how to proceed with the rest of the analysis. Essentially, this involved:

1. Stratifying the trip-data by a trip-attribute (purpose, mode, length, time of day), or a socioeconomic attribute (vehicles available to household, employment status, driver license status, etc.) or a demographic attribute (age, gender); and
2. Stratifying the segmented trip-data from step (1) by respondent-status, that is, informant or non-informant, and then computing the person trip-rates for these two respondent categories.

Table 1 presents the estimated trip-rates for the two respondent categories, informants and non-informants, after stratifying the travel data by trip-purpose. Home-based work (HBW) and home-based school (HBS) trip-rates were found to be similar across the two respondent-status categories, while home-based discretionary (HBD), and non home-based (NHB) trip-rates for informants and non-informants respectively were found to be significantly different. The similarity in trip-rates for informants and non-informants for the trip-purposes of work and school are not surprising since trips undertaken for these two purposes are generally repetitive and, are therefore more easily remembered.

Table 1. Trip-Rate by Trip Purpose (trips per person)

Respondent Status	Home-Based Work	Home-Based School	Home Based Discretionary	Non Home-Based
Informant	1.462	1.747	1.264	0.558
Non-Informant	1.492	1.783	0.766	0.247

Table 2 presents the estimated trip-rates for the two respondent categories, that is, informants and non-informants, after stratifying the travel data by mode used for the trip. Across modes, significant differences exist between corresponding trip-rates for informants and non-informants for the auto modes (e.g., 2.070 versus 1.230 trips/person), and modes categorized as "other". However, estimated transit trip-rates for informants and non-informants are similar (0.310 versus 0.313 trips/person respectively).

Table 2. Trip-Rate by Mode (trips per person)

Respondent Status	Auto-Driver	Auto-Passenger	Public Transport	Other
Informant	2.070	0.310	0.310	0.128
Non-Informant	1.230	0.481	0.313	0.211

Table 3 presents estimates of person trip-rates for the two respondent categories after stratification by period of time trip was initiated. Trip rates for informants and non-informants in the morning peak-period (6am - 9am) are similar (0.539 and 0.564 trips/person respectively). This is expected since the morning peak-period is dominated by work- and school-trips, which as stated earlier, are both repetitive and therefore easily remembered. However, trip-rates for these two respondent categories in the other time-periods indicated in the table are different, the percentage difference in corresponding trip-rates being largest for the off-peak periods (9am - 3:30pm, and 6:30pm - 9pm). Again, this is expected since the off-peak period is dominated by travel for discretionary purposes.

Table 3: Trip-Rate by Reported Time of Start of Trip (trips per person)

Respondent Status	6am – 9am	9am – 3:30pm	3:30pm – 6:30pm	6:30pm – 9pm
Informant	0.539	0.922	0.794	0.353
Non-Informant	0.564	0.568	0.645	0.270

Details of other one-way cross-tabulation results based on stratification by a trip characteristic can be found in [Badoe, 1998].

Tables 4 and 5 show estimated trip-rates for informants and non-informants after stratification of the travel data by household vehicle availability, and driver license status of person respectively. In households without a vehicle (Table 4), estimated trip-rates for the two respondent categories are comparable (1.471 trip/person versus 1.594 trips/person). However, for persons residing in households with at least a vehicle available, there is a significant difference between the corresponding estimated trip-rates for informants and that for non-informants. In single vehicle households, informant trip-rate is 2.795 trips/person, while the non-informant trip-rate is 2.087 trips/person. Similarly, in households with two or more vehicles, the informant trip-

Table 4: Person Trip-Rates by Household Vehicle Availability (trips per person)

Respondent Status	0-Vehicle Household	1-Vehicle Household	2^{+}-Vehicle Household
Informant	1.594	2.795	3.265
Non-Informant	1.471	2.087	2.396

Table 5: Person Trip-Rates by Driver License Status (trips per person)

Respondent Status	Non Driver License Holder	Driver License Holder
Informant	1.551	3.081
Non-Informant	1.811	2.433

rate is 3.265 trips/person, while that for non-informants is 2.396 trips/person. This suggests possible interaction between household vehicle availability and trip underreporting.

