RECENT INFORMATION ON THE UNDER-REPORTING OF TRIPS IN HOUSEHOLD TRAVEL SURVEYS

David Ashley, Sinclair Knight Merz, Melbourne, Australia

Tony Richardson, The Urban Transport Institute, Victoria, Australia

David Young, David Young Consulting, Auckland, New Zealand

ABSTRACT

As far back as the 1970s there was evidence of under-reporting of household travel in the travel diaries obtained in household surveys. In the past, such data was often collected by direct personal interview, but in recent years many household travel surveys in Australia and New Zealand have relied on self-completion questionnaires.

It has been speculated that this more cost-effective survey method suffers from greater household travel under-reporting and the purpose of this paper is to discuss the magnitude of travel under-reporting from some recent household travel surveys, and to examine ways in which this under-reporting can be corrected.

Various methods are used to establish the level of travel under-reporting and to correct for it, and these are fully explained.

Some limitations in comparing household travel diary data with field traffic counts are highlighted, bearing in mind that comparisons of different data sets require them to be wholly consistent in the definition and coverage of the outcomes being compared.

The paper ends with reflections on the implications of travel under-reporting for the balance that is sought in the design of household travel surveys between data quality, low cost and high response rates.

1. INTRODUCTION

The primary motivation for this paper is to remind transport modellers using household travel survey data of the potential for travel under-reporting in these surveys, noting that some of this "under-reporting" relates to travel that was not intended to be measured in a household travel survey (e.g. travel by non-residents and travel by commercial vehicles). The paper brings together some recent experience of travel under-reporting in Australia, New Zealand and elsewhere and describes methods of correcting for it. In doing so it highlights differences between these surveys in the extent of under-reporting and the correction methods utilised - which can be related to the trade-offs between data quality, data quantity and survey resources described below. Accounting for under-reporting is considered reasonably standard practice and the collation of recent experience in this paper provides a timely reminder of its potential and importance for surveyers and modellers.

In considering issues of non-reporting and non-response, one needs to view them in the context of the trade-offs inherent in the design and conduct of travel surveys between data quality, data quantity and survey resources. As described in Richardson, Ampt and Meyburg

(1995), and illustrated in Figure 1 below, one is continually balancing the trade-offs between these three variables, and within data quantity and quality there are further trade-offs. Of specific relevance to this paper, data quality is a function of the survey method chosen but also of the quality control and follow-up procedures applied to each survey method.

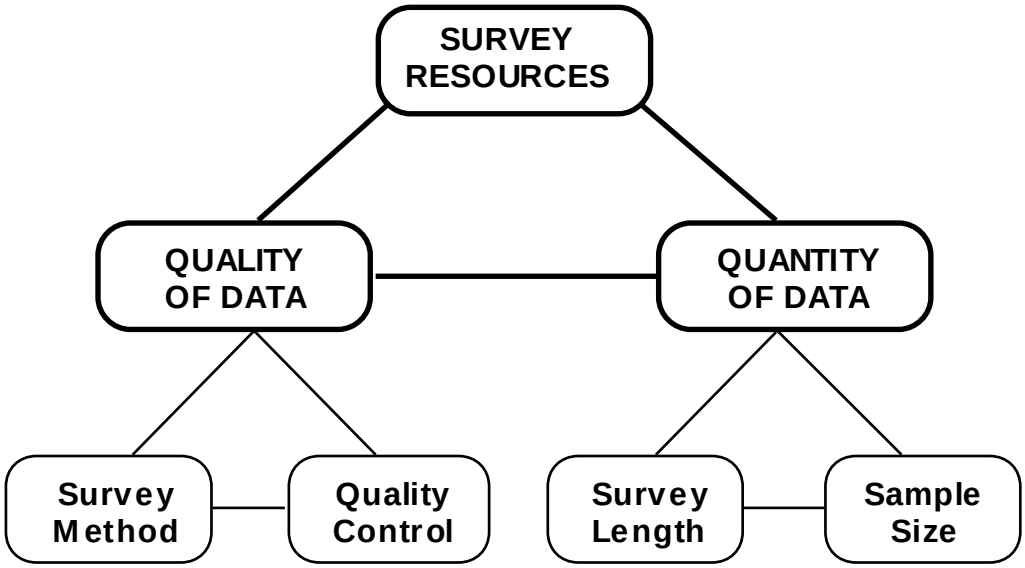

Figure 1 Trade-offs in Design and Conduct of Travel Surveys

As far back as the 1970s there has been evidence of under-reporting of household travel in the travel diaries obtained in household surveys. In the past, such data was often collected by direct personal interview, but in recent years most household travel surveys in Australia and New Zealand have relied on self-completion questionnaires. As this more cost-effective survey method suffers from a greater potential risk of travel under-reporting, as raised by Richardson and Ampt (1994), the issue is particularly relevant here. There have also been developments over recent decades in quality control and follow-up procedures to deal with identified under-reporting which are also relevant to this paper.

