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**Missing and inaccurate  
information from travel  
surveys: Pilot results**

**By**

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**NUMBER:** Working Paper ITLS-WP-10-07

**TITLE:** **Missing and inaccurate information from travel surveys: Pilot results**

**ABSTRACT:** During the implementation of a major regional household travel survey, known as the Victorian Integrated Survey of Travel and Activity 2007 (VISTA07) in Victoria, Australia, a pilot survey was undertaken using GPS to validate the diary survey results, similar to a number of studies in North America and Europe. The pilot results suggest that, as has been reported in most overseas studies, respondents generally underreport their travel significantly. Further, it is also found that respondents tend to overestimate trip times and underestimate (seriously) the distance of their travel. It is also noted that there are a significant number of respondents whose reporting is quite accurate, whilst a minority report significantly different information from what the GPS measures. However, a result found in this study that has not been reported before is that there is a very significant difference between the accuracy of reports from those asked to carry a GPS and those who were not asked to do so. This result suggests that the levels of underreporting of travel found in previous studies may be underestimated to a greater extent than previously believed particularly when one considers that VISTA07 uses a face-to-face recruitment methodology. It must be noted, however, that this was a pilot survey and that the sample size is too small to generalise the conclusions, which should not be used to scale any VISTA07 results.

**KEY WORDS:** *Travel surveys, transport, GPS applications, trip analysis*

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## 1. Introduction

The purpose of this study was to undertake a pilot study in which some of the households that agreed to undertake the Victoria Integrated Survey of Travel and Activities (VISTA07) of 2007-8 were recruited to also carry Global Positioning System (GPS) devices with them for the week that included the VISTA07 diary day. As has been done a number of times elsewhere (Wolf et al., 2003; Forrest and Pearson, 2005; Bradley et al., 2005; Wolf, 2006; Bricka and Bhat, 2006; Stopher et al., 2007a), the idea was to use the GPS records to validate the self-reporting of travel in the VISTA07 diaries. This study was designed as a pilot study, to determine the feasibility of undertaking such a GPS validation in the context of VISTA07 and also to determine whether there was evidence of underreporting of travel and misreporting of travel times and start and end times, as has been found in other surveys elsewhere.

Fieldwork for the GPS validation pilot commenced in early June about two weeks after commencement of the fieldwork for VISTA07, allowing time for the fieldwork procedures for VISTA07 to be settled in prior to adding the recruitment of GPS households. It was intended that the GPS survey should take place over about 6 weeks, although one additional week was required to ensure that the target of 50 complete households was reached in the GPS pilot. This paper documents the results of recruitment and response by households, the resulting data, and the analyses that were conducted on these data with a view to understanding how well people report their travel in the VISTA07 self-report diaries.

## 2. Survey process

### 2.1 *Recruitment of households for the GPS pilot survey*

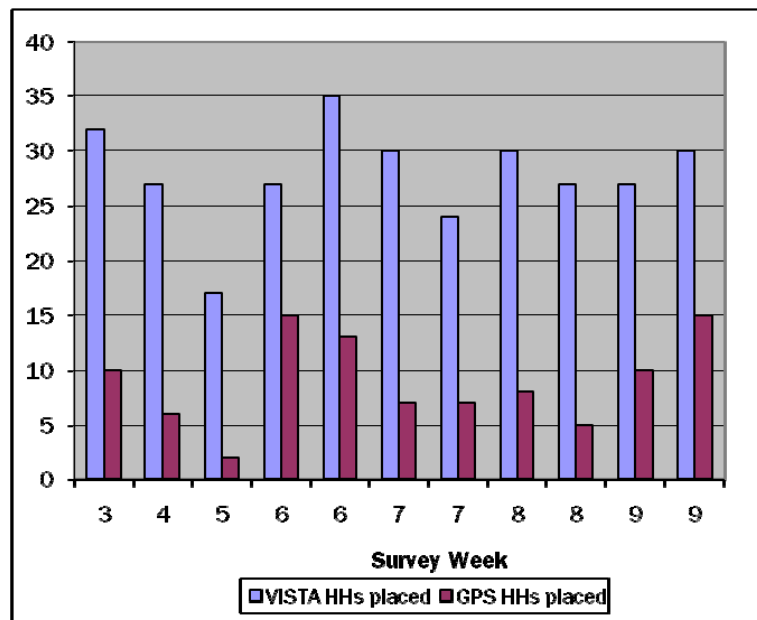
The VISTA07 survey was conducted by having interviewers recruit households by a visit to the household address, discuss the survey and leave self-completion forms for the household to fill out. A day within the next week was assigned as the travel day for purposes of the VISTA07 survey. Recruited households were then to be visited following the travel day, when completed forms would be picked up. If interviewers were unsuccessful in picking up forms on the return visit, a mailing envelope was left for respondents to use to return the surveys. After a household agreed to participate in VISTA07, the representative of the household was asked if the household would also be willing to undertake a week-long GPS survey. It was made clear that this would be in addition to the VISTA07 survey and that the household was under no obligation to accept the GPS survey. If the household was willing to undertake the GPS survey, or asked for further clarification, the interviewer explained the conduct of the survey and that it involved each member of the household 14 years old and over to take and use a small GPS device for the coming week, carrying it with them wherever they travel. It was also explained that the devices would be collected by the interviewer at the time of his or her return to collect the main VISTA07 survey materials. Arrangements were made, however, to leave a courier envelope and label at any household where collection of the devices was not possible by the interviewer on the following weekend.