Estimated person trip-rates for informants and non-informants not possessing a driver's license (Table 5), are quite comparable (1.551 trips/person versus 1.811 trips/person). By contrast, estimated person trip-rates for the two respondent categories for those in possession of a driver's license are quite different (3.081 trips/person versus 2.433 trips/person), again suggesting interaction between this variable and trip underreporting.

Comparison of person trip-rates for informants/non-informants, following stratification by other socioeconomic and demographic attributes respectively, indicated most of the variables to be possibly associated with trip under-reporting, albeit to different degrees [Badoe, 1998].

In sum, the one-way cross-tabulation analysis suggested that trips be stratified by purpose and by mode and trip-length prior to any further analysis. Further, since nearly each socioeconomic or demographic variable investigated appeared to have some association with the differences in estimated trip-rates, a multivariate analysis, which would consider all the variables simultaneously, appeared necessary to isolate those that had statistically significant association with trip-underreporting.

Analysis of Variance of Trips Stratified by Purpose

The analysis in the preceding section showed several variables to be associated with the underreporting of trips. However, as stated above, there are likely to be interactions among some of these trip-maker, trip, and household attributes, which imply that the potential impact of some variables might be revealed only after other variables have been considered. Thus the contribution of each attribute towards explaining the variation in the reported trips made by each person should be assessed simultaneously with all the other attributes, that is, within a multivariate framework.

The results of the one-way cross tabulations suggested that the subsequent statistical analysis be performed using the trip-data after stratification by trip-purpose, that is, on home-based work trips, home-based school trips, home-based discretionary trips and non-home based trips. They also suggested analyzing the data by mode as well as trip-length.

The tool used to investigate the variation in reported person-trips as a function of the trip-makers' socioeconomic, demographic and trip characteristics is Analysis of Variance (ANOVA) procedure implemented within the General Linear Model framework in SAS (SAS is a commercially available statistical package).

Two conditions were used to guide the interpretation of the ANOVA results from SAS. First, the primary interest was with the statistical significance of the respondent-status variable and the interaction terms involving the respondent-status variable with the other trip-maker characteristics. Second, for practical reasons, the objective was to keep the number of subgroups that would be selected for adjustment for trip underreporting to be reasonably small. Thus not all necessarily identified statistically significant interaction terms were pursued. To help identify the subgroups that would be adjusted for underreporting, the proportion of explained variation given by the hypothesized model and, more importantly, the F-values of the interaction terms involving the respondent-status variable were examined. In particular, the interaction term involving the respondent-status variable with the largest F-value that exceeded the critical value was selected for development of adjustment factors for the data.

Figure 1 illustrates in a simple "tree-diagram" the overall results from implementing the analysis of variance procedure using trip-data of the subgroups specified in the figure (the models are not presented here