No doubt related to the continued reliance on household travel surveys internationally, there is a large amount of academic literature on the subject and many conferences are devoted to it. For those interested, we give a brief introduction to the literature at the beginning of the paper.

While our main interest is in current Australian and New Zealand experience of travel under-reporting in household surveys, it has proved difficult to obtain information on the performance of most of these surveys and on the quality of the secondary data sources used for comparison, and we have therefore enlarged the geographic coverage of the paper slightly to provide a greater range of evidence.

In the paper we also discuss the various methods which have been used to establish the level of travel under-reporting and we broadly document the ways of correcting for it (for greater detail, readers are referred to the relevant literature).

The paper ends with some reflections on the implications of travel under-reporting for the balance that is sought in the design of household travel surveys between data quality, low cost and high response rates.

2. UNIT AND ITEM NON-RESPONSE IN HOUSEHOLD TRAVEL SURVEYS

The literature classifies household survey expansion errors into non-reported data (or "item non response") and household non-response (or "unit non-response"). The latter is concerned with the bias introduced by households who choose not to respond to the survey at all. While corrections to a thus distorted sample can be made by disaggregating the sample weights by household and personal characteristics, the discussion in Richardson, Ampt and Meyburg (1995) also raises the issue that the non-responding households may have different travel behaviour to their responding equivalents.

In the American literature, non-response has been the subject of Transport Model Improvement Programme (TMIP) studies. A recent report (NCHRP, 2008) proposes standardised survey procedures and discussed both unit and item non-response. The issue of non-response corrections is highly relevant in US travel surveys, where responses rates are generally far lower than obtained in Australia, New Zealand or Europe. Concerning unit response bias, the report recommends the following variables should be used in tests for bias:

- household size;
- vehicle availability;
- household income (if collected);
- ethnicity of each person in the household;
- age of each person in the household; and
- gender of each person in the household.

More generally, Ampt and Bonsall (1997) provide a review of current issues in survey research, referencing the conferences that deal with survey issues and also those specifically focused on this topic. There is also a section devoted to the "problems of non-response".

The specific issue of trip under-reporting (one aspect of "item non-response") in household travel surveys is raised in Ortuzar and Willumsen (2001) under the heading "OD Survey Data Correction, Expansion and Validation" where the potential under-estimation of non-mandatory trips is raised. For self-completion surveys, one suggestion made therein is to collect additional validation travel data by direct personal interview, from which can be derived trip correction factors for the main, self-completion survey.

This method derives from Richardson, Ampt and Meyburg (1995), where the topic is dealt with under the heading "Corrections for Non-Reported Data". Here much evidence on travel under-reporting from earlier surveys in Europe is discussed and it is concluded that non-response rates vary by mode (it is more prevalent in non-motorised trips), trip purpose (affecting shopping and recreational trips particularly) and respondent characteristics. The section goes on to discuss in detail how validation surveys have been used to correct for under-reporting and how 'internal' data in self-completion surveys relating to proxy reporting and late completion of travel diaries can be used to reduce travel under-reporting.

In the literature and in international practice, there appear to be three general means of establishing trip under-reporting in travel diaries:

- based on "internal" analyses of biases within the HTS data set;
- using "validation data" specifically designed for the purpose;
- using independent sources of travel data.

The first of these methods is common in Australia and New Zealand where self-completion travel diary surveys have been used. The procedure reflects the expectation that travel will be

under-reported in two circumstances: (1) when the diary is filled in after the travel day (and trips are thus forgotten) and (2) when the travel diary for a person in the household is completed by another person (proxy reporting) who may not be aware of every trip made.

The analysis typically involves comparing diary trip rates for the above contexts with those for diaries completed on the travel day by the person making the trips. The resulting under-reporting weights may be disaggregated by trip and person characteristics. The examples of Auckland, Brisbane and Victoria are discussed below.

The second method involves duplicating the travel diary data collection for a sub-sample of the survey respondents, using methods which are either less susceptible to bias or are more rigorous than is applied in the main survey. The under-reporting levels are then established by comparing the trip rates for the main survey with those for the more rigorous method. In these methods the duplicate data is collected from persons/households who also respond to the main survey, enabling a direct, accurate assessment of under-reporting in the main survey to be made.