The pilot GPS survey was targeted into specific suburbs during the third through ninth weekends of the main survey. Each suburb for each weekend was targeted for 42 households to be attempted. The take-up rate for the GPS element of the survey varied from a low of 12 percent to a high of 56 percent. Differences appeared to be due partly to the sociodemographic make up of households in the targeted suburbs, partly to the experience of the interviewers, and in the case of the suburb in week 5 simply bad timing (primarily student households during final examination week). The average take-up rate was 32 percent, which was about the expected level. Table 1 summarises the results of recruitment for the GPS survey. In some cases, the week number appears twice, because two different suburbs were targeted on those weekends.

As can be seen from Table 1, in no week were the 42 recruited households achieved and the recruitment of GPS households was often influenced by the success rate of overall recruiting. In week 8, it should be noted there were only about 30 GPS devices available, so that the recruitment rates are artificially lower for the two suburbs, because recruiting stopped when most of the devices had been assigned. Figure 1 illustrates the comparative recruitment rates by week from Table 1.

VISTA07 Survey Week	3	4	5	6	6	7	7	8	8	9	9	Total
Delivery Dates	9-10 Jun	16-17 Jun	23-24 Jun	30 Jun - 1 Jul	30 Jun - 1 Jul	7-8 Jul	7-8 Jul	14-15 Jul	14-15 Jul	21-22 Jul	21-22 Jul	
VISTA07 HHs placed	32	27	17	27	35	30	24	30	27	27	30	306
GPS HHs placed	10	6	2	15	13	7	7	8	5	10	15	98
Take-up rate	31%	22%	12%	56%	37%	23%	29%	27%	19%	37%	50%	32%
GPS units placed	19	17	3	30	21	16	10	17	10	22	20	185

*Table 1: Results of GPS fieldwork*



*Figure 1: Recruitment of VISTA07 and GPS households by suburb*

## 2.2 Compliance with the requested GPS task

For this survey, the aim was to obtain 50 complete households, where a complete household for the GPS survey was defined as all household members over the age of 14 completing the GPS survey (a complete household might not necessarily complete VISTA07 diaries or may only partially complete the diaries.) In fact, 58 complete households were obtained, together with 18 partially complete households. As in all surveys, people will often agree to do the survey, but then not complete it. In the case of a GPS survey, there are two possible non-compliance actions. In the first, the individual does not use the device. In the second, the device is used, but is left at home, intentionally or not, on the diary day. Compliance results are shown in Table 2, (in the same format as Table 1).

For the 18 partial completions, one or more members of the household, given a GPS device, complied with the survey, while the other member or members of the household did not comply on the diary day. There were no households in the sample where the entire household did not travel on the diary day. The rate of no travel days of 15 among 137 individuals is an acceptable rate, since it is generally expected that this should lie between 5 and 20 percent for data that include weekends and weekdays. The only days counted as no travel days were ones where the GPS had no data on the travel day and the diary also indicated no travel on the travel day. Households were also asked to complete a form to indicate if they forgot to take the device with them on any day, and if any days were no travel days. Although a number claimed a no travel day, if there was diary data reported for the travel day, this was not counted as a no travel day. There were several such occurrences in this sample. If there was no data on the GPS for the travel day, and there was no diary, then this was assumed to be a no travel day.

VISTA07 Survey Week	3	4	5	6	6	7	7	8	8	9	9	Total
GPS HHs placed	10	6	2	15	13	7	7	8	5	10	15	98
GPS units placed	19	17	3	30	21	16	10	17	10	22	20	185
Complete Households	8	3	2	10	6	4	2	8	2	9	4	58
Partially Complete Households	0	1	0	2	4	1	2	0	1	3	4	18
GPS Devices with Data/No Travel Days	17	12	3	19	19	12	4	17	6	14	14	137
No Travel Days	1	9	0	1	2	1	0	1	0	0	0	15 (10.9%)

**Table 2: Compliance with the GPS task**

From Table 2, it can be seen that there is substantial variation by location in completion of the GPS task. Figure 2 illustrates the completion of the GPS survey by households, while Figure 3 shows completion by individuals and the incidence of no travel days.