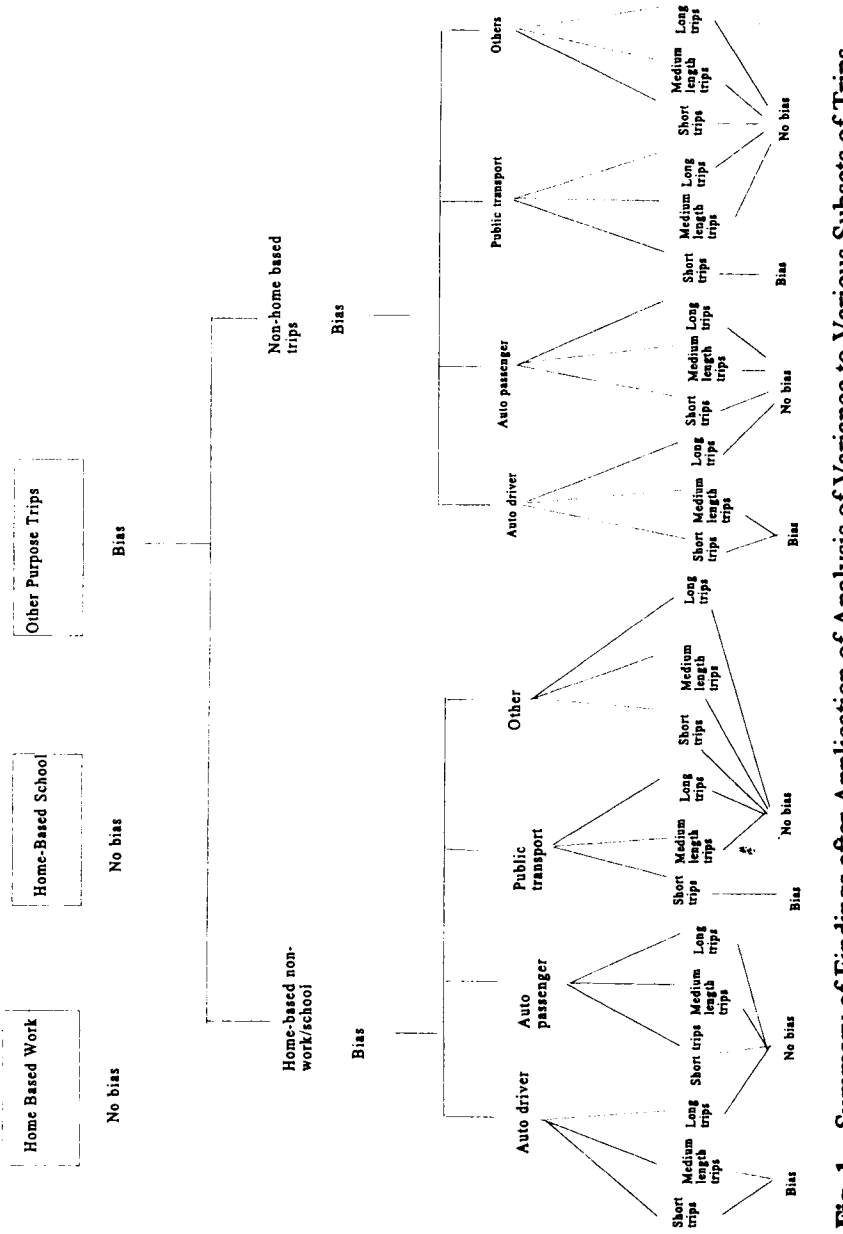

Fig. 1. Summary of Findings after Application of Analysis of Variance to Various Subsets of Trips

since they are numerous). Using a 5% significance level criterion, the results indicated that the respondent status variable did not contribute significantly to explaining the variation in trips for home-based school and home-based work trips respectively. Hence these two categories are classified as "not under-reported" due to reliance on informants for provision of travel information.

In the case of home-based discretionary and non-home based trips, however, the effect of the respondent status variable and its interaction with some of the other trip-maker variables were found to be significant at the 5% level. These two classes of trips were therefore retained for further analysis.

In the subsequent analysis, the HBD- and NHB-trips were each stratified by mode and trip-length, and the ANOVA procedure implemented using the resulting subgroups of trip-data. The second, third and fourth levels of the tree-diagram in Figure 1 show the final outcomes of this subsequent analysis as well. Three subgroups of trips from the home-based discretionary category and three subgroups from the non-home based category of trips were determined to require adjustment for under-reporting due to the use of informants. These are in the case of home-based discretionary trips:

(1) trips of short, and medium trip-length respectively made using the auto-driver mode; and,

(2) trips of short trip-length made using public transport.

In the case of non home- based trips, these are:

(1) trips of short, and medium trip-length respectively made using the auto-driver mode; and

(2) trips of short trip-length made using public transport.

These identified subgroups were in turn stratified by time-period in which trip was initiated (that is, morning peak-period, evening peak-period, or off-peak periods), and analysis of variance performed on the resulting data. For both trip-purposes the ANOV A results for the different trip start-time periods indicated that the auto-driver trips, identified to be under-reported, had to be stratified by the "driver-license status" variable prior to estimating adjustment factors for the underreporting of trips. In the case of transit trips that were under-reported, the analysis of variance results indicated that the trip data be stratified by the variable "vehicles available to the household" before estimating factors to adjust for the under-reporting of trips made in the different time periods.