One example of this method is to contact a small subset of those responding to the main survey and re-check every component of their travel diary. Through this process unreported trips are identified and appropriate weighting factors can be inferred and applied to the whole sample. This method was used in the Victorian Activity & Travel Survey (VATS) during the 1990's, and has been reported in Richardson (2003). In that study it was found that trip rates obtained from the face-to-face interview with non-responding households was the same as the trip rate obtained from early respondents to the self-completion questionnaire, suggesting that the choice of survey method was not a cause of any perceived under-reporting in the self-completion survey.

Another example is the use of GPS data to track the selected persons through their daily trip making, and then compare the GPS results with the travel diary. This method was used in Sydney, California and Melbourne, as discussed below.

The third example would usually be required in any modelling exercise. This is to compare the trip matrices obtained directly from the household travel survey, or indirectly through a modelling exercise, with independent data such as traffic and public transport counts or intercept surveys. The examples of London, Christchurch and Auckland are discussed below.

In the second and third cases described above, household travel survey data is compared with other independent data sources. Here, the validity of the comparisons and the interpretation of the implications rest on the consistency and accuracy of these data sets. As GPS data and count data have their own specific biases, and these must be accounted for when making comparisons with the household travel survey data.

For example, GPS surveys suffer from loss of GPS signals at the start of trips which can mean that short trips may be unobserved entirely or that the duration of longer trips may be curtailed. GPS surveys also fail to directly measure the qualitative aspects of travel such as trip purpose and mode, and must be imputed from other data.

Similarly, traffic and public transport count data often includes elements of the total population that are not covered by household travel surveys, such as travel by non-residents of the region and travel by vehicle types not covered by the survey (e.g. commercial vehicles, especially vans which are difficult to categorise as household or commercial vehicles).

3. EVIDENCE OF TRAVEL UNDER-REPORTING IN INTERVIEWER APPLIED QUESTIONNAIRES

For UK city models, it has been common to use independent origin-destination (OD) data collection in the form of cordon and screenline intercept interview surveys to evaluate the extent of any trip under-reporting in household travel surveys. With the constraints on roadside interviewing in Australia and New Zealand and the lower focus on public transport intercept surveys in Australia, this is not common practice.

3.1. London

An example of the use of count data for comparison purposes is the validation of the 1991 London household travel survey (Meehan et al., 1994) consisting of 60,000 household face-to-face interviews.

The in-mode data used to validate the household travel survey consisted of roadside interview surveys at 850 sites around London and rail surveys collected by British Rail (for surface rail routes) and London Transport (on underground services) based on self-completion questionnaires handed out at the entries to stations. It is standard practice in London to collect in-mode data concurrently with household travel survey data every 10 years at the time of the national population census.

Meehan et al (1994) compared the travel patterns derived from the household travel survey with those from the in-mode data. The comparisons indicated overall car trip under-reporting in the HTS was small (about 6%), but was concentrated in the interpeak (15%) and evening (22%) and most affected the home based other (14%) and NHB (27%) trip purposes.

For rail, the HTS trips were under-reported for British Rail services by 11% but the under-reporting of 31% for London underground services was much higher. For the latter, the HTS under-reporting was greatest in the interpeak (45%). Bus trips were under-reported by 9% in the HTS.

In their paper, the authors show a considerable appreciation of the issues of consistency and coverage of the data sets with discussions of the differences between the surveys and the validity of the comparisons. For example, adjustments were made to account for different trip purpose definitions and all comparisons between the surveys were restricted to London residents' trips.

3.2. Sydney

In Sydney, Stopher et al (2005) used GPS data to validate the HTS travel diaries in 2003/4. A sub-sample of the households responding to the direct interview was also provided with in-vehicle GPS units and wearable GPS units. GPS data was thus obtained for one travel day of 118 persons from 70 households.

For this sub-sample of households the trip patterns reported in the travel diaries were compared with those measured by the GPS units. The overall HTS trip under-reporting was found to be 7%, seemingly comparable with the overall figures for London.

However, while overall under-reporting levels are relatively low in these two examples of interview-applied questionnaires, the London statistics appear to confirm what has long been

established: that the under-reporting rates may vary significantly by mode, purpose and time period and that for some segments travel under-reporting can be high, even with personal interview techniques. No similar disaggregate statistics are available for Sydney.

3.3. Melbourne

In Melbourne, Stopher and colleagues (PlanTrans, 2008) also used GPS data to collect data which they attempted to compare with travel survey data from the Victorian Integrated Survey of Travel and Activity in 2007 (VISTA07). Stopher concluded that there was "about 19% under-reporting of travel" in the VISTA07 diary survey compared to the GPS survey, when travel was measured in terms of Stops. Additionally, trip durations were found to be 10% higher in the VISTA diaries than in the GPS recordings, while trip distances were about 22% lower.