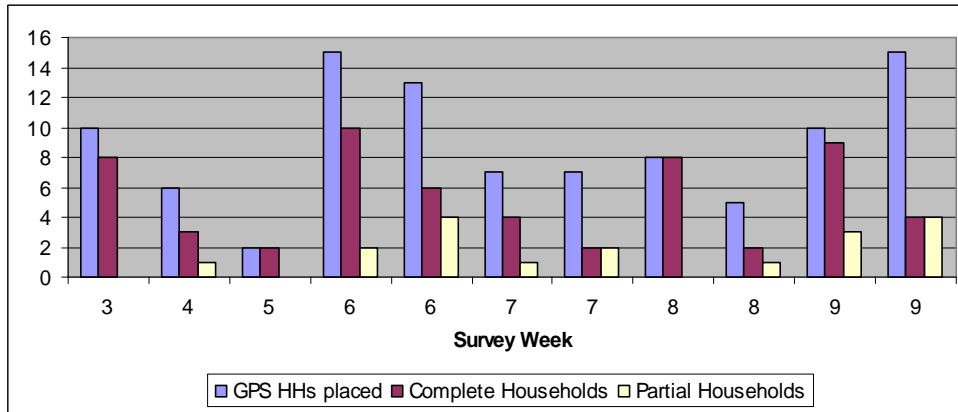


Figure 2: Household completion of GPS survey

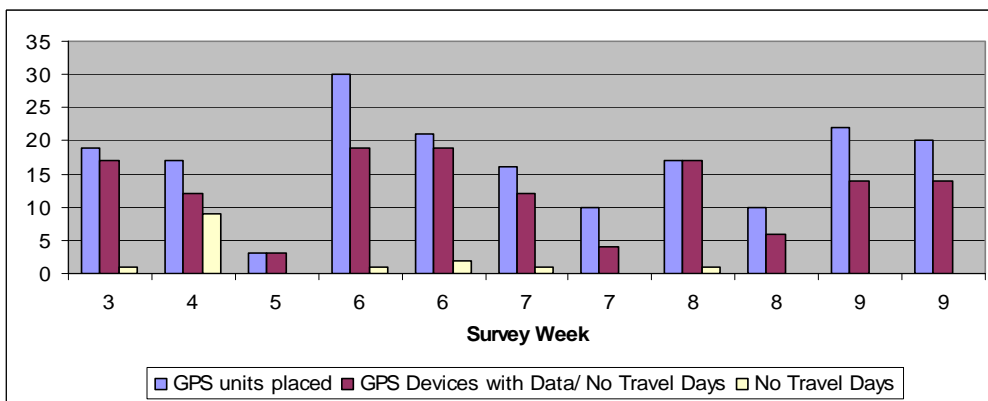


Figure 3: Individual completion of GPS survey

Overall, 76 households of the 98 recruited provided full or partial completion of the GPS task, representing 77.6 percent of recruited households. Of those, 58 provided complete responses, representing 59.2 percent. Of the 185 devices distributed to households, 137 were returned with data, representing 74 percent of the distributed devices. These are high compliance rates for a GPS survey.

### 3. Comparison of GPS and diary records

This section of the paper provides a brief summary of comparisons between the VISTA07 diary data and GPS data.

#### 3.1 Trip reporting

From the 58 households that provided complete information, there were complete person days of data for diary days. However, there are useable data from a further 38 devices from partial households. For seven people, there was a complete mismatch between what the GPS recorded and what was filled out in the trip diaries. These seven people recorded 40 trips in their diaries for the diary day, with an average travel time of 14.8 minutes. The GPS recorded 29 completely different trips (by time and location) with an average duration of 19.4 minutes. After checking the data for some of these individuals, in some cases, no correspondence was found between the diary trips and any of the days for which the GPS had been used. In one case, however, a substantial group of the trips reported in the diary for Tuesday appeared in the GPS record for Thursday, suggesting that this person may either have filled out the diary sometime after the diary day and telescoped the travel during the preceding

week, or had intentionally reported Thursday instead of Tuesday, Tuesday being their assigned diary day.

Nine people left diaries blank or refused to complete the diaries, but used the GPS devices. These nine people made 42 trips, averaging 18.5 minutes in duration, for a total of 777.8 missing minutes of travel. Sixteen people did not provide GPS data. These 16 people, according to their diaries, made 75 trips, averaging 16.3 minutes each in duration for a total of 122.5 minutes of travel missing. Eleven individuals claimed not to travel on the diary day and had no recorded travel on their GPS devices, and another four had no trips on the diary day either on their GPS or in their diaries and are therefore assumed to have not travelled on the diary day.

There were 113 people for whom comparisons can be made between GPS and diary data (137, minus 15 with no travel on the diary day, minus nine with no diary data for the diary day). Seven of these had a complete mismatch between diary data and GPS data, leaving 106 people for whom comparisons could be made. For those 106 persons, there were 434 stops that matched between GPS and diary. This is an average of 4.10 stops per person. However, for these same 106 people, the GPS showed an additional 105 trips that were not reported in the diary. A few of these (about seven) represent cases where the individual reported a single stop in the diary, where the GPS identifies that there was a break in the trip, such that it should have been reported as two separate stops. For the 434 matching stops, the average trip length is 17.1 minutes, while for the 105 missed stops, the average trip length is 16.3 minutes, which is not much different than the matched trips. This implies that, unlike results from some previous studies (e.g., Forrest and Pearson, 2005; Wolf, 2006), the trips that are missed from the diary but reported by the GPS are not necessarily much shorter trips than average. They are, in fact, on average, only five percent shorter. A summary of these trip statistics is provided in Table 3.