Estimation of Factors to Adjust for Underreporting of Trips

The procedure for estimating factors to adjust the subgroups of trips made by non-informants, identified to be under-reported, was simply to bring the non-informant trip-rate to the level of the informant trip-rate in each of the under-reported trip-categories. Thus, adjustment factors, defined as the ratio of the informant trip-rate to the non-informant trip-rate in the under-reported trip-categories, were estimated. These factors were used to determine the additional number of trips required to raise the non-informant trip-rate to be equal to that for informants.

Table 6 lists the adjustment factors obtained. These range from a low of 1.072 to a high of 2.709 for home-based discretionary trips, and from a low of 1.078 to a high of 4.082 for non home-based trips.

The numeric figures in the table show that the adjustment factors for HBD and NHB trips of short trip-length made by auto are in all instances of larger magnitude than the corresponding adjustment factors for HBD and NHB trips of medium trip-length also made by auto. This suggests that the trips that tend to go unreported are often short, and perhaps for purposes not thought by the trip-maker or informant to be important enough to remember or report. Further, the factors for the morning peak-period are in general smaller than the factors for the periods in the post-morning peak, a not surprising result since most discretionary trips are made primarily outside the morning peak when the informant is relatively more unlikely to have complete knowledge of them.

Gender also has an important impact on the underreporting of non home-based trips of short length made by automobile during the afternoon-peak and evening off-peak periods. The factors obtained indicate that the level of underreporting is greater for females than for males, a reflection of the fact that females generally tend to undertake more discretionary trips on behalf of the household than their male counterparts (e.g. shopping, taking children to and from daycare, etc.).

The adjustment factors also show that the underreporting of transit trips is associated with household vehicle availability. Clearly, and as one would intuitively expect, the level of underreporting here is greater for households without a vehicle available than for households that have at least one vehicle available since people in the former category of households are comparatively much greater users of public transport. Interestingly, the adjustment factors for public transport are largest during the morning peak-period, when work-trips are dominant. However, it is within this same period that working-parents with young

Table 6: Summary of Factors for Adjusting Underreported Trips made by Non-Informants

Description of Subgroup of Trips	Additional Categorization		Start-Time Period of Trip	Adjustment Factor
Home-based discretionary trips of short trip-length, made by auto-driver mode	Person has a driver's license		6:00am – 9:00am	1.479
			9:00am – 3:30pm	1.910
			3:30pm – 6:30pm	1.774
			6:30pm – 9:00pm	1.603
Home-based discretion-ary trips of medium trip-length, made by auto-driver mode	Person has a driver's license		6:00am – 9:00am	1.246
			9:00am – 3:30pm	1.850
			3:30pm – 6:30pm	1.658
			6:30pm – 9:00pm	1.581
Home-based discretionary trips of short trip-length, made by public transport	No vehicle available		6:00am – 9:00am	2.709
			9:00am – 3:30pm	2.124
			3:30pm – 6:30pm	1.765
			6:30pm – 9:00pm	1.448
	One vehicle available		6:00am – 9:00am	1.807
			9:00am – 3:30pm	1.589
			3:30pm – 6:30pm	1.321
			6:30pm – 9:00pm	1.000
	Two or more vehicles available		6:00am – 9:00am	1.000
			9:00am – 3:30pm	1.072
			3:30pm – 6:30pm	1.159
			6:30pm – 9:00pm	1.361
Non home-based trips of short trip-length made by auto-driver mode	Person has a driver's license		6:00am – 9:00am	1.595
			9:00am – 3:30pm	2.938
	Gender	Male	3:30pm – 6:30pm	2.203
		Female	3:30pm – 6:30pm	3.467
		Male	6:30pm – 9:00pm	2.087
		Female	6:30pm – 9:00pm	3.732
Non home-based trips of medium trip-length, made by the auto-driver mode	Person has a driver's license		6:00am – 9:00am	1.374
			9:00am – 3:30pm	2.611
			3:30pm – 6:30pm	2.025
			6:30pm – 9:00pm	2.001
Non home-based trips of short trip-length, made by public transport	Zero vehicles available		6:00am – 9:00am	4.082
	One vehicle available		6:00am – 9:00am	1.117
	Two or more vehicles available		6:00am – 9:00am	1.379
	Driver license status	Yes	9:00am – 3:30pm	3.248
		No	9:00am – 3:30pm	3.431
	Zero vehicles available		3:30pm – 6:30pm	2.030
	One vehicle available		3:30pm – 6:30pm	1.288
	Two or more vehicles available		3:30pm – 6:30pm	1.078
	Zero vehicles available		6:30pm – 9:00pm	2.691
	One vehicle available		6:30pm – 9:00pm	1.281
	Two or more vehicles available		6:30pm – 9:00pm	1.000

children also undertake trips to either a day care, or caregiver.