The GPS results reported by Stopher needed to be reconsidered in the light of three factors:

- the reported analysis was testing only a one-sided hypothesis (i.e. what travel was missing from VISTA) rather than a two-sided hypothesis (i.e. what travel was missing from both methods);
- the matching of VISTA and GPS Stops was not straightforward and was therefore a source of potential inconsistency; and
- the initial analysis was based on draft unweighted VISTA data.

For the above reasons, the GPS data was re-analysed in the final survey report (TUTI, 2009), using the most recent VISTA07 data. The analysis examined under-reporting in both data sets, i.e. travel not reported in VISTA07 that appeared in the GPS data, and travel that did not appear in the GPS data but was reported in the VISTA07 diaries.

An initial analysis of the GPS data, compared to the uncorrected VISTA07 data, showed that there may be about 12% under-reporting of Stops in the VISTA07 data (compared to 20% under-reporting of stops in the GPS data), 10% under-reporting of Travel Time in VISTA07 (c.f. 14% for GPS data) and 10% under-reporting of travel distance in VISTA07 (c.f. 7% for GPS data). The under-reported Stops are more likely to be Non-Home-Based Walk Stops, which are shorter in time and distance and slower than the Stops captured by both the GPS and VISTA07 data.

However, this initial comparison does not take account of two corrections made to the VISTS09 data as part of the overall data processing procedures:

- non-reported trip weights based on proxy reporting and time of diary completion (to be described more fully below); and
- trip distance adjustments based on streets actually use during trip, and using outputs from the RoadLink modelling analysis (McPherson, 1999)

After taking account of these corrections, and given the relatively small size of the GPS Pilot Survey (a total of a little over 300 matching stops from 85 respondents in the two databases), the Final Report concluded that the weighting and analysis procedures built into the VISTA07 survey accounted for any Non-Reported-Stops that might exist in the raw data collection procedures.

4. EVIDENCE OF TRAVEL UNDER-REPORTING IN SELF-COMPLETION QUESTIONNAIRES

A common viewpoint is that self-completion questionnaires are potentially more likely to suffer significant levels of travel under-reporting, as the following examples appear to demonstrate.

4.1. California

In the US, the Californian statewide household travel survey (Zmud and Wolf, 2003; NuStats, 2002) in 2000/1 of 17,000 households relied on telephone recruitment followed by a postal delivery of a self-completion travel diary and subsequent telephone interview (CATI) to retrieve the trip data recorded in the diary (note that this "self-completion" method is significantly different to that employed in recent years in Australia and New Zealand).

Validation data was additionally collected via GPS from 517 of these households, but only information from 292 households was complete. This related to 523 vehicles to which the GPS logger was attached. For these particular households, the GPS logger recorded 27% more trips than the CATI travel diaries.

However, the average trip rates in the CATI travel diaries for the sample of households monitored with a GPS data logger were much higher than those for the remaining unmonitored households in the statewide survey. It is suggested that the households involved in the GPS survey were more diligent in recording their travel data because of the independent measurements being taken, or that the demographics (and hence travel patterns) of those accepting the GPS were significantly different from those not accepting, or not offered, the GPS. As a result of this analysis, the car trips obtained in the CATI travel diaries were increased by 65% to account for travel under-reporting.

4.2. Brisbane

The South East Queensland Travel Survey (SEHTS) in 2004 was repeated in Brisbane in 2007. Initial comparisons showed significant reductions in average trip rates between 2004 and 2007. This problem was subsequently removed by correcting for non-reported stops in the household travel survey. The correction weights took account of the time delay for the travel diary to be completed and diaries filled in by proxy. The procedure involved developing additional trip weights which varied by the age and gender of the person and their mode of transport. Overall, these trip under-reporting weights increased the number of trips in the household travel survey by 15-20%, similar to the adjustments described above for VISTA07.

4.3. Christchurch

For the new Christchurch Transport Model (CTM), the 2006 data collection exercise included a household travel survey (CHATS06) supplemented by roadside interview (RSI) and public transport onboard surveys. The CHATS06 methodology was very similar to that employed in VISTA07 and SEQTS, using self-completion questionnaires with personal and phone contact by the survey company before, during and after the survey. A sample of call-back checks on the interviews was also undertaken. Model estimation was largely based on the CHATS06 data following adjustments to account for under-reporting, and some model components used the public transport onboard survey data.