Source	Count	Number of Stops		Average Time		Average Distance	
		GPS	Diary	GPS	Diary	GPS	Diary
GPS Devices with Data	137	-	-	-	-	-	-
Complete Mismatch	7	29	40	19.4	14.8	-	-
Diaries Refused/Blank	9	42	0	18.5	-	12.1	-
GPS not used	16	0	75	-	16.3	-	5.5
Claimed No Travel Day	11	0	0	-	-	-	-
Valid Comparisons	105	-	-	-	-	-	-
Total Diary Trips	-	-	565	-	18.3	-	7.04
Total GPS Trips	-	539	-	16.9	-	9.0	-
Matched Diary-GPS Trips	-	434	434	17.1	18.9	9.5	7.8
GPS Only	-	105	-	16.3	-	6.6	-
Diary Only	-	-	131	-	16.4	-	4.7
Missed Diary Trips -- Car	-	56	0	18.4	-	10.9	-
Missed Diary Trips -- Bus	-	3	0	4.9	-	1.8	-
Missed Diary Trips -- Rail	-	3	0	8.2	-	5.9	-
Missed Diary Trips ~ Walk	-	43	0	14.9	-	1.4	-

*Table 3: Results of comparison of diary and GPS stops*

There are also stops that were missed by the GPS but reported in the diaries. In many cases, these are stops at the beginning of the day, often not very long; stops in the middle of the day, where it appears that the device may have been left at work or home, whilst the person travelled, and stops at the end of the day, when it seems clear that the individual did not take the device with them. The trips from these stops average 16.4 minutes, which is similar to the trips missed out of the diaries and total 131 in number. However, these trips are not relevant to the issue of checking diaries with GPS.

From this analysis, it appears that the underreporting of travel, based on the GPS is 18.6 percent ( $= 105/(434+131)$ ), which accords with experience in the USA for GPS validation of CATI surveys (Forrest and Pearson, 2005; Wolf, 2006; Bricka and Bhat, 2006), although the sample size in this pilot is too small from which to draw statistically significant conclusions. Unlike those validations, however, the average trip length of the missed trips is only five percent less than the average trip length of the trips that match. There are 35 individuals for whom the trips recorded in the GPS match the trips recorded in the diary. In addition, the 15 people who indicated a no travel day also match between the GPS and the diary. Thus, from 128 people (137 minus those who did not complete diaries) who provided GPS data that could be compared, 50 provided an exact match, while 78 did not. Further, for these 128 people, we have a count of 434 matching trips, 131 recorded in the diaries that were not recorded by the GPS, 106 that were recorded by the GPS and not by the diaries, plus 69 trips that represented a complete mismatch between the diary and the GPS. For this last group – the complete mismatch – it cannot be said how many trips these individuals probably made on the diary day. As a result, to estimate an average trip rate, these seven individuals should be excluded. This would mean that there are 121 people who apparently made 670 trips, of which 565 were recorded in the diaries. The average trip rate estimated from the diary survey alone would be 4.67 trips per person per day, whereas, with the addition of the GPS trips, it would be 5.54 trips per person per day, an increase of 18.6 percent. These results are summarised in Table 4.

Description	Count
Persons with both GPS and Diary Data	128
Number of Complete Mismatches between Diary and GPS	7
Number of Valid Comparisons	121
Number of Exact Matches between Diary and GPS	50
Number of Matching Trips between Diary and GPS	434
Number of Trips recorded by GPS and not Diary	106
Number of Trips recorded in Diaries and not by GPS	131
Total Trips by Diary and GPS	671
Number of Trips recorded by Diary	565
Average Trip Rate by Diary (trips per day)	4.67
Average Trip Rate by Diary and GPS (trips per day)	5.54
Underreporting by Diary (trips per day)	0.87
Underreporting as Percent of Diary Trips	18.6%

*Table 4: Analysis of trip misreporting*



### 3.2 *Travel mode, purpose, speed, time, and distance*

It is useful to analyse the trips that were recorded by GPS but omitted from the diaries by mode and purpose. Using the addresses provided by respondents, and GIS data on transport networks and land use, software procedures (Stopher et al., 2007b) were used to estimate the mode of travel and the trip purpose for the GPS trips. As a calibration step, a comparison was made between the mode and purpose results for matched trips, comparing the results from the VISTA07 diaries with the results of the programs for mode and purpose on the GPS trips. The results of this calibration showed that about 10 percent of trips were mismatched on mode, but of those 90 percent were trips that were not split in the diaries but represented two actual trips with a difference in mode (e.g., car and walk), and about 18 percent were mismatched by trip purpose.

Of the 106 missed trips, 57 were by car with an average travel time of 17.5 minutes and an average travel distance of 10.7 kilometres (and an average speed of 36.7 km/h). A further 34 were walk trips, with an average time of 16.8 minutes and an average distance of 1.28 kilometres, with an average speed of 4.6 km/h. The remaining missed trips comprised three bus trips, three rail trips, seven bicycle trips and two trips whose mode could not be determined. The bus trips averaged 4.9 minutes in duration and covered an average of 1.83 kilometres, while the rail trips averaged 10.7 minutes and covered an average of 4.83 kilometres. The missed bicycle trips averaged 12.0 minutes and covered an average distance of 2.4 kilometres for an average speed of 12.1 kms/h, and the two trips with unknown mode averaged 28.8 minutes in duration and travelled a distance of 19.67 kilometres at an average speed of 41.0 kms/h. These results are summarised in Table 5.