The effect of applying each of these adjustment factors to the trip-records they correspond to is presented in Tables 7 and 8. These are reported at an aggregate level and by mode. Only the categories of trips adjusted for are shown. The results show a narrowing in the difference between modal trip-rates for informants and non-informants as a result of the adjustment process. Prior to adjustment, the home-based discretionary auto-driver trip-rate for informants and non-informants were 0.847 and 0.407 respectively. After adjustment, these figures were 0.847 and 0.684 respectively. Similarly, for non-home based trips, the auto-driver trip-rate prior to adjustment was 0.434 and 0.157 for informants and non-informants respectively. After adjustment, these rates are 0.434 and 0.360 for informants and non-informants respectively.

The impact of the adjustment process on total trips by transit was somewhat minimal (Tables 8 and 9) notwithstanding that some of the adjustment factors were large in magnitude. This is because overall transit share of home-based discretionary trips and non home-based trips made during the off- peak hours, when transit service is generally poor, are comparably low. Thus, application of the adjustment factor does not translate into any large changes in the patronage numbers.

Comparison of Corrected and Expanded Trips with Screen-Line Counts

Table 9 presents the percentage difference between assigned-vehicular volumes and screen-line counts. These screen line counts were done in 1995 hence strictly speaking the numbers are not applicable. Nevertheless, they are used here since it was the only information available, and also the expectation was that the changes to the counts over the one-year period would not be large as to lead to different conclusions. The counts were taken over a 15-hour period, from 6:00 AM to 9:00 PM. The numbers indicate that for the morning and evening peak-periods, the traffic volumes from traffic assignment are in reasonably good agreement with the screen-line counts. In particular, the morning peak-period, which is dominated by trips for the repetitive purposes of work and school, has the smallest error. If the interest in planning were the peak-periods only then the effect of the adjustment process would be satisfactory. However, current legislation requires planning to provide amongst others, information on mobile emissions associated with a particular transport - land use system, which requires

Table 7. Home-Based Discretionary Trips made between 6am and 9pm, and Stratified by Mode – Before and After Applying Adjustment Factors

		Auto-Driver		Auto-Passenger		Public Transport		Other	
		Informant	Non-informant	Informant	Non-informant	Informant	Non-informant	Informant	Non-informant
	# of persons	2305044	2989511	2305044	2989511	2305044	2989511	2305044	2989511
Before adjustment	# of trips	1953217	1215995	333654	591163	187625	93317	54836	29418
	Trip-rate	0.847	0.407	0.145	0.198	0.081	0.031	0.024	0.010
After adjustment	# of trips	1953217	2045207	333654	591163	187625	125448	54836	29418
	Trip-rate	0.847	0.684	0.145	0.198	0.081	0.041	0.024	0.010
Change in # of trips			829212				32131		

Table 8. Non Home-Based Discretionary Trips made between 6am - 9pm, and Stratified by Mode – Before and After Applying Adjustment Factors

		Auto-Driver		Auto-Passenger		Public Transport		Other	
		Informant	Non-informant	Informant	Non-informant	Informant	Non-informant	Informant	Non-informant
	# of persons	2305044	2989511	2305044	2989511	2305044	2989511	2305044	2989511
Before adjustment	# of trips	1001500	469931	109834	163242	73856	44171	32476	21785
	trip-rate	0.434	0.157	0.048	0.055	0.032	0.015	0.014	0.007
After adjustment	# of trips	1001500	1075276	109834	163242	73856	72554	32476	21785
	trip-rate	0.434	0.360	0.048	0.055	0.032	0.024	0.014	0.007
Change in # of trips			605345				28383		

good information on trips made during both peak and off-peak periods. Quite concernedly, in the case of trips initiated during the off-peak periods, which are dominated by non-work, and non-school trips, significant differences exist, the volumes from traffic-assignment being much lower than the corresponding counts. Further analysis of travel during this period would be required to adjust for the indicated significant underreporting.