After applying the "internal" factors relating to unrecorded stops in the expansion of the household travel survey (as described above for Brisbane), several further adjustments were made to the expanded CHATS06 trip data to account for under-reporting of light vehicle driver, light vehicle passenger and public transport passenger trips (we presume that the light vehicle category encompasses both cars and light commercial vehicles).

The level of trip under-recording in the CHATS06 data was inferred through a somewhat indirect procedure, as follows.

A best estimate set of light vehicle driver trip matrices (by time period) was determined by applying matrix estimation techniques to a set of prior trip matrices. These prior matrices by time period were created by combining the RSI vehicle matrices with CHATS06 vehicle trips for those parts of the matrix unobserved in the roadside survey.

The resulting best estimate light vehicle trip matrices were then compared with trip matrices derived solely from the CHATS06 data. These comparisons indicated an overall under-reporting level of 7.5% in the AM peak period.

As the AM peak consists of a large number of commuting and education trips (53% of all trips between 7am and 9am), it was assumed that for these purposes the 7.5% under-reporting would also apply to the other time periods. The remaining differences in the interpeak and PM peak period vehicle matrices were attributed to under-reporting of light vehicle trips for purposes other than commuting and education, giving under-reporting estimates for these other purposes of 44% in the interpeak and 25% in the PM peak.

The trips in CHATS06 were factored by the modellers to account for these assumed under-reporting levels.

For public transport trips, the CHATS06 and onboard surveys were compared, and various correction factors for the CHATS06 matrices deduced. However, the CHATS06 sample sizes for public transport trips were small, and it is doubtful whether significant conclusions can be drawn from the adjustments. Overall, however, there appears to be no evidence of significant under-reporting of public transport trips in the CHATS06 data.

Our description of the Christchurch situation perhaps illustrates the difficulties in interpreting comparisons of travel diary data with independently-derived traffic data sources. In developing models (and trip matrices), many assumptions need to be made in the development of best modelling estimates which make it difficult to interpret the outcomes with confidence. In this case the independent data is actually modelled data (using matrix estimation) and our understanding is that it includes travel by non-residents and light commercial vehicle trips, both of which are not covered in the household travel survey.

Consequently, it would not be valid to interpret the differences between the two data sets purely as "under-reporting" in the household travel diary.

4.4. Auckland

The development of the new Auckland Regional Transport model (ART3) was based on a household travel survey, plus passenger transport intercept and external cordon intercept surveys in 2006. The Auckland HTS (AHTS06) followed the same format as Christchurch (CHATS06): a self-completion questionnaire and personal and phone contact with the survey company. For the model estimation, the data from all three surveys was combined.

The modelling distinguished heavy commercial vehicles (HCVs), light commercial vehicles on commercial trips (commercial LCVs) and other light vehicles (cars and other LCVs).

Being based on matrix estimation techniques, the HCV matrices reproduced screenline counts well.

Light commercial vehicles on commercial trips (commercial LCVs) were distinguished (approximately) by observation in a sample of manual counts. The observed proportions of all light vehicles flows derived from the sample of count sites were transferred to the full set of automated counts to estimate commercial LCV traffic flows on all screenlines. As expected, the LCV employers' business (EB) trips observed in the household travel survey significantly under-estimated the observed commercial LCV counts (by approximately 50% in the peaks and 20% in the interpeak), because the AHTS06 survey specifically excluded such travel in the survey specifications. Appropriate correction factors were therefore incorporated in the trip matrices.

Finally, comparisons were made between the remaining modelled light vehicle matrices (comprising car and non-business LCV trips) and the classified counts. While the AM and PM peak period matrices were within 6% of the counts, the modelled interpeak matrices under-estimated the counts by 38%.

To investigate the reasons for this shortfall, the modellers assigned the same light vehicle matrices from the household travel surveys and again the shortfall in light vehicle trips was 38%, after the proxy reporting weights were included. These weights were by age and sex, and increased the interpeak light vehicle trips in the household travel survey by 6%.

In addition to the household travel survey, a major public transport intercept survey was undertaken in Auckland. Comparison of the public transport trips in the two surveys revealed a 25% shortfall in AHTS06 compared with the intercept surveys. The interview samples were too small in AHTS06 to permit analysis of the shortfall by time period and mode.

Like Christchurch, there are inconsistencies in these comparisons associated with modelling light vehicles and trucks and the contribution of non-residents' travel (although the latter would be expected to be small), affecting the interpretation of these traffic comparisons. In the case of public transport trips, the more important issue is that the estimates from the household travel survey are subject to significant uncertainty because of the small survey samples, for which reason the intercept surveys formed the basis of the modelling.