The fact that substantially more than half of the missed trips are trips by motorised vehicles suggests that the omission of these trips is of consequence to correct reporting of travel in the study area. These figures, if upheld in a larger sample, suggest that there is an under-reporting of about 11 percent of motorised vehicle trips (car, bus, and train). It is also notable that the average trip length of the omitted car trips is above the average trip length for all trips reported in the diaries. By trip purpose, the missed trips recorded by GPS comprised 32 home-based other (HBO), 9 non-home-based work (OW), 63 non-home-based non-work (OO), and 2 for which purpose could not be determined. There were no home-based work trips that were missed, as would be expected. The missed car trips were also analysed separately by purpose, and it was found that the 57 trips comprised 27 HBO trips, 6 OW trips, and 24 OO trips. The average times, distances, and speeds were also estimated for these trips and are shown in Table 6.

Mode	Number of Trips	Average Distance	Average Time	Average Speed
Car	57	10.7 kms	17.5 mins	36.7 kms/h
Walk	34	1.3 kms	16.8 mins	4.6 kms/h
Bus	3	1.8 kms	4.9 mins	22.4 kms/h
Rail	3	4.8 kms	10.7 mins	27.2 kms/h
Bicycle	7	2.4 kms	12.0 mins	12.1 kms/h
Unknown	2	19.7 kms	28.8 mins	41.0 kms/h
TOTAL	106	6.9 kms	16.6 mins	24.9 kms/h

*Table 5: Analysis of mode for diary missed trips*

Purpose and Mode	Number of Trips	Average Distance	Average Time	Average Speed
HBW	0	0	0	0
HBO	32	9.9 kms	21.1 mins	28.3 kms/h
OW	9	3.9 kms	10.6 mins	22.3 kms/h
OO	63	5.4 kms	14.7 mins	21.8 kms/h
Unknown	2	19.7 kms	28.8 mins	41.0 kms/h
HBW Car	0	0	0	0
HBO Car	27	11.4 kms	22.2 mins	30.9 kms/h
O-W Car	6	5.1 kms	10.4 mins	29.8 kms/h
O-O Car	24	11.3 kms	19.7 mins	48.4 kms/h

*Table 6: Purpose of missed trips – total and car*

Table 6 shows that the majority of missed trips are non-home-based trips, which are presumably trips that occur within a tour. Similarly, even among the car trips, the majority are still non-home-based. On average, the OO trips are about the same length as the HBO missed trips and both of these are slightly longer in both distance and time than the average missed trips by car. These are clearly not the short trips that might have been expected to have been missed. It should also be kept in mind there is some potential error in the allocation of the above trips by both mode and purpose, as noted earlier.

### **3.3 Accuracy of times, distances and duration**

In the VISTA07 diary survey, respondents are asked to report the start and end time of each trip that they undertake, and the locations of the start and end of the trip. From the difference between the start and end times, the duration of the trip is determined, while the distance of the trip is computed from the locations provided for the start and end of the trips. We have not been able to ascertain the precise method used but believe that it is based on the Euclidean distance, since Melbourne has predominantly a grid system of streets. Thus, we can compare the start times, end times, duration and distance of the trips between the GPS and the diary records. It should be noted that there will be times when the GPS does not gain a fix until shortly after the start of a trip, so that the GPS derived values may be slightly low, and the start times could be a little late.

#### **3.3.1 Start and end times**

In comparing start times, no start times were recorded exactly correctly, but there were 26 that were recorded to within one minute of the time shown by the GPS. The differences between GPS and diary start times are shown in Figure 4, where a positive value indicates that the diary trip was recorded as starting earlier than the GPS, and a negative value shows the diary trip starting later than the GPS. A total of 173 of the 434 matched trips (40%) were recorded in the diary with a start time within  $\pm 5$  minutes of the GPS time, while 255 (59%) were recorded in the diary with a start time within  $\pm 10$  minutes of the GPS start time. However, 53 trips were reported as having a start time that was more than 30 minutes different in the diary from the GPS start time. Of the total 434 matching trips, this represents 12.2 percent. As expected, since the GPS will sometimes not start to record until after the trip has started, there are 193 positive values and 169 negative values, showing the tendency of the diary records to be a little more likely to show an earlier start time than the GPS, although it is not a very marked difference.

The absolute maximum difference observed between the GPS and diary is 135 minutes, which is a negative value, indicating that the GPS showed the trip as starting over two hours earlier than was claimed in the diary. The largest positive value was 120 minutes, showing the GPS as indicating a stat

two hours later than the diary. The average difference in start times was -1.0 minutes, with a standard deviation of  $\pm 25.0$  minutes. The fact that the mean is negative suggests that, in contrast to the counts of positive and negative values, the GPS, on balance, shows trips as starting earlier than they are recorded in the diary, probably because the very high discrepancies are more frequent in the negative values than in the positive values.