Table 9. Difference between Screen-Line Volumes Obtained from Assignment of Adjusted and Expanded 1996 TTS Data and Ground Counts for 1995

Boundary	Morning Peak-Period	Evening Peak-Period	Off-Peak Period
West Metropolitan Toronto Boundary	-0.72	-13.79	-28.86
North Metropolitan Toronto Boundary	-3.25	1.86	-26.64
East Metropolitan Toronto Boundary	7.53	3.40	-3.63

Comparing the numbers in Table 8, which reflect the level of trip under-reporting that exists in the 1996 data after adjustment for proxy interviewing, to the corresponding numbers for the 1986 TTS reported in Hassounah *et al* [1993], the 1996 TTS shows smaller magnitudes of error. Further, comparing the adjustment factors obtained in this study to those reported in Hassounah *et al* [1991], it is observed that for comparable groups, the factors obtained in this study are smaller in magnitude. For example, for HBD trips of short-length made using the automobile, the adjustment factors reported in Hassounah *et al* [1991] range from 1.404 to 3.625, while the factors obtained in this study for this same trip-subgroup range from 1.479 to 1.910. This would suggest that the improvements in the 1996 survey procedures translated to measurable improvement in the quality of data collected.

Counts have their sources of error as detailed by Hassounah *et al* [1993]. However, the instances of large percentage differences between the counts and assigned volumes suggest that there is still some under-

reporting of trips that has to be adjusted for. This, however, is beyond the scope of this paper.

Summary and Conclusions

The primary objective of this paper was to examine the issue of the underreporting of trips in telephone interview travel surveys resulting from reliance on informants to report the travel patterns of other members of their households. The data for the study was drawn from the 1996 TTS.

The paper adopted a multivariate statistical approach to investigate this issue. More specifically, the statistical tool used for the analysis was the Analysis of Variance technique as implemented within the General Linear Model framework in SAS, a commercial statistical package. This technique assesses the overall ability of the specified variables in a model to account for the variation in the reported trips made and also determines which of the specified variables in the model are statistically significant.

The study results led to the conclusion that home-based work and home-based school trips were not under-reported as a result of interviewing by proxy, a not surprising result given the almost daily repetitive nature of such trips. However, some segments of home-based discretionary and non-home based trips were significantly under-reported. These segments were primarily home-based discretionary and non home-based trips of short and medium trip-length made by car. Gender, driver license status, and household vehicle ownership were found to be strongly associated with the underreporting of trips in the above-mentioned categories and, therefore, estimated adjustment factors were dependent on the values these variables took.

A comparison of corresponding adjustment-factors for underreporting obtained in this study with those reported by Hassounah et al [1993] suggest that improvements in the survey procedures translated to improvement in the quality of data collected. However, notwithstanding this improvement in data quality there still appeared to be some additional incidence of trip-underreporting stemming from sources other than proxy interviewing. This was evidenced in the comparisons of assigned volumes with screen- line counts. This additional underreporting is of greatest significance in travel that takes place during the off-peak periods.

Given the overall level of underreporting encountered for travel during the off-peak periods, techniques aimed at enhancing trip-information recovery from informants should be devised. In this respect would-be informants, through the advance letter, could be encouraged to document the daily travel of their respective household-members in the week household is expected to be interviewed. Clearly this could be onerous on informants given that the interview could be conducted on anyone of five days in the week. However this period of "documentation" could be lessened if the household is given a shorter pre-specified "time-window" within which the interview would be conducted, e.g., plus minus a day of a date specified to a household.

Interviewers must do more to prod/encourage informants to actually ask and prod members of their respective households for details of their discretionary trips, particularly so when the non-informant has a driver's license and had a vehicle available for travel on the day for which trip information is sought.

The above suggestions could have implications for the time needed for the completion of an interview and hence on the overall size of sample that could be surveyed in a given time period with fixed resources. However it would likely improve upon the overall quality of information obtained.

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