5. EVIDENCE OF TRAVEL UNDER-REPORTING IN HYBRID SELF-COMPLETION/INTERVIEW QUESTIONNAIRES (for Wellington)

For the development of the Wellington Regional Transport Model in 2002, SKM commissioned household travel surveys and rail intercept surveys.

The Wellington household travel survey is unusual in these examples in combining self-completion with direct interview techniques. As summarised in Table 1 below, in comparison with the Auckland survey, the household travel data (only) was collected through direct interview rather than by the self completion method used in Auckland. Additionally, and related to this, there was more direct contact of interviewees with the field staff, and

interviewer training and questionnaire checking procedures were more extensive in Wellington than Auckland.

Table 1 Household Travel Surveys in Auckland and Wellington Compared

Survey Procedures	Household Travel Survey	
	Wellington	**Auckland**
Field staff training	Interviewers were required to read training manual and submit a written test, and then attend 2 full days training in groups of no more than 10 interviewers.	1 full day training session for all field staff, plus 1-hour re-briefing at start of first shift for each field staff member.
Questionnaire delivery	In person. Respondents were requested to complete the Household questions. Memory jogger travel diaries were left with household.	Delivery in person attempted; otherwise, survey pack was left at address. 80% of households were contacted personally.
Questionnaire Collection	Interviewer attended the household in person to gather the travel diary data, working through the memory jogger. Interviewer then recorded the travel data on the travel section of the questionnaires.	Questionnaires were either collected personally from householders or the householder left the questionnaire outside for pick-up by the field staff at a pre-arranged location.
Field checking	Interviewer checked questionnaire. Then supervisors checked each interviewer's work.	Questionnaires checked for completeness in terms of the household and person questionnaires and travel diaries for each household member.
Editing	Logic checks made by trained coding staff and all queries returned to the field staff who made follow-up phone contact with respondents.	Households whose questionnaires failed automated logic and range checks were contacted if a phone number was available (as was almost always the case)

The household survey expansion process in Wellington corrected for sample bias (non-response) by applying additional household bias correction weights varying by household type (a function of the number of adults, working adults and children in the household), similar to the household and person expansion factors derived for Auckland.

In the initial studies, the car trip matrices derived from the survey were compared with forecast matrices for the same year from the previous version of the model, which validated well against traffic counts – across the screenlines there were 136,600 private vehicles in the household survey data and 125,700 vehicles in the existing model. Consistently, the new model developed from the HTS revealed no significant under-reporting of vehicle travel when compared with independent traffic counts on the cordons and screenlines in the region.

Direct comparisons of the rail trips in the HTS with those collected in the rail intercept surveys also revealed no under-reporting (Table 2) - the main trip purposes (work and education) were closely matched and, overall, the household survey reported more rail trips than were observed in the rail survey.

In summary, there was no evidence in Wellington of household travel survey under-reporting of trips.

Table 2 Comparison of rail Trips in the Household and Rail Intercept Surveys

Quantity	Household Survey	Rail Survey	Difference
HB Work	21,579	22,126	-2%
HB Education	5,441	5,317	+2%
Other Trips	11,327	4,637	+144%
All	38,347	32,079	+20%

6. HOW TO REDUCE AND CORRECT FOR TRAVEL UNDER-REPORTING IN SELF-COMPLETION HOUSEHOLD TRAVEL SURVEYS

Given the cost-effectiveness of self-completion questionnaire travel diaries within the trade-off situation described in Figure 1, in that they are able to maximise sample size and achieve acceptable quality levels within a given survey budget, it is likely that they will continue to be used. The challenge is to maximise the quality of the data collected by these surveys by the use of various quality control procedures to ensure that they record the travel data to an acceptable degree of completeness.

Some relatively inexpensive procedures can be employed to ensure that most travel is recorded, or at least any non-reported travel can be allowed for in the weighting and expansion process. In recent self-completion diary surveys conducted in Victoria, Queensland and New Zealand by The Urban Transport Institute, two specific procedures have been employed:

- clarification interviews (by phone) with respondents to obtain missing or inconsistent information recorded in the diaries
- non-reported trip weights, based on who completed the diary and when it was completed.

The Clarification Interviews are an attempt to obtain clarifications of inconsistent data from the respondents themselves, by phoning them during the data entry and editing process. These calls take place after the data enterers have already inserted some missing travel (especially access and egress trips to and from public transport, and trips home during and at the end of the day). The Clarification Calls are used to obtain information directly from the respondents when the missing information cannot reasonably be inferred. Theoretically, these Clarification calls could be extended to do a more complete re-interview, but this would not be suited to a phone interview and would also significantly increase the data editing cost.