A similar analysis of the end times of the trips shows that 25 diary trips were reported as being within less than one minute of the GPS time, and that 143 trips were within  $\pm 5$  minutes. The number of diary trips that were within  $\pm 10$  minutes of the GPS end time was 226. These figures show that ending times (which are not subject to error in the GPS) are reported less accurately than start times. Figure 5 shows the overall results, with positive values showing that the diary time preceded the GPS ending time, and negative values showing that the diary time was later than the GPS time.

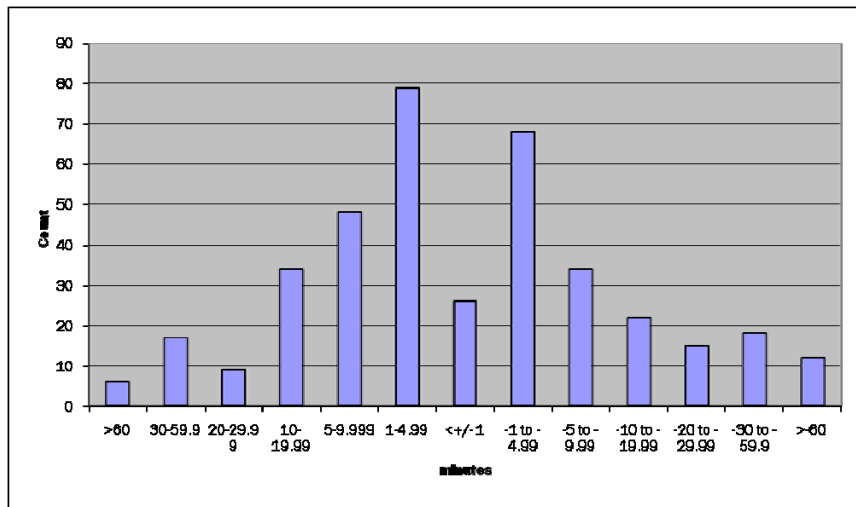


Figure 4: Comparison of GPS and diary trip start times

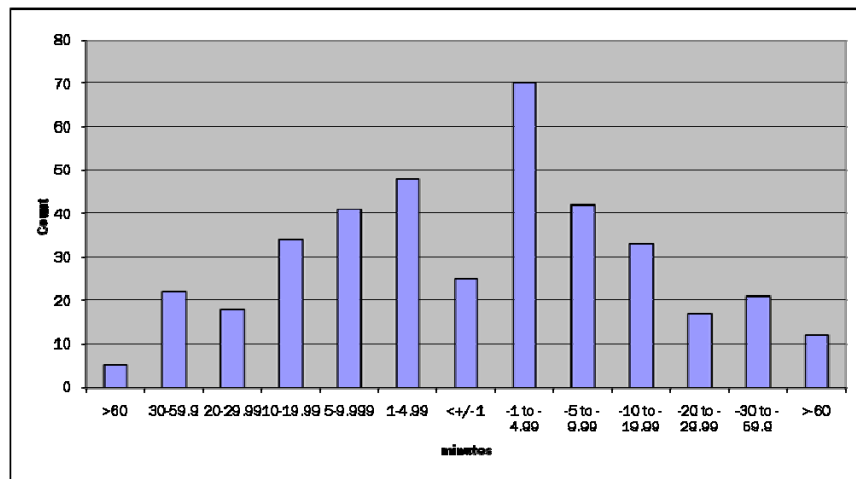


Figure 5: Comparison of GPS and diary trip end times

There are 60 trips (13.8%) reported in the diaries as ending more than 30 minutes before or after the time shown by the GPS. In the case of the end time, there are 168 positive and 195 negative values, suggesting that people are more likely to record that the trip ended later than the GPS shows. The balance of positive and negative values is, thus, reversed from the start times. The absolute maximum value of difference for end times is a negative value of 135.7 minutes, again indicating that the GPS showed the trip ending over two hours earlier than was claimed in the diary. The largest positive value was 116 minutes, showing again a similar error of nearly two hours of the diary trip ending before the trip end was shown in the GPS record. The average difference in end times is -1.4 minutes, showing

again that the diary records are on average indicating that trips ended later than shown by the GPS, and the standard deviation is  $\pm 25.8$  minutes.

### ***3.3.2 Trip duration***

As expected, given the small average differences in start and end times, the diary-based trip durations are not hugely different from the GPS values. In fact, the diaries provide a total of trip durations for the 434 matched trips of 8,196 minutes, compared to 7,417.1 minutes from the GPS devices. The means are, respectively, 18.9 minutes and 17.1 minutes. This suggests that the durations estimated from the recorded diary start and end times are about 10 percent higher than those measured with the GPS. This result is very similar to findings elsewhere internationally (Forrest and Pearson, 2005; Wolf, 2006).