The major procedure for accounting for non-reported trips is to correct for them in the weighting and expansion process. To this end, two specific questions are included in the self-completion surveys; who filled out the travel diary, and when was it filled out. In analysing this data, very similar results have been obtained across all the TUTI surveys and the VISTA07 results are produced below, although a previous paper (Richardson, 2006) has reported on the SEQTS surveys from 2003-04.

As shown in Figure 2, this percentage is not constant across the population of respondents. The highest proportion of proxy respondents was for children, who had their questionnaires completed for them by their parents (which is one of the reasons why the survey does not ask for completed diaries from children under the age of 5). While this level of proxy reporting may seem high, it is useful to compare it with the limited information published on proxy reporting in other travel surveys. Using data from the US National Household Travel Survey 2001 (a CATI survey), Wargelin and Kostyniuk (2004) report proxy response rates of 34% to

38% for persons over the age of 18. If the VISTA07 results were limited to those over 18, then the proxy reporting rate would only be 25%, and hence lower than that obtained by CATI.

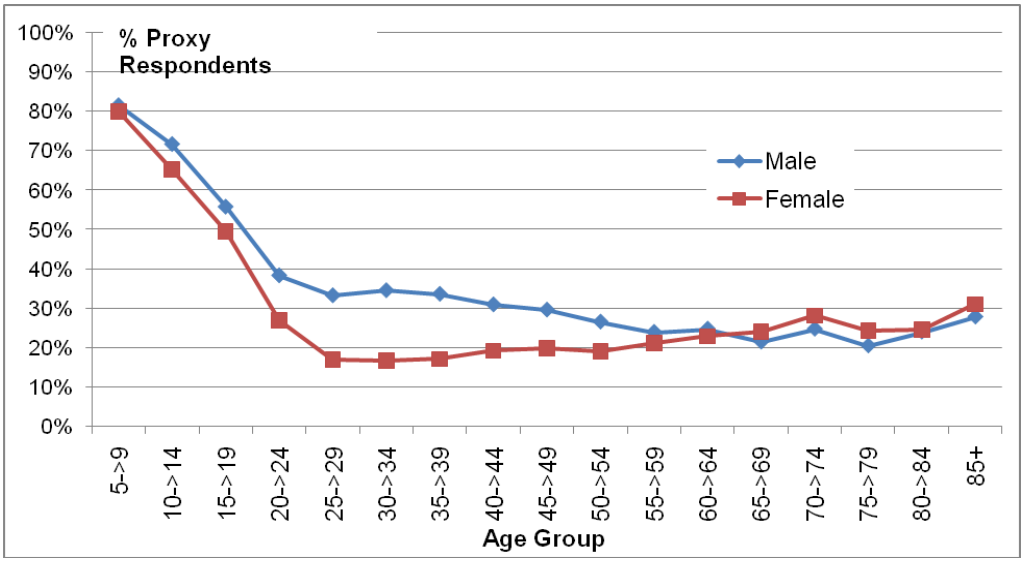

Figure 2 Proxy Reporting as a Function of Age and Gender

The timing of the completion of the Travel Diary, in relation to the Travel Day itself, is shown in Table 3. It can be seen that 54% of the diaries were completed on the Travel Day, 23% of the diaries were completed on the day after the Travel Day, and 23% were completed at some other time of the week (close to the time when the questionnaires were collected).

More of the Self-Reported diaries were completed on the Travel Day (57%) than those completed by proxy (47%), as shown in Figure 3. Apart from very young respondents (who were mostly proxy-reported), there was a tendency for more completion on the Travel day with increasing age.

On the basis of the analysis of the VISTA07 data on proxy reporting and time of completion, a set of Non-Reported Stop Weights was developed for the VISTA data based on age and gender of the respondent, whether the trip stage was home-based or non-home-based and on the modal grouping of the trip stage (car driver, car passenger, non-motorised, public transport and other). It was assumed that those who self-reported on the Travel Day would provide the best data with the least number of non-reported Stops, and the Stop rates of others within the same category were then related to the Stop rate of this group to derive a factor to be used to account for non-reported Stops. The complete set of weights is too extensive to be summarised here, but is included in the Final Report for the VISTA07 survey (TUTI, 2009).

Table 3 Timing of Completion of Travel Dairy

	Type of Reporting		
Time of Completing Diary	**Proxy**	**Self-Reported**	**TOTAL**
Completed on Travel Day	47%	57%	54%
Completed on day after Travel Day	25%	22%	23%
Completed at some other time	28%	21%	23%
TOTAL	100%	100%	100%

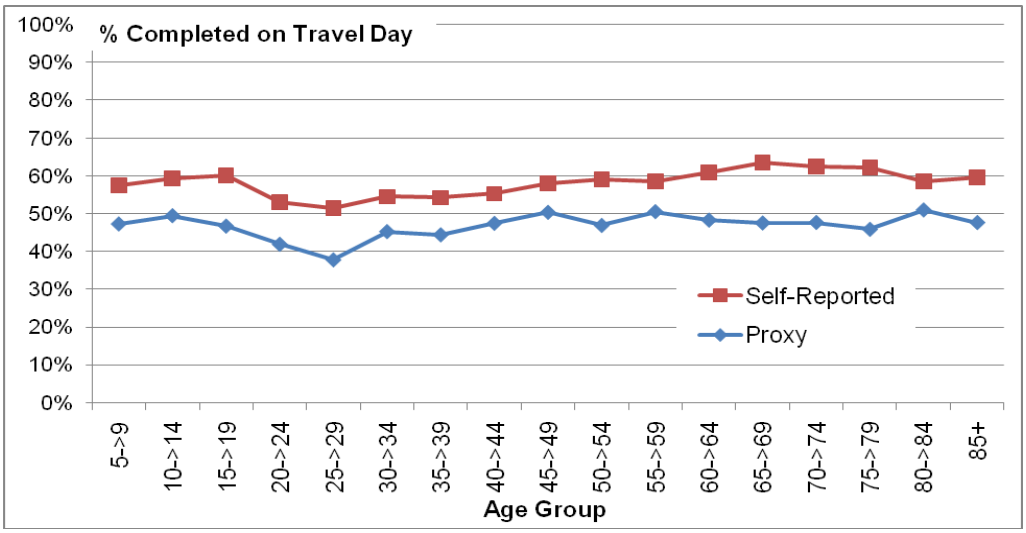

Figure 3 Delay in Completing Diary by Type of Reporting as a function of Age

The effectiveness of these Proxy Weights in accounting for non-reported trips is evidenced by the fact that they corrected for almost all the non-reported trips recorded in the parallel GPS survey that ran in parallel with VISTA07.

Having explained the inexpensive procedures which can be used to reduce the impacts of under-reporting, there are clearly other more expensive procedures that could be employed either to increase the proportion of trips that are recorded in the travel diary (especially short, non-motorised or discretionary trips). Using the examples which we have reviewed, these include:

- greater reliance on personal interviewing for the whole survey (as in Sydney), for the travel diary alone (such as Wellington) or for a designed sub-sample of the data as an independent check on the level of accuracy (as suggested by Ortuzar and Willumsen);
- the use of other survey methods such as GPS to develop sample evidence on under-reporting ("validation" data).

The additional expense of these procedures, within a given survey budget, would of course have implications for the achievable survey sample size.

7. COMMENTARY/CONCLUSIONS

The main purpose of our paper is to remind commissioners and users of household travel diary surveys that the trip-making outcomes obtained from any type of survey cannot simply be assumed to be accurate. This applies both to personal interview and self-completion methods, although the latter are possibly more susceptible to trip under-reporting. In addition, any secondary data used for comparison is also just an estimate of travel behaviour, with its own set of biases and limitations.

As we have argued, the apparent travel deficiency in the data used for modelling may stem not only from under-reporting in the household travel surveys but also from limitations in the coverage of the surveys, including omissions in regard to commercial vehicle travel (in which we include light commercial vehicles and utilities) and the travel by non-residents.

The ample literature on the subject confirms the importance of the topic and the evidence which we have assembled shows quite clearly that survey travel shortfalls for certain modes and segments can be high – see for example California, London, Christchurch and Auckland.

Generally, the information which we have assembled appears to confirm what was already known (and reported in the literature) – that the risk of travel under-reporting is likely to be most significant for short, non-motorised, discretionary trip purposes in the non-peak travel periods and greater for the more cost-effective self-completion questionnaire and CATI techniques than for direct interviews.

In this situation it is important that methods for correcting for such under-reporting are planned for and the necessary supplementary data collected. We have discussed some of the options for this in the paper under the headings of internal, validation and independent data.

Ultimately, the validation of a model system, and thus the household travel survey on which it is based, must be demonstrated against independent data. It is very evident from the examples we have discussed that comparisons between travel diary surveys (or the outputs of models based on them) and independent data serve an important purpose. They provide an overall indication of the quantity of travel not reported in, or not designed to be measured by, the diary survey and, as we have shown, this travel shortfall can be highly significant.

The examples also suggest that there is an issue to be considered over the extent and nature of the independent data which is collected. For example, while road traffic counts are generally universally available, with the increasing emphasis on public transport infrastructure in city strategies, the availability of public transport data for validation purposes becomes a bigger issue.

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