### ***3.3.3 Trip length***

Finally, GPS provides the trip length, which can be compared to a trip length determined from the origin and destination locations reported in the VISTA07 diaries. In this case, the diaries show a much lower estimate of trip distances than is shown by the GPS, possibly due to the algorithm used to calculate distance from the latitude and longitude values from the VISTA07 diary data, but also potentially because of inaccurate reporting by respondents of location of the origins and destinations. The total trip distance from the diaries was found to be 3,370.2 kilometres for the 434 trips that matched between the GPS and Diary surveys. This gave a mean trip length of 7.8 kms. In contrast, the GPS records give a total trip distance of 4,120.4 kms, with a mean trip length of 9.5 kms. This suggests that, given the locations reported in the diaries and the algorithm used to estimate distance, the diary distances underestimate actual travelled distances by about 22 percent. This is a larger discrepancy than has been found in a number of previous surveys of this type, where the distance discrepancy has been found, from other methods of computing distance, to be closer to 10 to 15 percent in error. It has also been more common for diary surveys to provide overestimates of distance rather than underestimates, as found here.

## **4. Comparisons of GPS and non-GPS households**

Comparisons were made between those who used the GPS devices and those who did not. The first issue of interest is to determine whether having the GPS might lead to more accurate completion of the VISTA07 travel diaries. To measure this, the average number of trips reported per person from those who used GPS devices was calculated and compared to the average number from those who did not use GPS. Persons from GPS households reported an average of 4.94 trips per person per day, while those who did not use the GPS reported 4.29 trips per day. The GPS households reported significantly more trips at the 99 percent level of significance ( $t = 2.41$ ). This indicates that the underreporting of trips is significantly greater than deduced just from the GPS households, because these households reported 15 percent more trips per day than did the households that did not take GPS. This suggests that the underreporting of trips may be as high as 34 percent, rather than the 18.6 percent determined from the GPS households.

Another important difference found between GPS and non-GPS households is that, while the average household size of GPS households was slightly larger than for non-GPS households (2.57 vs. 2.47), the number of persons reporting trips in their diaries was much larger for GPS households (average of 2.41 persons per household) than for non-GPS households (average of 1.99 persons per household). The difference in household size between the two samples is not significant even at 90 percent ( $t = 0.53$ ). However, the difference between the two samples on persons reporting trips is significant at 99 percent. These results are summarised in Table 7. The figures are slightly different from those reported earlier, because not all households could be used in this analysis.

If we now add in the 0.87 trips per day that the GPS recorded that were omitted from the diaries, the person trip rate increases for the GPS households to 5.81 trips per person per day and the total trips per

household would then be 14.0 trips per day per household, compared to 8.54 measured by the diary. This represents an underreport of 63.9 percent.

Some comparisons of other variables are interesting to note between the total sample, the GPS sample, and the non-GPS sample. These are summarised in Table 8. Generally, the differences between the GPS and non-GPS households are small. However, consistent with what has already been observed, the proportion of one-person households is lower for the GPS households, while 2, 3, and 4 person households are higher in the GPS sample. The GPS sample households are slightly more likely to live in a separate house or a terrace or townhouse and less likely to live in an apartment or flat. They are also more likely to own their home and to have lived there on average for about 4½ years longer. They are less likely to own only one car, but more likely to own three or more cars and they are less likely to own or have recently used bicycles. Examining the means of all of the descriptive statistics for the sample and calculating the t-statistic for comparison of means between the GPS and non-GPS samples showed that only the years lived at the address was significantly different between the two samples, and this was significant at 95 percent but not at 99 percent. Hence, it can be concluded that, on all other measures, there is no statistically significant difference demographically between those who only undertook the VISTA07 diaries and those who undertook both VISTA07 diaries and GPS measurement.

Statistic	GPS Households	Non-GPS Households
Stops per Day (Trips per Day per Person)	4.94	4.29
Difference (GPS-nonGPS)	0.65** (15.15%)	--
Persons per Household Providing Diary Data	2.41	1.99
Difference (GPS-nonGPS)	0.42** (21.1%)	--
Trips per Household	11.91	8.54
Difference (GPS-nonGPS)	3.37** (39.5%)	--
Additional Stops per Day per Person Recorded by GPS	0.87	--
Trips per Household (GPS plus Diary)	14.00	--
Difference (GPS – nonGPS)	5.46** (63.9%)	--

\*\* Statistically significant at 99%

*Table 7: Comparison of diary results from households with and without GPS*

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Variable	Categories	Total Sample	GPS Households	Non-GPS Households
Household Size	1	24.9%	22.8%	28.7%
	2	31.8%	32.9%	31.0%
	3	18.0%	19.0%	16.3%
	4	15.9%	17.7%	14.7%
	5+	9.4%	7.6%	9.4%
Dwelling Type	Separate House	62.7%	60.8%	59.7%
	Terrace/Townhouse	13.7%	17.7%	14.0%
	Flat/Apartment	23.6%	21.5%	26.4%
Dwelling Ownership	Owned	51.5%	58.2%	47.3%
	Being Purchased	21.0%	16.5%	20.9%
	Rented	26.2%	24.1%	30.2%
	Occupied Rent Free	1.3%	1.3%	1.6%
Average Years Lived at Address		12.99	16.30	11.73
Registered Vehicles	0	7.7%	8.9%	8.5%
	1	39.9%	36.7%	44.2%
	2	36.5%	32.9%	34.1%
	3+	15.9%	21.3%	13.2%
Total Bicycles	0	46.4%	51.9%	46.5%
	1	20.6%	15.2%	23.3%
	2	15.0%	15.2%	14.7%
	3+	18.0%	17.1%	15.5%
Total Bicycles Used in Past 14 Days	0	76.8%	84.8%	75.2%
	1	12.4%	6.3%	14.0%
	2	6.4%	3.8%	7.8%
	3+	4.3%	2.5%	3.1%
Cars	0	12.0%	13.9%	12.4%
	1	47.6%	41.8%	49.6%
	2	30.5%	30.4%	30.2%
	3+	9.9%	13.9%	7.8%
4WDs	0	82.8%	82.3%	87.6%
	1	15.9%	15.2%	12.4%
	2	1.3%	2.5%	0.0%

*Table 8: Comparative sociodemographic values for GPS and non-GPS households*

## 5. Factoring of diary data

The results of this pilot of 58 households suggest that levels of underreporting of trip rates, misreporting of trip distances, and misreporting of travel times are sufficient to warrant a larger GPS validation subsample to develop reliable correction factors. The small sample size of this pilot survey, however, does not itself provide statistically reliable information to develop such factors, nor to suggest any corrections to the VISTA07 data. Evidence drawn from our own work and from overseas suggests that a full sample of at least 350 households should be collected, from which to estimate reliable factors for three reasons. First, evidence indicates that levels of underreporting vary by sociodemographic characteristics, so different factors may be needed for different population segments. Second, to establish correction factors for distance and time, categorisation by purpose and mode has been found to be necessary. A sample of 350 households would yield about 700 missed trips by GPS. It would then be possible to make reliable estimates of factors to apply to the data. Third, it is necessary to build into the factoring process any potential effects that may have arisen on diary completion as a result of the GPS survey.

The intent of GPS validation of travel diaries is to permit the development, if possible, of factors that can be applied to correct diary records to represent the total travel that is estimated according to the GPS devices. This is not, however, a simple matter of multiplying the diary trips by a factor of 1.2. In fact, there is a possibility that some of the diary trips that were not recorded by the GPS are actually trips that were misreported in the diaries. It is a known fact that people tend to telescope events in their memory. In VISTA07, households are given diaries on a Saturday or a Sunday, with a diary day set as a day during the coming week, and diary pick-up scheduled for the following weekend. It is eminently plausible to suggest that a number of individuals will actually not fill out their diaries until hours before or the day before the interviewer is due to pick up the survey forms. At that point, the individual may be recalling travel from several days prior to the day on which the diary is actually filled out. This is likely to lead to a telescoping effect.

## 6. Conclusions

This pilot survey has shown that there may be substantial underreporting in VISTA07, and that it may be in the order of slightly less than 20 percent of total trips reported in the diaries, based on the GPS households, but nearly 60 percent based on the non-GPS households. The survey has also indicated that there are probable discrepancies between the duration of travel and the distance of travel between GPS and diary records. The pilot survey results also showed that the majority of missed trips are non-home-based trips, and that the car trips that are missed are of substantial length and duration (11.5 kms and 22 minutes for non-home-based trips). The pilot survey has also shown that it is possible to recruit a significant sample of households to undertake a GPS validation survey, although the success rate of recruitment is highly variable with the sociodemographic characteristics of the population of the subregions within which VISTA07 was conducted. In particular, it was found to be very difficult to get GPS devices into households living in units, especially security units, and also to be very difficult to gain cooperation from student households (i.e., households comprising a number of unrelated students). Overall, the extra time required to place GPS devices at households, including both fieldwork and clerical time, amounted to less than 10 minutes per household, and was found to drop dramatically once interviewers had gained familiarity with the process.

Of particular concern is that while the average household size is not significantly different between GPS and non-GPS households, there is a substantial difference in the number of household members who completed diaries between the GPS and non-GPS households. Indeed, for the GPS households, there is an average of about 6 percent missing for diaries from GPS households, compared to 32 percent for non-GPS households. This will lead to gross errors in trip rates per household, which average 11.91 for GPS households and 8.54 for non-GPS households. On the other hand, there do not appear to be any significant biases between those households that accepted GPS and those that did not, except in terms of the length of time the household has occupied the current address, where the GPS

households have a longer period of residence. Furthermore, if we then adjust for the underreporting of the diaries of those households that received GPS devices and compare this to the households that did not receive a GPS, the overall difference jumps to 35 percent at the person level and to almost 64 percent at the household trip making level. This finding alone suggests that the levels of underreporting of travel found in previous studies may be underestimated to a greater extent than previously believed. It is, however, important to keep in mind the small size of the pilot sample used here and specifically that these results cannot be applied at this time to any revision to VISTA07 data. They are indicative only of the potential merits of undertaking a larger scale GPS validation survey.

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